MODELLING LAND USE DECISIONS OF SMALLHOLDER FARMERS IN TONGA FOR AGRICULTURAL POLICY AND PLANNING

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The main objective of the study was to develop an understanding of Tongan smallholder farmers' decision making regarding the utilisation of their limited land resources. This enables assisting planners and policy makers in their assessment and evaluation of government policy measures. A secondary, but associated objective, was to analyse and describe the Tongan household farming system and aspects of the goals, priorities, and constraints that influence the decisions. The objective was to be more realistic than past studies by improving the ways in which social and cultural values, beliefs, attitudes, and intentions can be incorporated. In particular, the multiple goals and preferences of Tongan smallholders, and behaviour related to non-economic goals such as socio-cultural and church obligations, were incorporated.

Some insight is provided into the physical, economic, and social environment of the farming systems. Using a systems research framework, the dynamics of the smallholder farming system, its structure, decision making processes and the environment within which decisions are made, were explored. A cohesive conceptual framework for linking social, cultural and psychological processes to land use decisions was developed and allowed the development of a goal programming (GP) model to portray the decision-making process of three main farm types of Tongan smallholder farmers (progressive, emergent and marginal). This involved identifying and quantifying the resources, objectives, constraints and the many demands on the farmers' available time and limited resources that influence decision-making. In addition, three agro-ecological zones were identified and a total of eight representative models developed to describe the different farm situations.

The models were subjected to validation and verification before being used to explore the effects of a number of agricultural policies. It was concluded that the models, as developed, were effective as policy analysis tools and adequate for modelling the different farm types and different agro-ecological zones which characterise Tongan agriculture. Particular attention was paid to government policies which might facilitate the successful implementation of a development strategy for increasing productivity. The main instruments explored included (a) regulations on farm size and tenure security, (b) investment in agricultural research and extension for generating improved

technology, (c) market and institutional supports for market prices (changes in market prices as well as market avenue), and credit policies, and (d) influencing farmer's goals and priorities.

The result of this research clearly shows that the production plans are determined not only by the resources available, the technology and the institutional constraints, but also by the preferences and importance attached to the farmers' objectives and goals. Modelling experiments for different policies concluded that feasible policy options do exist and these should help to improve the performance of the agricultural sector in Tonga, and of the smallholders in particular. The results suggest the key areas for the Government to address in enhancing agricultural growth. These include (a) facilitating access to land under a secure tenure, (b) orienting the national agricultural research program towards more adaptive research, (c) improving the marketing system, (d) improving the skills and motivation of smallholders through education, training, and incentives, and (e) encouraging the development of farmers' groups.

Key words: Tongan smallholders; Subsistence farmers' goals; Policy Analysis; Tongan Farming Systems; Goal Programming; Model; Adaptive Research; Land Tenure; Multiple Goals; Farmers' Groups

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Malo 'aupito

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CHAPTER 1

INTRODUCTION

In this introductory chapter the broad perspective within which the present study is located together with the objectives of the study, its research subject and theoretical orientation are described and the thesis outline presented.

1.1 Smallholder Agriculture Development in Tonga

In Tonga, the agriculture sector forms a substantial part of the national economy. Characterised by its smallness in terms of population, land area and per capita income, it is geographically fragmented and vulnerable to natural disasters. 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.

The role of agricultural production is manifested in several ways: as a source of food, employment, cash income, foreign exchange and as a source of raw materials for processing (World Bank, 1991). It 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[1] 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.

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[1] *A tax allotment is a parcel of land (normally 3.3ha) for farming registered under a male citizen over the age of 18*

1.2 Research Rationale

Agriculture development is fundamental to a strong Tongan economy. It is the dominant productive sector and holds good prospects for growth. Historically, it is quite evident that as agriculture goes, so goes the nation. The complicated nature of agricultural development in Tonga stems from the fact that government, in an effort to meet the aspirations of their citizens, is compelled to accelerate the pace of agricultural developments. 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 is currently looking for opportunities to diversify the economy particularly within the agricultural sector. 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. Tonga must therefore prioritise its needs and focus on the development of strategies for growth, diversification and intensification of agriculture. '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.

Dillon and Hardaker (1993) note that those responsible for formulating development plans and policies, however, make few of the day-to-day decisions that affect agricultural performance. Agricultural growth and development depends upon the production decisions and actions of the smallholder farm households. Most production decisions on how to allocate resources among different farming activities are taken by individual households. So, too, are decisions on the disposal of farm produce, and on how much commodity to sell into alternative markets. The success of efforts by agricultural planners to ensure that these decisions are made in accordance with development objectives in the agricultural sector depends on understanding the decision making process and strategies of smallholder farm households.

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

These policies have been aimed at enhancing and promoting the productivity of smallholder farmers in the hope of increased export production through new crops and technologies.

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 1.1 and show that targets set proved to be far too ambitious.

Table 1.1: Projected and actual export returns (*in T$m*) from agriculture products 1991 - 1995.

YEAR	1991	1992	1993	1994	1995
Projected Returns	19.02	14.97	21.35	30.80	38.06
Actual Returns	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. From a planning viewpoint, there is evidence of inadequate elaboration of development goals and objectives, superficial identification of resources and insufficient knowledge concerning resource interactions. These have all created confusion and uncertainty, particularly as regards the role of agriculture in the Kingdom's development.

Most of the policymakers have essentially an economic approach; the importance of the socio-cultural dimension of agricultural development is usually grossly underestimated. In the traditional economic approach, agricultural policies have been developed on the premise that farmers' main objective is to maximise profits. This approach also assumes that improved technology and education leads to improved decision making at the farm level and will automatically improve agriculture. However, development programs based on such approaches have inevitably failed. It is argued that traditional development projects have erred by focusing unduly on technical and economic prescriptions, ignoring the need to adapt development assistance to the local cultural and social environment and ensure that the target beneficiaries identify with such assistance efforts. Traditional economic theory provides limited guidance in the selection of variables to explain the land use decisions of smallholder farmers. A strict profit maximisation framework fails to encompass attitudinal variables as profit maximisation is a minor farm objective in developing countries. There are other important factors, institutional, social, and political, that tend to impede decision-making for agricultural development.

Some observers (eg. Beets, 1990; Dia, 1991; De Wilde, 1967; Hau'ofa and Ward, 1980) have argued that apart from the many physical, economic and technical factors there are many socio-cultural and

psychological considerations involved in the way a smallholder makes decisions. They attribute the failure of many previous agricultural development programs to a lack of an appreciation of the socio-cultural and traditional cultural values as well as a poor understanding of the inherent social norms and obligations of target beneficiaries that influence economic farm decision-making. The smallholders' social decision-making environment is prescribed by their culture, which determines values, cognition, beliefs, and experiences which are all important components of their decision-making frame of reference. These values strongly influence the behaviour and decision making strategies of the target beneficiaries or farmers and are crucial aspects of development. 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.

Research and studies in decision making for agricultural development in Tonga have been neglected in the past primarily because of the expense and the lack of well-trained personnel from various disciplines required to carry out appropriate research. Generally, amongst the vast literature published on smallholder farming development, only a few are directly relevant to the smaller South Pacific Island nations. Although much has been written about Tongan traditional agriculture (Delforce, 1990; Hardaker, 1975; Sevele, 1973; Thaman, 1976) relatively few detailed microanalyses and management studies have been undertaken to understand the decision making strategy of smallholders farmers to develop guidelines for policymakers and change agents in the development of agriculture. While some headway has been made in this behavioural research area for smallholder farmers (Hardaker, 1975; Delforce, 1990), much more attention is needed to understand the decision making process and to incorporate multiple goals and social factors in the overall production decision system of a Tongan smallholder farmer. A major weakness of the literature reviewed is the absence of a cohesive conceptual framework for linking social, cultural and, psychological processes to economic decisions of smallholder farmers. There is no literature available to focus exclusively on Tongan smallholder farmer's decision making processes and strategies and to take account of the social and cultural dimensions that are highly significant in Tongan society.

1.3 Research Objectives

Tongan smallholders have limited resource endowments and multiple goals or objectives. Within this framework, the smallholder farmers are faced with a range of constraints that will influence their decisions on utilising their land. The study will address the following questions: How do smallholder

farmers choose what crops to grow, how much to grow, how to grow it, and when? What are the important variables that determine agricultural decisions? How do smallholders' own conceptions and choices match the present economic decision models? What implications might the findings have on the design of agricultural policy and development programs in Tonga? Thus, two principal hypotheses of this study are that:

1. Actions of smallholder farmers may best be understood not only in terms of the **dynamic structure** of the agricultural system, but also through a better understanding of the decision makers' **goals, priorities, values and the social/cultural environment** within which production decisions are made.

2. The actual behaviour of smallholder farmers in Tonga cannot be described by a single profit maximisation objective. Multiple objectives must be incorporated in the decision process.

The research proposition is that Tongan farming systems are inherently dynamic and complex, and are governed by the unique decision making behaviour of the smallholder and its household. It is clear that decision-making on the Tongan smallholder farm involves a complex interaction between goals, constraining factors, resource limitations, enterprise choice and techniques, on which higher-level decisions impinge. Therefore, it is the general aim of this study to develop an understanding of a Tongan smallholder farmers' decision making regarding the utilisation of its limited land resources in terms of identifying goals, priorities, and constraints that influence their decisions. Using a systems research framework, the Tongan household farming system is defined in terms of its component parts, their interactive behaviour and their interrelationships. The goal is to be more realistic in modelling of farmers' land use decisions by improving the ways in which social and cultural values, beliefs, attitude, and intentions are incorporated. Emanating from this, the detailed objectives of this study are:

(1) To observe and report the dynamics of smallholder farming systems - its structure, decision making and the environment within which decisions are made.

(2) To identify and quantify smallholder farm household objectives, goals and their priorities.

(3) To understand the significance of social and cultural values for land use decisions by smallholder households.

(4) To provide a cohesive conceptual framework for linking social, cultural and psychological processes to land use decisions.

(5) To develop a goal programming (GP) model to portray the decision-making process of Tongan smallholder farmers.

(6) To use the model to explore effect of policy incentives on smallholder farmers' decisions and production.

Support to smallholder farmers through development programs and policies must always be based on a detailed understanding of the social and economic realities of households - their goals and objectives, preferences and values, and the many demands on their available time and limited resources. Modelling a Tongan smallholder farm involves identifying and quantifying the resources, objectives, and constraints that influence decision-making. Too little is known about the competition for farm resources and the nature of smallholder farmers' objectives and constraints to evaluate the efficiency of their decisions. Ashby (1926) stated that '***If we want to know how or why a farmer acts in a certain way or how to induce him to act in a certain way, we have to enquire why men act, and especially why men act as they do when they live in the sort of social environment and general circumstances in which farmers live.***' (Ashby, 1926 p 5). The present study seeks to understand how, in particular situations, farmers' behaviour is related to objectives, resources and technology, and the way in which these in turn are related to customs, social values, and institutions. There is a need to identify the constraints on the smallholder farmer behaviour and policies that might most effectively relax these constraints.

This study should provide a useful focus on the range of issues involved in the decision making process of smallholder agriculture in Tonga. It is crucial for successful development planning that policymakers, planners and agricultural extensionists understand how smallholder farmers make decisions and the logic they use, and who and what influences their decisions. The central theme is that a detailed understanding of present production processes and decision making behaviour in smallholder agriculture can be of paramount importance in determining the relevance, practicality, and potential success of proposed policies, changes and innovations for development of agriculture in Tonga. This study should allow planners and policy makers to predict farmers' responses to new resources, techniques, market opportunities, institutions and policies. The analytical framework necessary for such predictions needs to contain endogenous social values, customs, and institutions. Subsistence and semi-subsistence farming systems are, generally, highly complex - more so than commercial systems, if only because their analysis can be reasonably based on the separation of commercial from non-commercial activities. 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.

1.4 Outline of Thesis

The thesis comprises three main parts. Part 1 contains the introduction (Chapter 1) and a review of land use decision modelling approaches and methodology (Chapter 2). In this chapter the choice of multiple goal and objective programming is justified as the most appropriate methodology given the objectives of this study and the nature of the farming system involved. Chapter 3 presents an

overview of the study area, that is background information on the Tongan economy, agriculture and farming systems. Chapter 4 explains the methodology and research design employed in this research. It also includes a brief description of the approach and methods used in the study.

Part 2 is a system analysis covering the initial analytical stage of the modelling process to determine the nature and behaviour of the system components and sub-systems. The interaction between components is considered. The systems analysis stage of this study involves the use of ideas from the literature, data analysis and subjective observations and assessments.

Chapter 5 provides a review and analysis of the agriculture organisation, institutional and economic environment. Major emphasis is given to policy formulation in agricultural development planning in developing countries and outlines how policies and development plans are being formulated in Tonga, and discusses their impacts. The analysis of the existing institutional and economic environment, including government support services, marketing infrastructures and channels and credit facilities, which have a significant impact on smallholder production decisions, are all presented. The key policies described will be addressed in the model application.

Chapter 6 provides the analysis of smallholder farming households' goals and objectives. The main objective of this analysis is to identify and evaluate the goals and objectives, and to derive an objective function suitable for the Tongan smallholder goal-programming model.

Chapter 7 provides an understanding of the land resource endowments of different smallholder types in terms of their access to land, and how it is being used. This allows decision variables and resource constraints to be derived. Chapter 8 provides an understanding of the resource endowments of different smallholder household's types in terms of access to labour and capital, and how they are being utilised.

Chapter 9 presents a review and analysis of the socio-economic environment in which smallholder farmers operate. The main objective is to investigate and understand the significance of social and cultural values for land use decision behaviour and the relationship to the decision-makers. It also analyses the influence of village or community groups and other organisations on individual household decision making.

PART 3 is the system synthesis, model development and evaluation phase. System synthesis involves providing a coherent and logical conceptual framework and the implementation of this framework into a working computer model. It involves explicit consideration of the multiple objectives smallholder farmers have and the characteristics of the system, thus allowing the development of appropriate procedures for representing these aspects.

Chapter 10 provides the detailed design and development of a Multiple Objective Goal Programming (MOGP) model to portray the decision-making process of Tonga smallholder farmers. Chapter 11 includes the results from testing and assessing the usefulness of the model. An important part is model validation while involves the testing of the verified model's ability to mimic the operation of the real world situation. In Chapter 12, the models are put to their intended purpose with a series of experiments to examine and explore the effects of policy instruments on the different smallholder farm types' achieving their goals and objectives as well as the nation's goals.

Chapter 13 gives a summary of the research findings and conclusions are drawn. The overall value of the study is discussed and consideration given to the implementation of the model for the assessment of different policies under a range of farming conditions and situations. The scope for further research is discussed. The reference list and appendices complete the thesis.

CHAPTER 2

A REVIEW OF DECISION MODELLING METHODOLOGY

2.1 Introduction

Decision-making is an integral part of the management of any kind of organisation. It is an ongoing process in which the decision-maker evaluates the available alternatives and selects a course of action. The basic steps involved in any decision-making process, outlined by Harrison (1987), include (i) defining the objective(s), (ii) identifying possible choices, (iii) collection of relevant information, and (iv) drawing of appropriate inferences. Success involves interdisciplinary knowledge and these aspects of decision making are best illustrated within the framework of a set of models as demonstrated below. Ideally, a decision making model should include variables that will help explain the real world phenomenon being modelled and assist the decision-maker to predict real world phenomena with sufficient consistency and accuracy to be of considerable value.

In this chapter the literature related to modelling of farm level decision-making methods, including the history and comments on developments to date, is reviewed. A brief overview of multiple objective programming techniques is also provided and the choice of Goal Programming modelling is justified as the most appropriate methodology given the objective of this study and the nature of the Tongan smallholder farming system.

2.2 Modelling Approaches to Household Studies

Over the last three decades there has been increased recognition of the importance of household farm decisions. Researchers have focussed on understanding the process and strategies of farm households' decision-making in terms of land use and production decisions (Upton and Dixon, 1994). While many decisions are made without much consideration of alternatives, important decisions require careful evaluations. Farmers must decide what to produce, what technology to use, and how to allocate their resources of land, labour and capital among the alternatives open to them as well as make decisions on marketing. It is in regard to these important and crucial decisions that analysis of alternatives and actions is invaluable.

The development of appropriate models of choice is central to the study of farm decision making (Ellis, 1988). Modelling behaviour is fairly advanced, with various models having been used and new ones constantly being developed for agriculture in the developed and in developing world. In the literature, three main approaches have been used to analyse farm households in farm systems modelling, each derived from a different perspective: the economic, sociological and psychological.

2.2.1 Economic approach

The economic approach to farm household decision making is based on the classical theory of the firm. Here the farm is seen as no different from any other large or small-scale business with the assumption that the underlying objective of the farm decision-making complex is to allocate resources in such a way as to maximise profit, at least in the short term (Barnard and Nix, 1973). Therefore, economic land use models assume that farmers are highly responsive to the demands of the market and, operating in an environment of perfect information, make land use decisions based solely upon the principles of profit maximisation. As a result, agricultural land use patterns are determined purely by economic factors, such as market prices and gross margins. To maximise profits within resource constraints is to achieve the economic optimum. Any deviation from a strategy of economic optimisation may be quantified in terms of profit foregone. For example if a farmer chooses to allocate limited resources to a less profitable enterprise (for reasons of preference, subsistence output or prestige), the effect of that decision can be quantified in terms of potential profit sacrificed. In this way, profitability has tended to become a yardstick by which all other production motives are evaluated.

A wide range of mathematical programming techniques which optimise a single objective function with or without risk and uncertainty have been reported in the literature (for example, Amir *et al.*, 1991; Ghadim *et al.*, 1991; Wossink *et al.*, 1992). These modelling attempts have failed to accurately reflect the realities of decision making. This is partly because of the restrictions of the modelling framework adopted and partly because the models make basic assumptions about rationality that is not upheld in the real world. For example, studies of farmers' economic rationality in developing countries using Cobb-Douglas production functions and cross-section data have concluded that farmers act as profit maximisers within their technological and institutional constraints (Hopper, 1965). This approach has been criticised because methodologies explicitly incorporating risk considerations are probably a more realistic basis for making policy recommendations directed at the modernisation of traditional agriculture (Dillon and Anderson, 1971; Wolgin, 1975).

The failure of traditional economic models of land use to correspond to the reality of poor resource farmers has led to the acceptance of the significance of other important factors involved in decision making processes (Nowak, 1987; Strauss *et al.*, 1991). Most important is the human factor which is

vital in the land and resource use decisions of farmers (McRae, 1993; Reid *et al.,* 1993). Farmers make decisions with respect to the multiple goals they have and the physical, economic and the socio-cultural environment in which they operate.

2.2.2 Sociological approach

The sociological approach acknowledges the fact that economic and ecological conditions are not the only factors guiding farmer choices and decisions in a production system. The nature of social systems, such as norms, beliefs, cultural values and communication patterns, have a significant influence on farmers' production decisions. It would be pointless to promote crops or techniques that do not correspond to the true interest of the farmers or for which the needed resources are unavailable.

Rogers and Shoemaker (1971) described two different social systems, a traditional and a modern social system. The traditional social system is characterised by a less developed or simple technology, a relatively low level of education, little communication with outsiders, and a lack of favourable orientation to change. These attributes account for a low adoption of improved technology and innovations among farmers. In contrast, the modern social system, which features in developed countries, is characterised by a well-developed technology with a complex division of labour, a high value on education and sciences (extension and research), rational and business like social relationships and a generally positive attitude to change. It is important for development planning to ensure that policies and technology are compatible with the existing social system. Reid *et al.,* (1993) point out that new technology should address farmers' constraints and their circumstances in order to ensure that they are relevant to their farming systems. Parker and Townsley (1995) also note the importance of a qualitative approach to studying human behaviour pertaining to farmers' circumstances and goals on decision making which reflect the close association between farm management and the disciplines of behaviour and social psychology.

Numerous sociological studies have clearly demonstrated that economic profitability is not necessarily the main motivating factor. Farmers also attach high value to the social and "lifestyle" aspects of farming, such as independence, following family traditions and being able to work outdoors (Gasson, 1973; Greer, 1982; Fairweather and Keating, 1994; Austin *et al.*, 1998). Dasgupta (1989) for instance, found that Punjab farmers in India attached greater importance to social approval and less to financial return. These studies strongly suggest that purely economic models cannot capture the full complexity of farmers' motivation and behaviour. Technical and economic factors are extremely important, but not necessarily the only factors, and in some decisions not really critical. This has led to the consideration of social factors, including demographic variables such as age, education, marital status, family size and structure, in later studies (Feder, *et al.*, 1985; Nowak, 1987; Lynne *et al.*, 1988; Strauss *et al.*, 1991). These factors were incorporated to

improve the predictive ability of these models but, to date, confirmation of this in the literature is sparse and the empirical modelling reported has failed to explain more than 60 percent of actions, at best.

2.2.3 Psychological approach

The third perspective on understanding and modelling farm decisions adopts a psychological-behaviourist approach. Behavioural models are founded upon the premise that there is often a significant differential response among farmers to actual or potential opportunities in the economic sphere. Their socio-personal characteristics, rather than economic forces, therefore largely determine the degree to which farmers respond to economic stimuli. To date, the approach has been limited to investigating farmers' perceptions of the quality of life, farming values, satisfaction with farming, and risk taking but, generally without the credibility of well validated tests and often without reference to behaviour. This approach could be improved by introducing personality and work style factors in addition to cognitive ability tests and closer correlation of attitudes with behaviour. However, psychological variables such as perceptions, values and attitudes on their own are insufficient for general modelling decision making. According to Linder (1987), the decision making process requires the individual to search and evaluate information before choice can be made. Such a process depends on individual's ability and preferences based on past experience; factors such as cognitive ability, personality and preferred style of working should be included in the model under this approach.

A behavioural approach to the study of agricultural land use patterns involves, amongst many other components, the use of concepts from "*decision theory*". The proponents of decision theory have attempted systematically to describe those variables that influence entrepreneurial choices by farmers. Early attempts to model agricultural land use patterns through a behavioural perspective revolved around the work of von Neumann and Morgenstern (1944), who constructed the foundation of game theory. Game theory maintains a normative theory of behaviour while recognising the presence of uncertainty in the decision-maker's environment. This involves the construction of a payoff matrix. This matrix illustrates possible outcomes of various strategies available to the farmer, given a number of possible circumstances (Halter and Dean, 1971). The optimal decision, at least in the farmer's mind, may be selected according to various criteria. Halter and Dean (1971) review the various criteria such as Wald's "standard of judgement" and the Laplace criterion. According to Wald's standards, a farmer selects a strategy based on a pessimistic forecast and, accordingly, chooses the least risky farming practice. In contrast, according to the Laplace criterion a farmer selects a strategy based on the assumption that each possible circumstance (eg. weather or market conditions) is just as likely as the next. The latter criterion is commonly referred to as the average approach. These criteria have been incorporated into various linear programming models for whole farm planning (Anderson *et al.*, 1977).

The role of risk in agricultural behavioural and decision models is generally recognised today. Agricultural production is a typically risky business. Farmers face a variety of price, yield, and resource risks, which result in unstable income and production from year to year (Mapp *et al.*, 1979). Empirical applications of behavioural models and theoretical considerations indicate the importance of incorporating risk into the analysis of farmer's decision making (Anderson *et al.*, 1977; Roumasset, 1976; Barry, 1984). The omission of risk in farm-level decision models of traditional agriculture may lead to results that bear little, if any, semblance to farmers' actual behaviour. Agricultural decision models that fail to not include risk considerations may overestimate output levels of risky crops and fail to recognise the importance of diversification in traditional agricultural production systems (Wolgin, 1975). Hazell and Norton (1986) also pointed out that ignoring risk may also lead to an overvaluation of some inputs, and an incorrect prediction of technology choices.

2.2.4 Integrated approach

The literature acknowledges the fact that decision-making in agriculture is a complex process involving a large number of factors. Apart from the sociological and psychological factors, there are many physical and economic considerations involved in the way a farmer makes his decisions (Beets, 1990). Astroth (1990) point to the existence of numerous causal factors and that, attempting to model agricultural land-use decisions is a difficult task. He further noted that, any theoretical model developed to explain agricultural land use economic decisions must take account of psychological and sociological realities provided by models of behaviour. While each of the three modelling approaches has its own particular strengths, there is a need for a more holistic approach to modelling decision making and farm households' behaviour. The most successful approach may well come from combining the three approaches into a single integrated framework. Such an integrated approach will be more realistic and greatly assists policy making, enabling the identification of possible trade offs between economic and non-economic objectives. It would also assess the impact of government interventions through development policies in market, land inputs, products, technologies and infrastructure on farmers' decisions on resource utilisation.

With the construction and empirical testing of analytical models, many researchers have been concerned with the empirical testing of such models in various economic settings throughout the world. No attempt has been made, however, to develop a behavioural model specifically tailored to the characteristics of smallholder farmers in developing smaller island nations. As a result, land use models from developed and larger developing countries have had limited success in modelling land use patterns of smallholder agriculture in developing countries (Upton and Dixon, 1994). It is evident that both behavioural and economic forces greatly influence the patterns of agricultural land use in less developed economies. Therefore the construction of a land use decision model requires the selective integration of economic and behavioural paradigms. An integrated approach to modelling smallholder farming land use can incorporate a variety of goals and risk aversion behaviour, while at the same time

recognising the importance of, for example, marketing and economic factors in the decision making process of smallholder farmers. It was this need for a more appropriate smallholder land use model that prompted this study. From its inception, the primary goal of this research has been to develop a behavioural land use model specifically designed to fit the characteristics of the smallholder agricultural system in Tonga.

2.2.5 Farm household systems

In terms of agricultural development planning, a good understanding of farm household systems is an essential prerequisite for effective policy prescriptions (Dillon and Hardaker, 1993). In general, modelling appears to provide a cost-effective way of understanding farm-household systems and assessing a wide range of possible system changes which may occur as a result of government policy interventions (Upton and Dixon, 1994). Agricultural system research modelling to date has tended to mimic the biological sciences by concentrating on the detail of either the individual production system or production from the whole farm system. According to Dent *et al.*, (1986), a large proportion of these models exist for the simulation of crop and livestock growth, herd dynamics, animal welfare and crop protection, and therefore have limited utility (Doyle *et al.*, 1989; Sorensen, 1989; Lopez-Tirado and Jones, 1991). Very few models represent the agricultural system in its entirety and address the socio-economic element of the farming system. Applications of these models are limited by a suitable degree of understanding of the decision-making complex in which the models are formulated and set.

When modelling the dynamics of agricultural systems, economists recognise that farms vary but, rather than attribute this variation to social factors, they concentrate on defining farm types by structural variables such as farm size and enterprise mix. The socio-economic element of these farms has been assumed to be constant, and all farm-decision making units have been assumed to act as rational financial maximisers (Amir *et al.*, 1991; Ghadim *et al.*, 1991; Wossink *et al.*, 1992). However, common sense suggests that not all farmers or farm households within any given farm type are similar, and it is becoming increasingly apparent that few individuals maximise financial gain. Rather decisions are influenced by a range of factors including objectives, personality, attitudes and experience (Gasson and Errington, 1993; Duff *et al.*, 1991). The objectives and attitudes of farm households are shaped by the resources they possess or have access to, by past activities and policies that have, or are, influencing development and by their perceptions of what the future may hold (Phelan, 1994).

This review highlights the fact that many approaches have been used to understand the principles and decision-making process of farmers without a single approach being superior in all situations. While it is possible to develop a mathematical model incorporating all relevant issues, such a model will be complex and costly in resources and time. The nature and complexity of social interactions

render the task of documenting and understanding the decision-making process very complex. These difficulties may explain why, to date, scientists, economists and policymakers have largely ignored, or oversimplified, the role of the farm household in agricultural systems. The social aspects of agricultural systems have not received as much attention as the other areas. Consequently models of farm-household decision making are neither powerful nor transferable. This is unfortunate because models of whole farm systems are becoming increasingly desirable for policy assessment and their utility in this context is currently limited by the relatively poor quality of socio-economic models.

2.2.6 Modelling smallholder farming system - A Brief Review

Decision-making model builders in the field of farm management are aware that smallholder farm households in developing nations operate a complex reality (Hardaker, 1975; Lee *et al.*, 1994). This reality constitutes what social scientists divide neatly into areas of farm decisions - farm management, general production economics, political parameters, social interaction patterns and institutions, public relations, religious beliefs and behaviours. Smallholder farm households both produce and consume agricultural products, and operate in a myriad of biophysical, socio-cultural and economic environments (Beets, 1990). In addition, domestic tasks, social commitments and non-farm earning activities are integrated into the life of the farm household, competing with and contributing to agricultural activities.

Modelling of smallholder farming systems often involves a greater degree of complexity than is encountered with large-scale commercial systems (Bollard, 1977; Norman, 1974; Hardaker, 1975; Delforce, 1990; Upton and Dixon, 1994). Analysis of semi-subsistence production modes must take account of the strong interactions between the major system components – household, farm and off-farm. In particular, there is competition between the three for resources (land, capital, labour). In addition, the production system itself is also quite complex as smallholders often grow a diverse number of crops and have mixed cropping patterns; often mixtures of annual and perennial crops are grown and usually a few animals are also kept. Another important issue confronting the analyst of smallholder farming systems is the measurement of farming system performances. Dimensions other than profit maximisation loom large in many smallholders' objectives and the existence of multiple objectives and different priorities is common. Realistic monetary valuations of farm inputs and outputs can be difficult (Dixon *et al.*, 1994). Moreover, the decision-making strategy varies as influences of groups and village objectives are significant. An appreciation of this heterogeneity, complexity, and interdependence is necessary if the responses of smallholders and village communities to planned interventions are to be anticipated.

Clearly, the perceptions of policy makers concerning the realities of small-scale agriculture will condition their views about the priority issues to be addressed in development programs. For this

reason, the analysis of different types of smallholder farm households is important for effective agricultural policy design. Upton and Dixon (1994) note that various models have been used for such micro-level analysis, ranging from qualitative informal frameworks to more complex and complicated quantitative models involving computer analysis. The increasing development of microcomputer software and programs has allowed the development and use of far more sophisticated models than were previously feasible. Some of these models include econometric, simulation and mathematical programming models.

Traditionally, predictive models in the form of econometrically estimated supply response models and production functions have been used. These models were based on the neo-classical theory, which implied the existence of, or at least the rationality of profit maximising behaviour. In terms of allocative efficiency there has been a recurring debate on the extent to which farmers allocate their resources to maximise profit. Upton and Dixon (1994) point out a major limitation of using econometrical models and analysis for policy formulation in that many studies do not present the risk inherent in the model specifications, and only a few variables are considered with most factors being assumed to be fixed. Policy briefs based on the results of these studies rarely contain the basic assumptions, and therefore bear the risk of being interpreted too literally. Econometric models described above, while sometimes useful for expost policy analysis, are of limited value in the evaluation of new policy measures.

Simulation models have been used to explain real world systems. Simulation of time-dependent processes involves the specification of stated variables together with the flows of change, which may be either controlled by the decision-maker or subject to a pre-determined relationship (Upton and Dixon, 1994). Such models have proved valuable in exploring these processes over time, especially with the likely variability of perennial crop performance. As shown by Dent and Blackie (1979), price data can be incorporated to provide estimates of costs and returns for individual enterprises over and time profiles, and also show investment needs for individual enterprises. However, Dent (1991) noted that models that incorporate the complex dynamics and uncertainty of the biology, sociology and economics of whole farm household systems are rare and less likely to be used in the future. This is because the construction of whole farm simulation models, built up from basic biological and human behavioural relationships is a very costly and time-consuming process.

In this study attention has been directed to the modelling of farm-level decisions in semi-subsistence smallholder agriculture. It is through the construction and use of farm models that policymakers can better understand the options open to farm decision-makers, appreciate the effects of farmers' attitude, and help farmers to make better decisions. These judgements, however, require a better understanding of the nature and characteristics of the smallholder farming system. With a complex system of mixed cropping and livestock production, managed by farm households who must cope with a range of uncertain factors, including market prices, weather, pest and diseases, and

government policies, the analysis is difficult but clearly important. This better understanding can improve the diagnosis of agricultural development problems and constraints, and the formulation of policy alternatives. The *ex ante* assessments of the likely responses to, and impacts of, alternative agricultural policies and programs will also be enhanced.

2.3 A Review of Mathematical Programming Models

Mathematical programming models are particularly well adapted to the identification of critical constraints and the set of feasible alternative farm enterprises. In the policy analysis context, mathematical programming can be used to find the optimal farm plans for conditions with and without a given program or policy, and thus estimate the potential impact of the proposed change. Thus, assumptions about behaviour can be built into the model with a defined objective function and constraints. It can also calculate the relative value of scarce resources. Following the first application to agriculture that focused on maximising farm income subject to limited resource constraints (or minimising costs), the method has been modified and developed in various ways. The input-output coefficients, constraint levels and prices are often derived from farm and enterprise surveys.

2.3.1 Linear programming

In the early days of management science, and especially with regard to practical applications, the multiple objective nature of decision problems was largely avoided. Instead, the conventional linear programming (LP) approach, which optimises a single objective, was predominantly used. Linear programming is a mathematical programming technique for solving a problem of allocative choice of scarce fixed resources. The objective of linear programming is to maximise or minimise a linear function subject to a number of linear constraints. Resources in terms of land, capital and labour are scarce and limited factors in agricultural production. The study of linear programming enables an appreciation of the complex manner in which prices, yields and scarce resources interact during critical seasons to determine the best farm plan (Nuthall, 1996). The great advantage of linear programming is that it allows one to test a wide range of alternative adjustments and to analyse their consequences thoroughly with a small input of managerial time (Beneke and Winterboer, 1973). This single objective approach, usually in the context of a linear programming model, resulted in a large number of successful practical applications, which in turn stimulated greater research in this area (Piech and Rehman, 1993).

Hardaker (1975) developed a linear programming model of the production and consumption opportunities of a typical rural household in Tongatapu, Tonga. The model explored opportunities for use of the fixed resources (land and labour) in agricultural production. The product utilisation activities included food consumption alternatives along with specified minimal nutritional needs for the farm

family. Cash constraints were also incorporated, so the model represented the farm household interrelationships through the provision of family food supplies, the generation of cash and a minimal level of cash surplus. The objective function was specified as the maximisation of net cash surplus, after essential living costs had been met. On the basis of the linear programming results, Hardaker deduced that most Tongan farmers were using their resources efficiently in the sense that they appeared to allocate them in a manner consistent with their beliefs and preferences. Although the linear programming results indicated that it would be theoretically feasible to produce a substantially greater agricultural output from Tongan farms, this would entail encouraging changes in farmer behaviour. Because such changes are notoriously difficult to bring about, Hardaker (1975) concluded the scope for intensification of Tongan agriculture with the present production technology and within the existing socio-economic environment and institutional framework was limited. In terms of the model of smallholder farmer decision making, Hardaker suggested that extension methods be viewed as a means of modifying farmer beliefs by firstly bringing these beliefs more into line with reality, and secondly reducing the degree of uncertainty in the farmer's mind. Hardaker recommended that since, in the traditional-type Tongan society, the views of older people are well respected, agricultural extension should involve the whole community, especially through group methods of extension.

Despite this empirical evidence, policy analyst and modellers in agricultural economics have not paid too much attention to the crucial role that should be given to several objectives and goals in building decision-making models. A major limitation of using a linear programming model in natural resources allocation and management decisions is that only a single criterion for determining the optimal strategy is used. In most cases, however, decision-makers, as noted before, have a number of objectives which they try to meet simultaneously. A major limitation of Hardaker's research is the failure to consider the multiple objective nature of Tongan farm households, and incorporate the social and cultural aspects that influence decision-making.

This section has presented some aspects and limitations of conventional linear programming models to describe smallholder farmers. Because of these limitations the next subsection will review the potential of multiple objectives and goal programming modelling to be used in this research to study the decision processes of smallholder farmers in Tonga.

2.3.2 Multiple objective programming models

It is increasingly accepted that multiple objectives are the rule rather than the exception in taking farm-level decisions (Gasson, 1973; Romero and Rehman, 1985; Dent and Jones, 1993). The limitations of linear programming and the recognition given to the existence of multiple objectives in decision making have led to the development of multicriteria decision making methods (Romero and Rehman, 1985; Flinn *et al.*, 1980; Piech and Rehman, 1993). These researchers showed that Multicriteria Decision-Making (MCDM) models could be applied as practical and realistic

representations of real farm planning problems. This supports the view that decision-making in agriculture involves several objectives or goals rather than the pursuit and maximisation of a single one. Romero and Rehman (1985) claimed multiple objective models give better results than single objective models.

Over the decade many strategies and modelling approaches have been devised to solve problems characterised by multiple objectives, or multiple criteria (Easton, 1973; Thampapilli, 1978) in agricultural decision making. However, the literature reviewed gives little guide as to the choice of the appropriate model for any given situation. The choice of technique generally has been left to the skills of the researcher or analyst who must consider the cost and time of achieving output and the availability of data required for model implementation. However, there are two main contrasting approaches to building multiple objectives decision models.

The first and most rigorous approach consists of defining a utility function comprising all relevant objectives for a given decision problem. Keeney and Raiffa (1976) chiefly developed this kind of methodology, known as Multi-Attribute Utility Theory (MAUT). MAUT is a theoretically sound approach based on the assumption of rationality underlying the classic paradigm of expected utility created by von Neumann and Morgenstern (1944). However, its applicability poses many difficulties. A major problem associated with the formulation of a MAUT model lies with the high degree of decision-maker interaction required to develop the function. This issue is particularly important in agriculture, where the cultural and educational background of the decision-maker may not be suitable for undertaking such an interactive process. Thus, within the context of a peasant economy, to question a person in charge of a family farm thoroughly about his/her preferences concerning different random lotteries and similar hypothetical questions in order to test independence conditions or assess utility functions can be problematic. Thus, very few applications of MAUT in the agricultural field can be reported (eg. Hearth, 1981; Delforce and Hardaker, 1985; Foltz *et al.*, 1995).

The second direction consists of looking for multi-criteria approaches without the theoretical soundness of MAUT, but which can accommodate in a realistic manner the multiplicity of criteria inherent to most agricultural planning problems. Among the possible substitutes of MAUT, the most widely used in the agricultural field are goal programming, multiobjective programming and compromise programming. Rehman and Romero (1993) analyse the pros and cons of these surrogates in agriculture. These methodologies were selected as appropriate for the purpose of this study. The general principles, assumptions and theory behind each modelling methodology are discussed below. The structure of the models and also the application of the model in decision making highlights some of the limitations of each methodology.

2.3.2.1 Multi-Objective Programming Model

Multi-objective programming (MOP), also known as vectorial optimisation, is a multiple criteria decision-making approach directed at this problem of simultaneous maximisation or minimisation of several objectives subject to a set of constraints. As the simultaneous optimisation of objectives is impossible, Piech and Rehman (1993) showed in MOP that instead of the Simonian notion of "satisficing" levels of achievement, it tries to establish a set of efficient or Pareto optimal solutions. The first stage is to generate the efficient set that separates the Pareto optimal feasible solutions from non-Pareto optimal ones. A set of efficient solutions is those feasible solutions that can achieve the same or better performances for all objectives and strictly better for at least one objective (Romero and Rehman, 1985). The elements of this efficient set are feasible solutions such that no other feasible solution can yield an improvement in one objective without causing degradation in at least another objective. The second stage consists of searching for an optimum compromise for the decision-maker among the efficient solutions. To undertake that stage it is necessary to incorporate in one way or another the preferences of the decision-maker. Formally, the general setting of a multiple objective programming problem can be expressed as follows:

$$Eff\ f(x) = [f_1(x), f_2(x), \ldots f_k(x)]$$

$$\text{Subject to} \quad x \in F$$

$$x \geq 0$$

where:

Eff means the search for efficient solutions in a maximising sense when "more is better" or in a minimising sense when "less is better".
$f_i(x)$ = mathematical function of the i_{th} attribute, $i = 1, 2, \ldots k$
x = vector of decision variables
k is the number of goals
F is the feasible set defined by the constraints of the problem.

There are several techniques to generate or at least approximate the efficient set. Among the most widely used are:

(i) ***The Weighting Method*** was first developed by Zadeh (1963) which combined all the objectives into a single objective function by attaching appropriate weights to each objective and then adding all the resulting components (Romero, 1991). The efficient set is generated through a parametric variation of weights. In other words, for each set of weights, the above model provides an extreme efficient point. It should be noted that the weighting method guarantees efficient solutions only when the weights are strictly positive (w > 0). In fact it has been shown (e.g. Cohon, 1978) that if one of the weights is zero and simultaneously there are alternative optimal solutions then the optimal solution can be inferior or non-efficient. Thus in a MOP problem with q objectives to maximise, the weighting method would lead to the following parametric LP model:

$$\begin{aligned} &\textit{Maximise} && w_1 f_1(x) + w_2 f_2(x) + \ldots\ldots + w_q f_q(x) \\ &\textit{Subject to} && x \in F \\ & && w \geq 0 \\ & && x \leq 0 \end{aligned}$$

where:

$f_i(x)$ = mathematical expression of the i_{th} attribute $i = 1,2,3,\ldots q$
x = vector of decision variables
F is the feasible set defined by the constraints of the problem
w is the weight, $i = 1,2,3,\ldots q$

(ii) ***The Constraint Method*** initially proposed by Marglin (1967), it involves optimising one of the objectives while others are placed as constraints. The efficient set is then generated by parametric variation of the right-hand-side values of the objectives treated as constraints. Thus, for a MOP problem with q objectives to be maximised, the constraint method would lead to the following parametric mathematical programming model:

$$\begin{aligned} &\textit{Maximise} && f_j(x) \\ & && f_i(x) \geq H_i \qquad i = 1,2,\ldots, j-1, j+1,\ldots, q \\ &\textit{Subject to} && x \in F \\ & && x \geq 0 \end{aligned}$$

where f_j (x) is the objective to be optimised. By parametric variations of the right hand sides H_i, the efficient set is generated. However, this method guarantees efficient solutions only when the objective restraints of the above equations are binding at the optimal solutions (Romero and Rehman, 1985). Several authors have shown that if for at least one value of the right-hand side H_i in the optimal solutions, any of the parametric restraints are not binding and if there are alternative optimal solutions then the optimal solution provided by above equation can be inferior or non efficient.

The details of the above method can be found in Cohon (1978) and Zeleny (1982). However, once the efficient set has been generated, the problem of helping the decision-maker (DM) to choose an optimal solution remains. Here again there are several possibilities but a widely used technique is Compromise Programming as proposed by Zeleny (1973).

The application of the Vector Optimisation approach has been criticised in the literature. Rehman and Romero (1993) discussed some of the issues related to the use of MOP techniques. Most of the drawbacks of the MOP approach are of an operational and computational nature. As regards the information that is required for MCDM techniques, the information required of the DM for MOP modelling is comparatively easy to obtain in comparison with the case for GP. MOP needs only the technical data concerning the restraints of the problem and the mathematical expression of the

objectives. However, no knowledge of the DM's preferences is required. There is nothing wrong with this approach. MOP is just a technical device to separate feasible and efficient solutions from those which are simply feasible.

MOP has a more complicated procedure of obtaining solutions, but appropriate software packages now exist for generating the efficient solution set. In terms of output produced, MOP models generate abundant and very useful information to analyse any decision-making problem. In fact, the decision-maker is presented with a set of efficient solutions (farm plans), from which the decision-maker can pick and implement the most suitable one. This set represents the transformation curve or production possibility frontier making it possible to derive the trade-offs between the objectives under consideration. This advantage of MOP is significant when two objectives are involved, as it is possible to display the transformation curve graphically. Rehman and Romero (1993) noted that several authors have reported applications where there are few objectives and the input/report matrix size is about 50 or so variables. However, one of the major operational problems associated with larger MOP models is that the amount of output (efficient sets) produced can be excessive thus making it extremely difficult for a DM to make a choice from such an array of information. Steur (1994) reports results obtained through a simulation of MOP problems where models with 40 constraints, 50 decision variables and 5 objectives generate almost 3000 extreme points. Thus the MOP technique is not recommended for larger models as it could lead to computational difficulties or result in too many solutions to choose from.

The problem of too much output in this situation can, however, be mitigated in several ways. The size of the efficient set can be reduced by establishing compromise sets for different sets of weights that reflect the DM's preferences. Another possibility is to use criterion weights rather than fixed ones, as first developed by Steur (1976). This method is very effective in generating only that part of the efficient set, which is of actual interest to the DM. Steur and Harris (1980) proposed using filtering techniques to reduce the number of extreme efficient points by discarding efficient solutions that are not sufficiently different from other efficient solutions already retained by the filter. This saved a substantial amount of computer time and allows the size of the efficient set to be reduced considerably.

2.3.2.2 Compromise Programming

The MOP approach presented above can be regarded as the first stage of a decision making process. In fact, MOP divides the feasible set of solutions into two subsets: the subset of Paretian efficient solutions and the subset of inferior solutions (Romero, 1991). This division of the feasible set is herein undertaken in a mechanistic way without considering at all the preference structures of the DM. Once the nonefficient solutions have been eliminated, the second stage of the decision making process starts. The purpose of this stage is to determine the optimum solution from the efficient set. For this

purpose it is necessary to introduce the DM's preferences. This may be accomplished in one of several different ways. Zeleny (1973) proposed Compromise Programming (CP) as a useful technique.

Compromise Programming (CP) is designed to find a solution that is as close as possible to the ideal point. To measure the closeness, a distance function, which minimises the distance between each solution and the ideal point is introduced. Romero *et al.*, (1987) and Romero and Rehman (1985) present details of applying the distance function. Two metrics were used for this example: L_1 and L_∞. L_1 representing the longer distance geometrically, was minimised by using the following LP problem (Cohon, 1978):

$$\textit{Minimise} \quad L_1(w) = \sum_{j=1}^{n} w_j \frac{z_j^* - z_j[x]}{z_j - z_{*j}}$$

$$\textit{Subject to} \quad x \in F$$

$$x \geq 0$$

where F is the feasible set and x is the vector of the decision variables, z_j* and z_{*j} are ideal and anti-ideal values for the jth objective, $z_j(x)$ is the jth objective function and w_j are the weights attached to the jth objective.

CP produces the same information as MOP, but defining that part of the efficient set which is closest to the ideal point. The CP model, therefore, is easy to calculate using standard LP packages. For CP it is only necessary to elicit from the decision maker a set of weights, representing his preferences, which can be attached to the discrepancies between the ideal values for objectives, and actual achievements (Rehman and Romero, 1993).

CP, like MOP, works efficiently for moderately sized problems defined within a well-structured environment. However for large size problems defined within complex contexts, this kind of approach has very little interest and it becomes necessary to resort to more flexible decisional approaches. Goal Programming (GP) emerges within this pragmatic line.

2.3.2.3 Goal Programming

The Goal-programming (GP) model is probably the best known in mathematical programming for multiple objectives. Charnes and Cooper developed the Goal programming approach in 1961 as a modification and extension of linear programming as a planning technique (Lee, 1972; Ignizio, 1976). An important property of goal programming is its capability to handle management problems that involve multiple incompatible goals according to their importance. The algebraic formulation of a weighted goal-programming (WGP) model is formulated as follows:

Minimize $$Z = \sum_{i=1}^{q} [\ (W_i^+ \delta_i^+ \pm W_i^- \delta_i^-\ ]$$

Subject to : $$\sum_{j=1}^{n} a_{ij} x_j - \delta_i^+ + \delta_i^- = \delta_i \quad \text{for } i = 1, 2, \ldots, q.$$

and $$Cx \leq c \quad (\textit{system constraints})$$

$$x_j, \delta_i^+, \delta_i^- \geq 0 \quad \text{for } i = 1,2,\ldots, q. \text{ and } j = 1,2,\ldots n.$$

where:

δ_i	:	the goal associated with an objective;
x	:	$(x_1, x_2, \ldots, x_n)$:a n-dimensional vector of decision variables;
a_{ij}	:	technological parameters related to the system constraints;
c	:	the resources available;
C	:	the coefficients related to the system constraints;
w_i^+	:	the importance coefficient associated with the positive deviations;
w_i^-	:	the importance coefficient associated with the negative deviations.

During the last two decades the GP model has been frequently used as an aid to decision making with multiple objectives. Available in several versions, this model has been applied in various fields. Tamiz and Jones (1996) note that goal programming is popular due to the fact that it is simple and easy to understand and to apply. The Goal Programming (GP) model enables the decision-maker to take many goals into account in a problem where he or she has chosen the most satisfactory action among a set of acceptable options. Practically, this is expressed by searching the most satisfactory compromise among several objectives which are often conflicting (Romero, 1991). In fact, the GP model is based on concept of satisficing objectives (Simon, 1955) which differs considerably from the optimisation philosophy generally adopted in mathematical programming (Zeleny, 1982).

According to Hwang *et al.*, (1980), GP belongs to the category of the multiple objective programming models with a *priori* articulation of the decision-maker's preferences. That is, each goal under consideration (profit, safety, production level, etc.) is given a target or goal value to be achieved within the given set of constraints. The models, however, do not maximise or minimise the objective function in the linear programming sense; rather, they minimise the deviations, or differences among goals. The goal deviations are represented in one or two directions, namely, positive or negative. The unwanted deviations from these goals (under profit, under or over production, etc) are then minimised, considering the relative priority, or weight, assigned to the various goals (Tamiz and Jones, 1996). This is accomplished by minimising the deviations among the desired goals or target levels and the actual equalities through the addition of positive and negative deviation variables permitting either the under or over-achievement of each goal. Also, for each goal at least one of the two variables has to be zero. So the overall purpose of Goal Programming is to minimise the deviations between achievement of the goals and their aspiration levels; that is, to minimise the unwanted deviational variables. The minimisation process can be accomplished by several

alternative methods, and of these, two most widely used variants of goal programming are weighted goal programming (WGP) and lexicographic goal programming (LGP).

The weighted goal-programming variant considers all goals simultaneously as they are embodied in a composite objective function. This composite function tries to minimise the sum of all the deviations of various goals from their targets or aspiration levels (Rehman and Romero, 1993). Romero (1991) notes that weights are attached to the deviations according to the relative importance that the decision-maker attaches to each goal. The variables in the objective function are expressed as percentage deviations from targets to overcome the problem of incommensurable units used to measure different goals.

The other GP variant is lexicographic goal programming (LGP) which was first introduced by Charnes and Cooper (1961) and developed by Ijeri (1965), Lee (1972) and Ignizio (1976). LGP assumes that the decision maker can explicitly define all the goals that are relevant to a planning situation. It also assumes that decision maker not only attaches priorities to these goals, but also does so in a pre-emptive fashion (Rehman and Romero, 1993). In other words, the fulfilment of a set of goals situated in a certain priority is immeasurably preferable to the achievement of other sets situated in a lower priority. In solving the problem the higher priorities are resolved first, and it is only then that the lower priorities are considered, hence, the lexicographic order. The aim of this approach is to find the lexicographic minimum of a in the order stated by first determining the smallest value of the first component a_1, then the smallest value of the second component a_2 compatible with the value of a_1, and so on. The algebraic representation of a LGP is given as:

$$Lex-\min .a = [g_1(n,p), g_2(n,p),....g_k(n,p)]$$

Subject to,

$$f_i(x)+n_i-p_i=b_i \quad i=1,....,k$$

$$x \geq 0$$

"*Lex*- min" means a lexicographic optimisation process;

where g_k = *k-th* priority involving a given combination of elements for the n and p vectors, and k is the number of objectives; a is an ordered vector of the priority levels; n_i and p_i are deviational variables which represent the under- and over- achievement of the ith goal respectively, f_i is the mathematical expression for the ith attribute, and x is the set of decision variables to be determined.

Romero (1991) noted that if management is capable of establishing an ordinal importance of goals in a linear decision system, the goal-programming model provides the DM with the opportunity to analyse the soundness of their goal structure. In general, a programming model performs 3 types of

analysis: (i) it determines the input requirement to achieve a set of goals; (ii) it determines the degree of attainment of defined goals with given resources; and (iii) it provides the optimum solution under varying inputs and goal structures. The most important advantage of goal programming is it's great flexibility, which allows model simulation with numerous variations of constraints and goal priorities.

2.3.2.3.1 Applications of goal programming

In agricultural planning most goal programming (GP) applications have addressed the problem of determining an optimal cropping pattern by taking into account several goals. Wheeler and Russel (1977) analysed the planning problem of a hypothetical 600 acre mixed farm in the United Kingdom using a GP model. They considered goals of maximum gross margin, minimum seasonal cash exposure and the provision of stable employment for labour throughout the year. In subsistence agriculture there are two examples of interest. Flinn *et al.,* (1980) analysed a decision-making problem in the Phillipines where six goals were taken into account including the production of rice for family subsistence through to the generation of sufficient cash surplus. He concluded that there seems to be a misconception among many users of linear programming that Linear Goal Programming (LGP) structures and philosophy developed by Ijeri (1965) is simply linear programming with certain specialised constraints and activities. Rather, such a linear programming formulation of a problem is a subset of the more general multiple objective, LGP problem. A limitation of LGP is the monotonic ordering of goals, with no facility for a trade off between goals of different rank. Nonetheless, goal ordering has proved a useful approximation in empirical decision models as discussed by Roumasset *et al.*, (1979). Barnett *et al., (*1982) uses a similar approach to research a decision-making problem in Senegal.

2.3.2.3.2 Critical issues concerning the use of GP

GP is the most widely used MCDM technique but despite the success of its application which combines the logic of optimisation in linear programming with the decision-maker's desire to satisfy several objectives, it is has some limitations. Rehman and Romero (1993) note that the GP model simply provides the best solution under the given set of constraints and priority structure. Clearly, if the decision maker's goal priorities are not in accordance with those used in the model, the solution will not be the global optimum. For an effective application of GP, a clear understanding of the assumptions and limitations of the technique is a prerequisite.

Rehman and Romero (1993) noted the large amount of very precise information that is required for the decision-maker, such as objectives and target values, weights to be attached to each unwanted deviational variable, pre-emptive ordering of preferences and so on. Its critics have recognised this aspect of the use of GP as a weakness. However, Romero and Rehman (1989) discussed methods available to help reduce the problems encountered with GP such as the use of sensitivity analysis

during model implementation. The interactive use of GP described by Rehman and Romero (1993) is another approach to improve the reliability of the information acquired from the decision-maker.

There are, however, some serious problems when GP is applied mechanically without being aware of the logic underlying the approach. Romero and Rehman (1989) note certain situations where using GP techniques for decision making will either produce unexpected results or they will be inappropriate. The possibility of generating identical solutions from conventional linear programming and goal programming under certain circumstances means the analysts using GP techniques can conclude that either GP is superfluous, or is of limited usefulness. Romero and Rehman (1985) argued this is a misleading observation as the equivalence of solutions is to do with the formulation of the problem rather than the nature or potential usefulness of GP. That kind of problem occurred in some real applications of GP in agricultural planning problems (Flinn *et al.*, 1980; Barnett *et al.*, 1982) as has been pointed out elsewhere (Romero and Rehman, 1983).

Secondly, GP assumes infinite trade-offs between goals situated in different priorities. The inherent assumption of linear goal programming is that although trade-offs between goals can take place within a given priority, they cannot be traded-off across the boundaries of different priorities. In this context the idea of a trade-off implies the achievement of a goal, say G1, will have to be sacrificed for a unitary increase in another goal, G2, as compensation. In lexicographic structures of GP models, the trade-off among goals is possible only when they are in the same priority. This possibility is not allowed across different priorities as they are assumed to be independent of each other in a pre-emptive way. This appears to make the LGP model rather restricted but in fact this situation is not very different from the conventional LP structure where no trade-off is assumed to exist between the objective and the restraint set. However, in practical applications of LGP when a decision-maker is not confident about the pre-emptive ordering of priorities, a sensitivity analysis of the final solution should be given greater significance than is normally accorded to this activity.

Thirdly, there is a tendency for GP to produce non-efficient optimal solutions where the target levels have been set at very pessimistic levels (Zeleny and Cochrane, 1973; Cohon, 1978). This is more likely to occur where the optimal solution includes a large number of deviational variables. A possible remedy is to carry out a parametric analysis of the aspiration levels used in the model. This would show whether or not it is possible to increase the satisfaction of some goals without reducing the achievement of others.

Finally, a practical problem inherent in LGP occurs when the number of priorities is excessive so that a naive prioritisation occurs. This eventuates because the algorithms designed to solve GP problems assume that the first problem of the sequence has alternative optimal solutions. When there are no alternative optimal solutions, goals in the lower priorities are ignored. Romero and

Rehman (1985) noted that 'naive prioritisation' can be a serious weakness when the size of the problem is small in relation to the number of priorities

2.4 Conclusion

The main objective of this study was to devise and implement an approach which would allow the understanding and modelling of the decision making process used in Tongan smallholder farm households. The approach adopted was to study broad strategic aspects of decision-making and the behaviour of farmers rather than to focus on specific farming decision scenarios in order to develop a model giving a more realistic portrayal of the behaviour of Tongan smallholder farmers to changes in the environment. To be successful, the model must be consistent not only with the physical view of the farm, but also with the way decision makers behave or react to stimuli and changes over time with respect to agricultural development policies.

This review of methodology and farm decision modelling indicates the range of structures and approaches possible in modelling multiple objective decisions. No single approach is superior in all situations and different models have been used under different circumstances. Ignizio (1983) claimed there is not now, and probably never shall be, one single "best approach" to all types of multiple objective mathematical programming problems. The main features of the problem situation will lead the analyst towards the best approach from an analytical point of view. The choice depends on the situation of the problem, the nature of the system being modelled and the purpose of the model. Hazell and Norton (1986) note the important aspects in building a decision model: the decision-maker must identify the decision problem, select an appropriate model and adjust it to the particular problem. This is a crucial process, as errors made during this phase cannot be corrected during computations even if the best and most sophisticated mathematical algorithm is used.

Tongan agriculture is dominated by smallholder production. Decision modelling must therefore account for the complexity of smallholder farming systems characterised by the existing mix of enterprises (and alternatives to them) and the way these enterprises compete for the use of the limited resources available to farmers. It must take account of important differences between the various types of resources such as land, labour and capital. To gain a view of smallholder farm behaviour, the model must be consistent with the multiple objectives and preferences of the smallholder and be able to mimic the way in which these objectives are attained and measured. Therefore, on the basis of these criteria and the problem identified, the choice of a methodology favours a GP and MOP model. Goal Programming (GP) offers a number of appealing features in tackling the complexities of smallholder farming system discussed above. Tongan smallholder farmers operate within severe resource and other constraints to achieve multiple goals, and the

goal-programming model appears to be well suited to the problem. A detailed analysis of the Tongan smallholder farming system was undertaken and is described in Part 2 of this study.

CHAPTER 3

THE STUDY AREA

3.1 Introduction

This chapter contains a general overview of the study area and associated farming systems with general background information on Tonga, with particular attention being given to the features of the smallholder agriculture sector and traditional farming systems.

3.2 General Background

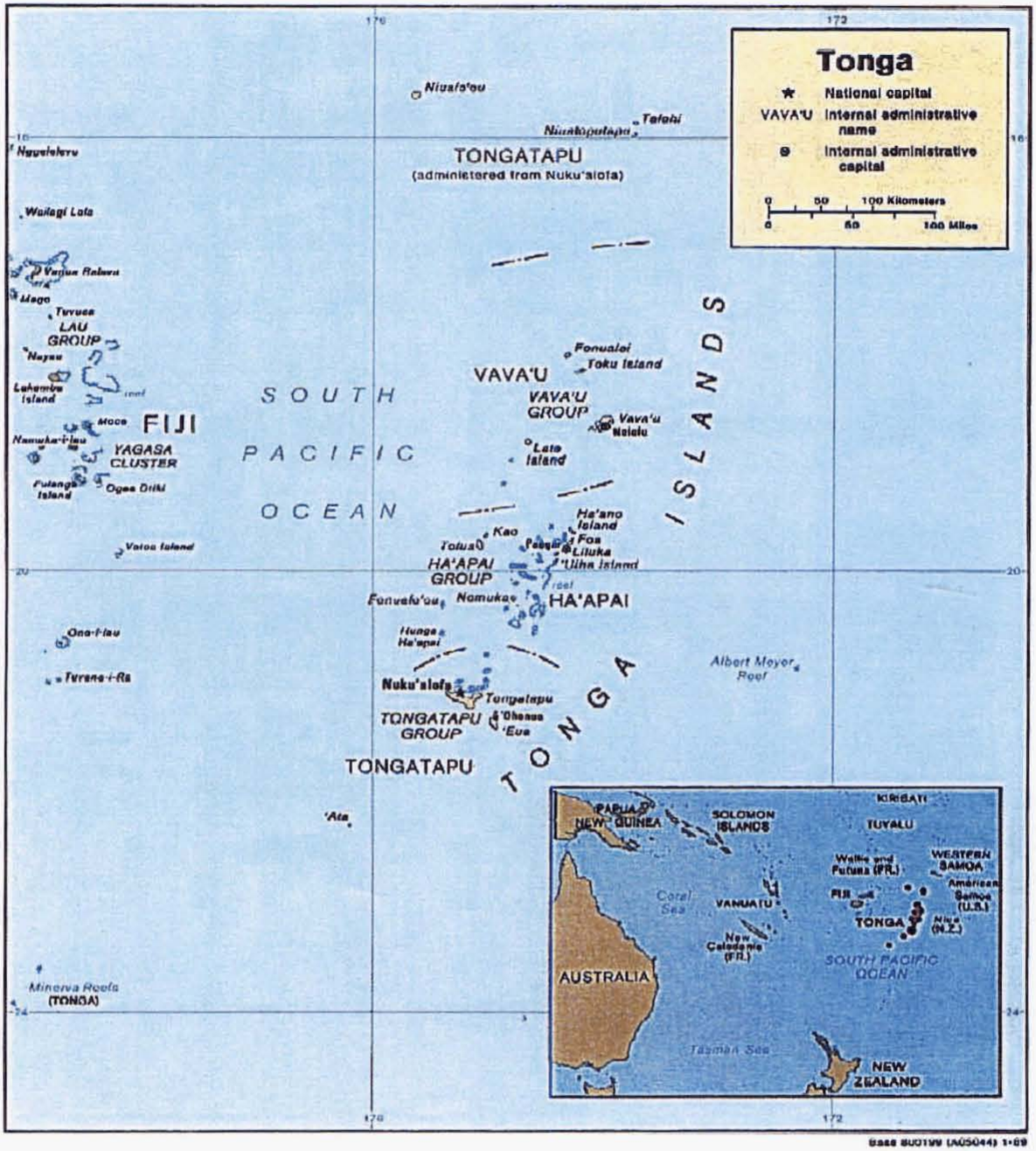
3.2.1 Physical setting

3.2.1.1 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^2 of territorial seas in the South Pacific. It is a small country, physically isolated from the main centres of the world population and trade by thousands of kilometres of ocean. 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^2. The total land area is 747 km^2 aggregated into the four major groups of Tongatapu and 'Eua (370 km^2), Ha'apai (119 km^2), Vava'u (143 km^2) and the two small Niuas (71 km^2) (see Figure 3.1). The largest of these is Tongatapu on which is located Nuku'alofa, the capital, where about 68 percent of the total population live.

The geographical distribution of the population in the main island groups is shown in Table 3.1. 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.

Figure 3.1: Map of Tonga



Source: Tonga On Line, 1999

During the ten-year intercensus period, the population of Tongatapu grew by 4.4 percent, that of Vava'u by 4 percent, while Ha'apai declined by 8.6 percent. The total number of households increased from 15,091 in 1986 to 16,174 in 1996. The inter-censual (1986 -1996) analyses revealed

the low average rate of population growth due to the significant migration of people to other countries. 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 3.1: Geographical distribution of the population in 1986 and 1996.

Division	1986	Percent	1996	Percent	Land Area (km^2)	Density/ km^2
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
TOTAL	***94,649***	***100***	***97,446***	***100***	***747***	***150***

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).

3.2.1.2 Geology/Geomorphology

The islands of Tonga were formed on the tops of two parallel submarine ridges stretching from Southwest to Northeast and enclosing a fifty kilometre wide trough. Several volcanoes, some of which are still active, exist along the western ridge, while many coral islands have formed along the eastern ridge, among them the Vava'u and Ha'apai island groups (Trangmar, 1992). Two types of coral islands can be distinguished;

(i) ***The low coral islands***, to which the Ha'apai group belongs, are flat and undulated islands of sand which rise to 15 metres above sea level and were formed on the coral reef platforms.

(ii) ***The raised coral islands***, which have been tilted by earth pressures, show a marked topography. Tongatapu, 'Eua and the Vava'u group belong to this coral island type. Soil fertility is good, most of the islands consisting of uplifted coral with an overlying soil developed from volcanic ash (Halavatau and Asghar, 1989).

3.2.1.3 Soils

Tonga is fortunate in being endowed with a good climate for agriculture and with fertile soils. The islands are of volcanic and coral origin. The soils of Tonga comprise two main soil types: a clay soil and a sandy soil (*tou'one*). The clay soil, known locally as *kelefatu,* varies in texture from light loams through to heavy clays, and is derived from weathered volcanic ash overlying coral bedrock and is highly friable, fertile and generally drains fairly quickly (Studien, 1983). It covers most of Tongatapu and Vava'u, and some parts of Ha'apai, often to a depth of two metres. However, regardless of texture, these soils have a moderate to high natural fertility due principally to the incomplete weathering of the volcanic ash. Because the soils are generally friable and free draining, and because of the mild, humid climate, plant litter decomposes quickly and the rapid circulation of plant nutrients contributes to the level of fertility (Halavatau and Asghar, 1989).

The second main soil type is sandy soil, known in Tonga as *tou'one*, and comprises sandy and less fertile soils. It is derived almost entirely from coral sand, and hence is mostly confined to the low coral island narrow strips along the coast (Trangmar, 1992). Sandy soil is particularly widespread in the low coral islands of the Ha'apai, where they occupy up to half of the area of some of the settled islands. The organic content of *tou'one* soils is easily depleted and the structure adversely affected by frequent cultivation. Crops grown on sandy soil generally yield less compared to those grown on *kelefatu* and are more vulnerable to short-term droughts (Maude, 1965). Some coastal *tou'one* areas are subjected to flood by high tides or storms and so are too salty for general agriculture. Otherwise, given careful management to conserve organic matter and structure, and with plant nutrients added as required, soils of the *tou'one* class are suitable for a variety of crops. But in the absence of these strict conditions, the productivity of these soils may decline seriously, and this is already happening in some areas, especially in Ha'apai (Evans,1996).

3.2.1.4 Climate

The climate of the Tonga archipelago is tropical maritime mild to warm, humid and moderately wet throughout the year, with a mean annual rainfall varying from approximately 1,770mm on Tongatapu and 2,350mm on Vava'u. Table 3.2 contains some basic climatic data for the three main regions from (1986 – 1995).

Table 3.2: Mean annual temperatures and total rainfall for the three main island groups.

Group	Mean Annual Temperatures (*in °C*)	Total Annual Rainfall (*in mm*)
Tongatapu	24.4	1728
Ha'apai	25.6	1780
Vava'u	26.5	2180

Source: Civil Aviation Department, 1997

There is a marked seasonality in the Tongan rainfall with two main seasons. The rainy season is characterised by a mean monthly annual rainfall of up to 250mm and an average monthly temperature of more than 26 °C. The "*hot wet season*" lasts from November to April, and about 65 percent of the total annual rainfall occurs during the wet season. The "*cool and dry season*" is from May to October, and has a mean monthly rainfall of less than 130 mm and lower temperatures of around 22°C (Thompson, 1985). A four to eight week drought often occurs during this season, which tends to influence crop growth and production, due to the rapid drying out of the soil. Rainfall seasonality is most marked on the Vava'u and the Ha'apai island groups.

High humidity occurs throughout the year. The annual mean humidity ranges from 77 percent in Tongatapu to 79 percent in Vava'u. The prevailing winds are Southeast Trades winds, which dominate during the months of May to October, a period when rainfall is lowest and when periodic water shortages occur, especially in the warmer season. Tropical cyclones also occur frequently. The cyclone season for Tonga runs from December through to April although deviations outside this period occur. Tonga experiences an average of two tropical cyclones per year. In the last nine years, five notable cyclones occurred (in 1990, 1992. 1993, 1995, and 1997) which were the most destructive in terms of the severity of damage and the vast area affected. Tonga is susceptible to occasional long periods of drought. 'Utoikamanu (1993) notes that of the three main island groups, Ha'apai is the most vulnerable to drought because of problems with the provision of an adequate water supply. During the last ten years, two notable periods of drought have occurred in Tonga (1992 and 1996) and caused a severe impact on agricultural production.

3.2.2 Social background

3.2.2.1 The Household

The basic social and economic unit in Tonga is not, and was not, the individual but the household, generally referred to as an ***'api***. Normally the farm household is defined as a group of individuals, eating and sleeping together (Thaman, 1976). In the past, most of the households were composed of extended[2] families (two or more nuclear families living in one household). All basic economic activities - production, consumption and the accumulation of goods are organised within the extended family (Studien, 1983). According to Sevele (1973), the economic activities connected with earning a livelihood are predominantly the business of the household members.

The decisions on cultivation of all land belonging to this extended family was the responsibility of the head of household (the *'ulumotu'a)*. Now, however, with changes in household structure, the decisions are being made differently. At present the trend is more toward nuclear families, comprised of a man and wife and their real and/or adopted children, which may also include unmarried brothers or sisters, a

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[2] *An extended family is a household consisting of two or more nuclear families.*

parent, or even a friend or relative. According to the last population census, the mean household size for Tongatapu was 6.7 persons in 1996 (Statistics Department, 1997).

One of the significant features of the Tongan society is its relatively homogenous nature, with an elaborate and well-established social system. Thus, although the household consisting of individuals bound by kinship ties is the basic unit of everyday living, the extended family which consists of varying numbers of kinship households, known locally as *kainga or famili*, also constitutes a socio-economic unit of considerable importance (Sevele, 1973; Thaman, 1976). Among themselves the members of the extended family form a unit of co-operation in activities requiring a lot of labour such as certain farming activities and house construction, but especially on occasions such as marriages, funerals, birthdays celebrations and festive occasions (Evans, 1996). Each of the various members has his position in relation to others and his obligations to, and expectations from, others are governed to an important degree by the kinship. Sevele (1973) considered these personal interrelationships, obligations and expectations as important components of the social fabric within which the Tongan household operates. The impact of these factors on household's production decisions is examined in Chapter 8.

3.2.2.2 The Village

In Tonga, as in most Pacific countries, the principal form of settlement is the village. There are altogether 145 villages in Tonga, and they vary greatly in size (Appendix 3). Apart from being a residential unit, the village is also a social, administrative and, to an important degree, an economic unit. Corresponding to the types of authority over land in Tonga are two types of villages, noble and government estates. In the noble estate village, the traditional status and authority of the noble, the chief of the village, constitutes a strong force, binding the members of the village together in common allegiance to him. Evans (1996) notes that the noble is recognised as having the authority to call upon every household in the village to supply gifts of food crops, livestock, mats, tapa cloth and other goods, whenever the need arises, for example, on the marriage or death of a member of Royalty or of the nobility. Although not bound by the law, the villagers display great respect to the noble and listen to, and carry out, his demands, partly in recognition of his traditional position as the village leader. The nobles' control of land distribution enables them to have a powerful influence on the villagers, especially those who are seeking land allotments.

3.2.2.3 The Church

Sisifa *et al.*, (1993) note the church is of considerably more social importance than the government and is the primary focus of the Tongan society. The Christian religion in its various forms has made a deep and permanent impact upon Tongans, and is an extremely important institution in Tongan society (Evans, 1996). Church activities and ceremonies play a prominent role in the lives of the Tongans. Much of the church financial support, as well as support in kind for ministers, teachers, and church officials, comes directly or indirectly from the agricultural system (Sisifa *et al.*, 1993). Sevele (1973)

claimed it is not uncommon for a family to give more than fifty percent of its annual income to support the church in the form of cash or church feasts. The strong co-operative and competitive spirit and energetic drive shown by the Tongans in church activities do not always extend to other activities, especially those connected with attempts to improve their material living conditions.

The importance of church has both positive and negative effects. Church group activities, particularly in subsistence cropping (*toutu'u 'ufi*[3]), are strong. Some district extension officers have used this to advantage in their work. In the field of education, the various churches play a very important role such as providing 90 percent of the secondary education with no financial assistance from the Government. On the other hand, church and community activities often take up much of their time and efforts at the expense of improvement to agricultural productivity (Sisifa *et al.*, 1993). The influences of church on household production decisions are discussed in-depth in Chapter 8.

3.2.3 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:

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[3] *Toutu'u 'ufi means a group-plot, made up of individually owned plots, of yams and associated crops.*

Allotment	*62.8%*
Unallocated Government land	*11.4%*
Unallocated noble's land	*6.9%*
Leases	*8.4%*
Small islands, lakes, lagoons	*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*).

3.2.4 Economic background

3.2.4.1 The Tongan Economy

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. As noted earlier, 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 3.3 shows the major items in the Tongan balance of payments for the period 1991/92 to 1996/97.

Table 3.3: Balance of payments (T$ million; fiscal years ending June 30th).

	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
Trade Balance	***-41.2***	***-51.4***	***-52.6***	***-72.8***	***-67.6***	***-57.2***
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
Overall balance	**8.6**	**10.1**	**-6.4**	**-16.6**	**-2.7**	**5.4**

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.

3.3 The Agriculture Sector

3.3.1 The importance of agriculture

Agricultural production is the predominant activity in the economy, and its role is manifested in several ways - as a source of food, as a source of employment, as a source of cash income, as a source of foreign exchange and a source of raw materials for processing. The agricultural sector has maintained a significant role in the economy as the major contributor to GDP, as shown in Table 3.4.

Table 3.4: 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 3.5 shows the total area and quantity of crops recorded in the Land Use and Crops Survey (MAF, 1994b).

Table 3.5: 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.

3.3.2 Performance of the agriculture sector

Agriculture has undergone major changes in the past decade, as has the Tongan economy. Table 3.6 shows the significant contributions of agriculture to Tonga's export earnings. Figure 3.2 show the structure of the exports and the contributions of the various components.

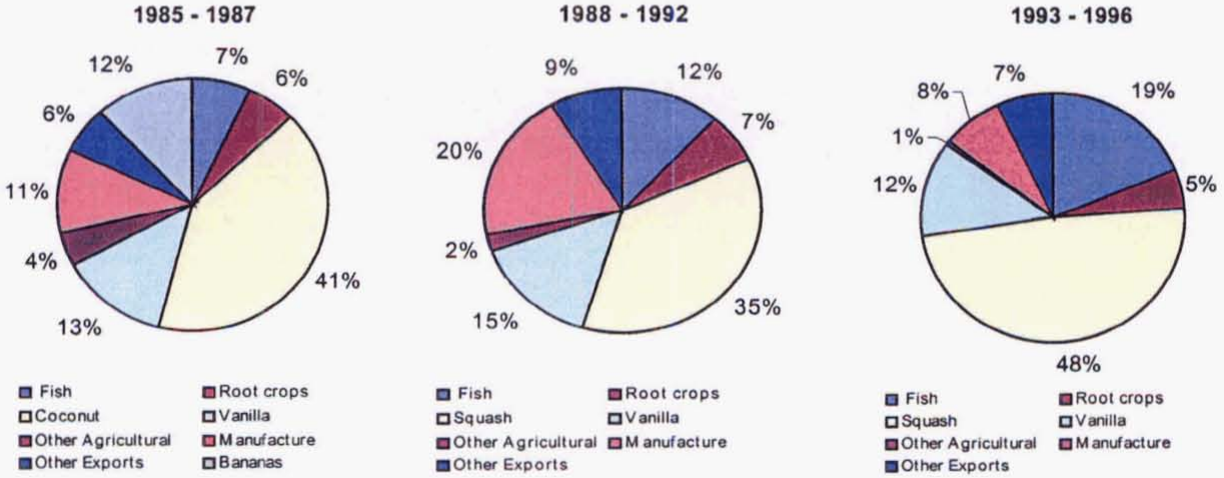
Table 3.6: Contribution of agriculture to Tongan export earnings.

Year	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*
Commodity					*(in FOB T$million)*					
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
Agriculture	***5.91***	***5.23***	***7.18***	***10.11***	***19.53***	***11.34***	***22.92***	***15.52***	***12.19***	***11.17***
% of Exports	***67***	***55***	***62***	***70***	***81***	***77***	***82***	***84***	***67***	***74***

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. Overall, the situation shown in Figure 3.2 indicates significant changes.

Figure 3.2: Structural changes in Tonga's exports (in percentages) between 1985 and 1996.



Source: NRBT, 1997

According to Sturton (1992), the performance of the agriculture sector in the 1980s was dismal. Production of all traditional commodities (for example, coconut and bananas) stagnated significantly. During the 1970s, coconut products represented over 70 percent of the exports. The drop in the world market prices of coconut products from an average of T$500 per ton to a low of T$200 per ton had a major impact on the coconut industry. Production of coconut products has declined from about 70 percent of the exports in the 1970s to about 41 percent in the 1985 -1988 and to a low of 1.8% in 1990 to 1993. This substantial decline not only induced a loss in the foreign exchange but also affected the employment opportunities created through copra and oil processing, and desiccated coconut manufacturing.

By the end of the 1980s there was a general disillusionment in the ability of the sector to contribute in a substantial way to development. Banana production, which was the second most important export earner, also followed similar trends falling from 12 percent in 1985-1988 to a low of 0.5% in 1990-1993. The production of bananas virtually vanished due to natural disasters, quarantine restrictions, and the termination of the subsidy scheme. By the late 1980s manufacturing and tourism offered greater long-run potential, yet during this period some important diversification resulted. Nonetheless, Tongan agriculture continued to move through the resulting transition phase with some considerable success. There has been some strong growth in exports of other crops; exports of vanilla and root crops and other vegetables have risen to counterbalance the decline in the traditional exports. In addition, Government policies for the encouragement of a manufacturing sector gave rise to the Small Industries Centre (SIC). However, these developments, taken collectively, were not sufficient to counterbalance the deterioration in the production of the traditional export commodities and the economy entered a period of prolonged recession.

The most notable development in the 1990s was the rapid growth of squash exports to Japan. This remarkable growth in the early 1990s led to the economy emerging from the recession. Production of squash for export commenced in 1987 and from 1991 to 1996, the total export earnings from squash amounted to a total of about T$60 million which is equivalent to about 63 percent of the agricultural exports and at least 45 percent of the overall export value. Details of present agricultural export commodities are reviewed in Chapter 5.

3.3.3 The Tongan farming systems

Tongan agricultural systems are fundamentally agro-forestry systems utilising bush, or grass, fallow followed for several years by a series of crops intercropped with coconuts and other trees to create a rotational, multi-storeyed fallow system. These farming systems have shown adaptability by readily incorporating new crops and technologies. Most importantly, they have proven robust, productive and sustainable. The productivity of the total system is higher than if any of these crops were monocropped (World Bank, 1990). The importance of the system lies not in some view of the past, but in fact that the

majority of Tonga's agricultural growth has come from smallholder farms (AGRICO, 1995). This intercropping, multi-storey, rotational fallow system with its root crop base has several very significant advantages:

(i) it minimises exposure of soils, reducing potential damage to soil structure and leaching of soil minerals;

(ii) labour inputs are relatively low and do not show the pronounced seasonal peaks in labour demand common in cereal-based systems;

(iii) the major crops (except yams) are storable in the ground and investment in farm storage facilities is unnecessary;

(iv) soil fertility is maintained;

(v) weed growth is limited;

(vi) it provides a high degree of protection from droughts and hurricanes;

(vii) it provides a high level of household and national food security;

(viii) it has developed through long experience and is therefore well adapted to the environment and to the needs of the Tongan rural households;

(ix) although based on traditional systems, it is much more flexible than commonly recognised. Farmers make changes to accommodate new ideas and opportunities or to adapt to changed circumstances. For example corn is sometimes grown with yams to provide a "trellis" for the yams, replacing the boughs cut from the bush that are normally used.

3.3.3.1 Food and Cash Crops Component

Intercropping is most widely practised with subsistence crops. A new forested area is either partially cleared by the slash and burn method or land is progressively cleared. The basic rotation pattern of traditional mixed cropping system is depicted in Figure 3.3.

Figure 3.3: The basic traditional mixed crop rotation pattern in Tonga.

MONTH	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Year 1	MX1 – Mixed Crop : Yam, Giant taro, Colcasia Taro, Plantain											
Year 2							MX2 - Xanthosoma Taro, Plantain					
Year 3							Sweet Potatoes – Monocrop					
Year 4	Cassava - Monocrop								Harvest-→ Fallow			

Source: Field survey, 1998

Yam (*Diosocrea alata*), the main crop, is almost always intercropped with giant taro (*Alocasia macrorrhiza*), plantain (*Musa paradisiaca*) and/or banana (*Musa sapientum*). Common taro (*Colocasia esculenta*) is often also planted as well as, or in place of, alocasia and/or plantain/banana. After a

period of 8-10 months, yam is harvested. American taro (*Xanthosoma spp.*) is then planted in the place of yams and is followed by sweet potatoes (*Ipomoea batatas*) and by cassava (*Manihot esculenta*) before the land is allowed to revert to fallow. Cropping sequences last from two to five years, after which the land is left fallow from two to six years. The average length of fallow has plummeted from 10-15 years to only about 3 years today, and in certain cases, to about 6 months. This creates a concern over the sustainability of the soil fertility due to a shortened fallow.

3.3.3.2 Livestock Component

In addition to traditional cropping, livestock also plays a significant role in the agricultural system of Tonga. The most frequently observed stock, owned by Tongans, include pigs, horses, chickens, cattle and goats. Pigs are the most important animals kept by Tongan smallholders in terms of nutritional significance and importance as gifts in the social system, and for feasts. These will be discussed in greater depth in Chapter 7.

3.3.3.3 Handicraft Component

Handicraft production plays an important role in village life for home use, as gifts on special occasions and for sale (AGRICO, 1995). Although principally the work of women, other household members commonly participate. Handicraft production includes *tapa* (or bark cloth) making and mat weaving, as well as production of baskets or other items for domestic use and some for exports.

3.4 Conclusions

In Tonga, smallholder agriculture is the main mode of agricultural production. The general picture, which emerges, is the important role these units have in Tonga's economy. Despite the mixed performance of the agriculture sector over the recent years, there is a potential for the country to expand its export market. 'Akolo (1997) pointed out that increased export growth can be achieved if advantage is taken of the possibilities to continue improving productivity of high value crops that have promising market prospects (such as squash, vanilla and kava). Farmers need to respond by expanding the use of improved farm techniques, and increased production through bringing unused land under cultivation. As such it has attracted the particular attention from the government and farming interests and more recently donor agencies and development planners.

Smallholder agriculture involves complex characteristics that appear to require further analysis. A number of features of Tongan smallholder farming systems are revealed which have implications for the modelling process. Firstly, the majority of agricultural smallholder producers in Tonga are semi-subsistence farm households. There is a predominance of diversified farming system production activities with a wide range of food, cash crops, and livestock. A significant proportion of part of the total product is retained within the household for home consumption and for social and religious

obligations. The remainder is sold. Secondly, the limited resource capacity (land, labour, capital) of smallholder farm households imposes severe constraints on both the range of production activities possible and the nature of commercial capabilities and so influences their decisions on utilising their land.

Following a general overview of the villages and associated farming system, a number of aspects were selected as being of key importance in modelling the decision framework of the system. Farmers' decisions relating to utilising limited land resources are influenced by the goals and preferences farmers have. Decisions also relate to the allocation of farm output and income for several objectives such as household consumption, church and social obligations and determine the level of production and investment in the agriculture sector. Similarly, farmers' response to proposed government agricultural policy and project innovations is likely to involve changes in behaviour, yet very little is known about the nature of their behaviour.

The next chapter provides a detailed description of the survey method used for data gathering and collecting key information for the study area.

CHAPTER 4

FIELD RESEARCH METHODOLOGY

4.1 Introduction

This study attempts to develop planning models that contain an understanding of Tongan smallholder farm household production and land use decisions. The fieldwork focussed on developing knowledge and information to provide both statistical and descriptive guidelines for understanding the dynamics of the decision making process in the village farm household regarding the utilisation of its limited land resources. The key issues to be addressed include:

(a) *How land use decisions are made in a smallholder farm household; who makes the decisions and what factors influence the decisions?*

(b) *What are smallholder farmers' objectives and motives? The goals need to be ranked and weighted.*

(c) *What do smallholder farmers see as key constraints to achieving those objectives?*

(d) *Obtaining information on the production system, household income, expenditure and consumption.*

The methodological approach used to collect data and identify and describe smallholder farming in Tonga is outlined in this chapter. In order to describe the farmer's behaviour, data from individual farm households and other sources was required. This chapter outlines the general procedures for sample selection and data collection, and describes the sources of data, sample size determination, criteria for sample selection, questionnaire administration and data collection procedures.

4.2 Research Approach

Any behavioural model should be specified to capture the principal interactions and behaviour of the Tongan smallholder farming system and should be capable of experimental manipulation in order to predict the consequences of changes in the determinants of the system's behaviour. Modelling is thus one of the techniques or tools that systems approaches employ.

Within the systems research framework, the present study is primarily concerned with the analysis of the Tongan smallholder farming system. It views the farm household system as a whole, and understands the connections and interactions between individual components. The Tongan smallholder farm household consists of three basic sub-systems, which are closely interlinked, and interactive (Hardaker, 1975; Brook, 1980):

- the ***household*** – the decision making unit which controls and establishes objectives for the system; provides labour, demanding food, other products and cash in fulfilment of set objectives.

- the ***farm*** and its crop and livestock activities, providing employment, food and cash for the farm family.

- the ***off-farm*** component which competes with farm activities for labour; providing employment and income generating activities that are becoming increasingly more important to supplement the well-being of farm families.

Systems analysis as defined by Anderson and Dent (1972) is the study of a system, its component parts, their interactive behaviour and their interrelationships between the major components. The systems approach is based on a thorough analysis of all elements and an understanding of the dynamics of the system. Smallholder farming systems analysis involves understanding the natural, socio-cultural and policy/institutional environment that influences decision processes at the farm-household level. This enables policy makers to diagnose constraints, and to identify and assess potential improvements, which should be addressed in development programs and policy design.

The study focussed on the farm household system as it ultimately controls the transformation of inputs into basic agricultural outputs (production). At the farm-household level the objectives are set by, and for, the farm household itself. It is therefore important that the farm household objectives, and the way they try to achieve them, are well understood. In most cases the proposed intervention packages at the farm household level will increase the linkage with systems. With development, the level of interdependence decreases and the linkages with other systems becomes more important. The farm-household becomes important in fulfilling the needs of systems higher up in the hierarchy at village and national levels.

Varying approaches and methods have been used during this study in an attempt to combine a depth of understanding with a breadth of coverage. To provide the information necessary a qualitative approach was adopted along with village and household case studies. An approach, characterised by information such as descriptions of situations, events, people's perceptions, interactions and observed behaviour, was considered to be most appropriate for an in-depth study of smallholder farm

household's decision making (Casley and Kumar, 1988). The analysis examined complex sociological, cultural and biological relationships within the villages and farm households by means of informal interviews with individuals or groups, and direct observations of local conditions, and a study of pre-existing or secondary information. These general methods were used together and interactively.

4.3 Field Visits

4.3.1 Initial visit

An initial four week research visit was conducted in September 1997. The main purpose was to continue to build an external framework for the study and to gather the secondary information required. This included an initial survey of the islands to build up an overview of ecological patterns, population, settlement and land use patterns, operation of present subsistence and cash cropping systems and administrative and economic structures. Information of a general nature relating to each region, such as population, land resources, agricultural production, transport and infrastructure facilities and various other aspects of the socio-cultural and political environment was also collected. A great deal of ethnographic, economic and technical, statistical and other material, both on macro and micro scale, is available. A considerable amount of information was also obtained from reports and surveys of Government Ministries. Furthermore, the author already had considerable familiarity with Tongan agricultural systems and administrations.

Information and data sources included land use and crop surveys, agriculture studies, statistical reports, annual reports, climatological data, maps, population census data, and previous island development studies and other research. Basic demographic data were available from the Statistics Department, which conducted population censuses in 1986 and 1996. Compared with most developing countries, Tonga is very well provided with information on the quality of its land resources, the tenure under which land is held, and the use to which it is put. The last agricultural census of the entire kingdom was conducted in 1986 and provided statistics on the areas under each of a range of crops or types of land use. The Policy and Planning Division of the Ministry of Agriculture and Forestry has also produced numerous surveys, reviews and statistical summaries from each sub region that provided valuable secondary information. These included the 1993 Land Use and Crop Survey, which is the second periodic survey on the structure of cropping, that gives the manner in which the agricultural land is being utilised, the ownership of cropped land, and the means by which farmers obtained the use of land.

The secondary information was crucial in the early stages of the research not only as it provided a broad perception of the project area but also helped identify data gaps that needed to be addressed during the main fieldwork. Because there is a reasonable base of social data and agricultural land use

data available, information gathering was focussed on data that was most relevant to the research objectives.

Specific tasks also undertaken included co-ordinating with various relevant Tongan Government ministries in the update and collection of basic and ongoing secondary data and information, and familiarisation with existing and planned agricultural aid projects which have implications for rural development. A large body of statistics and information on the smallholder economy has been collected from farm management surveys, household surveys and income and expenditure surveys. Such data are appropriate for the piecemeal application of the theory of the firm and consumer behaviour, but they are inadequate for analysing the complex interactions among economic activities within a household and a village.

The need for such data collection is not limited to academic interests. It should also be the basis for effective design of rural development programs and national development policies. For example, a program for the development and extension of a new crop should be evaluated by farm production surveys to indicate how the technology will affect farm outputs, costs, and returns. However, the program's impact on rural welfare through income re-distribution and consumption, and on local and national development through capital formation, cannot be evaluated without access to information on consumption and investment both at the household and the village levels.

4.3.2 Main research visit

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.

4.4 Data Collection

The methodology used in acquiring the necessary data during the main research visit included a household survey, key informant interviews and discussions, and personal observation.

4.4.1 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

The interviews used Semi-Structured Interviewing (SSI) and followed a guided questionnaire (Appendix 1). The survey questionnaire acquired information on the household size and structure, household income and expenditure, and supply of family agricultural labour. It also covered information on land access and utilisation, crop size, livestock raised, consumed and sold, marketing, credit, cropping calendar, output, and inputs used. Information on religion, customs, tradition, and beliefs was also included. Questions were asked in Tongan by the author and translated for recording. No time limit was placed on the interview to allow as much time as possible for the farmer to understand and answer the questions. Generally the interviews took about two hours for each household. It was possible to critically explore and study various issues with regards to land use decision making at length, which would otherwise not materialise with a standard quantitative survey.

4.4.2 Interviews of key informants

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*

Qualitative interviews with these people were essential for obtaining additional information, ideas and insights about farmers in the villages and the village itself. Small group meetings with women, usually with work collective work groups (*tou lalanga*) in their work places, and also with other groups, such as farmer's (*kautaha toungaue*) groups were conducted. The separate interviews with these groups proved to be useful, as group activities are significant at a village level. It provided a better understanding of group networks, policies, and activities, which have an impact on individual household productivity.

Informal *kava* meetings with some village members were also conducted in the evenings. These meetings included some village elders, farmers and youth, and the discussion was unstructured. Some of the major key issues of the study were raised for discussion, and the meetings were instrumental in getting the villager's views on these issues. The use of village kava meetings as a means of acquiring information blended well with the normal tradition of meetings, which gave village people the freedom to express their views and ideas.

4.4.3 Direct observation

Through careful observation, precise and detailed knowledge of the technological, economic and social relationships, which are at work in agriculture and village life, was also accumulated. Direct observation involved watching what people do, their behaviour, relationships, networks, and the farming process (Casley and Kumar, 1988). This was required by the need to go beyond outward appearances and probe the perceptions, motives, beliefs, values and attitudes of the smallholder farm household. Casley and Kumar (1988) note the central concept in participant observation is that researchers participate in the social reality experienced by the community under observation. In studying the economic behaviour of smallholder farmers, the researcher becomes a part of the rural community to the degree required in order to understand the smallholder farmers' perceptions of the constraints and opportunities open to them. It also involves the assessment of development packages, and farmer attitudes towards institutions and policies.

Direct observation was conducted because of the need to observe agriculture decisions and practices in their most natural setting. This included the way that decisions are made in village or district committees, growers' groups and associations, the technical advice actually communicated to farmers by the extension worker, and the daily operations of supporting institutions in rural settings. The resulting depth of insight is not easily obtained in any other way. Direct observation reveals behavioural patterns, social and economic processes, and environmental factors, which the

farmers themselves may not be aware of, or are unable to adequately describe. Participant observation thus is particularly useful in gaining insights about the conditions, needs and behavioural patterns of the rural poor and other vulnerable groups who are usually not able to articulate their problems and predicaments. An illiterate, old, poor farmer does not find it easy to explain his problems and needs, but a perceptive observer may see them clearly after spending a few days in the field.

4.4.4 Village studies

The bulk of material from the detailed farming system surveys and fieldwork was carried out within the framework of the village community. Thus most of the strongest claims put forth here are based on a village centred view. The village perspective is important, as it is the major geographical form in which individuals and other culturally significant social units interact and overlap in Tonga. As Evans (1996) pointed out, it is a particularly intense locus of interaction for all persons if for no other reason than the reciprocity, co-operation, and competition present within the village in the course of daily life. Within the village, people are interrelated through kinship and church membership.

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.

The main problem in adopting a village level approach is the choice of villages for study. In general, the villages chosen were selected for their potential to illustrate the complex relationships that determine household land use decision making within a village situation. The aim was not to choose villages simply to represent typical conditions, but rather the range of conditions, therefore the data obtained would not be expected to be used to calculate conclusive values for Tonga as a whole, though they would provide reasonable guidance.

Furthermore, the villages used were selected to constitute a set of benchmark villages reflecting major characteristics of interest in terms of agro-climatic (soil type, climate, etc.) and socio-economic (farm size, infrastructure, etc.) attributes. In undertaking the research, two main criteria were employed in the selection of surveyed villages. Firstly, the two villages from each sub-region should be representative of other villages in the same general location. The second criteria was that

the two villages from each region should be a 'noble estate' and a "government estate" village. The six villages selected from the list of villages (given in Appendix 2) were:

Village 1: Navutoka, Tongatapu

Navutoka village is situated on the north coast of the main island Tongatapu and in the Lapaha district. Navutoka is one of the King's Estate villages, and faces an extensive fishing ground. It is about 27km from the capital, Nuku'alofa. The 1996 population census showed that it had a total population of 812, almost equally male and female, in 134 households. The 1993 Land Use and Crop survey recorded a total number of 62 farmers and a cropped area of about 77 ha out of a total land area of 206 hectares.

Village 2: Masilamea, Tongatapu

Masilamea village is a Government Estate, situated on the western district of Tongatapu. It is connected to Nuku'alofa by 15km of sealed road. Masilamea is a relatively small village in Tongatapu with only 36 households and a total population of 276 people in 1996. The 1993 Land Use and Crop survey recorded a total number of 20 farmers and a cropped area of about 50 hectares. This represents 68 percent of the total arable land area available to this village.

Village 3: Ha'ano, Ha'apai

Ha'ano village is one of four villages on Ha'ano Island in Ha'apai. It is located on a noble's estate. The 1996 population census recorded a total village population of 126 in 34 households. In the 1993 Land Use and Crop survey, there was a total of 42 farmers with 30 hectares under crop, which was 47 percent of total land area that the villagers have.

Village 4: Koulo, Ha'apai

Koulo village is a government estate and one of the four villages on the main island Pangai. The 1996 population census recorded a total village population of 275 in 45 households. The 1993 Land Use and Crop survey recorded a total number of 29 farmers, cropping about 25 hectares, which is about 37 percent of arable land available to this village.

Village 5: Tefisi, Vava'u

Tefisi village, a noble estate, is situated on the Western district of Vava'u island. It is about 10 km from the capital Neiafu. In 1996 there were 100 households and a total population of 628 people. In 1993, 83 households grew a total cropped area of 185 hectares. This corresponds to 72 percent of the total arable land area available to this village.

Village 6: Feletoa, Vava'u.

Feletoa village is one of the four villages in the Leimatu'a district of Vava'u and is located on a Government Estate. It is about 8 km from the capital Neiafu. In 1996 there were 58 households and a

total population of 394 people. The 1993 Land Use and Crop survey recorded a total of 68 farmers. Out of the 90 hectares of arable land in the village, 78 percent was under crop.

Table 4.1: Population of the six villages by sex, 1986 and 1996.

	1986				*1996*			
VILLAGE	***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

4.5 Selection of Sample Households

The study area consists of three main agro-ecological zones, Tongatapu, Vava'u and Ha'apai. A total sample size of 110 households spread across the six selected villages was randomly selected and interviewed to collect resource and production data. A household was defined as "*those people who are generally bound by ties of kinship and usually live together in a single roof, and share a common source of food and answerable to the same head*" (Casley and Kumar, 1988 pp. 60). The surveyed samples were randomly drawn from a list of households compiled by the Statistics Department from the 1996 Population Census. The lists were revised and validated with each village officer ('*ofisa kolo*) to provide the updated numbers of existing households prior to selection.

It was decided that an initial sample of 18 households randomly selected be 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.

For the purpose of this study, to provide a realistic village model, village farm households were categorised into groups. The criteria for classifying farmers was based on the level of farm

management practices; hectarege and variety of crops grown; farm income level; and, the degree of farm commercialisation. These are all related factors. The degree of commercialisation is reflected in the significance of monetary circulation in the household operation. Using the household data collected from the survey and the criteria described, the median farm of each group was chosen as being representative resulting in representative farms of the following smallholder farmer groups. These are:

(i) Marginal or *subsistence- oriented* farmer – Marginal farmers comprised about 38 percent of sampled households with a total cropped area of less than one hectare per year. Marginal farmer households are poor, with an average agricultural earning of less than T$2000 per year. They commonly supplement their income through remittances from family members residing overseas and non-agricultural employment of household members.

(ii) Emergent or *semi-subsistence* farmer - Emergent farmers constitute a majority (53 percent) of the surveyed households. Emergent farmers are referred as those generating an average farm income ranging from T$2,500 to around T$6,000 a year. They tend to farm 1 to 2 hectares.

(iii) Progressive or *commercialised* farmer : Progressive farmers depend largely on farming activities for their livelihood. Compared to emergent and marginal farmers, progressive farmers operate on larger scale and generally farm more land. Constituting about 9 percent of the surveyed sample, their agriculturally derived income averages more than T$10,000 per annum.

The degree of representativeness of these median farms was tested by comparing the farm plans data of each selected farm to the average of the corresponding farm groups. Village agricultural production patterns are an aggregation of these three main groups. The detailed data collected from these representative farms allowed models to be developed for each particular farmer group to reflect the behaviour of each reference farm type.

4.6 Conclusions

This chapter provides an outline of the field research design and the analytical techniques used to assess the data. Part 2 of the study contains the information collected and its analysis. Thus, the next four chapters contain details of the organisation of agriculture in Tonga, farm household goals and objectives, current resource capacity and production, and the socio-cultural environment where smallholder farmers operate.

PART 2: SYSTEM ANALYSIS

This is the initial analytical stage of the modelling process. The system is studied to determine the nature and behaviour of its components and sub-systems including the interaction between the components. A literature review, data analysis and subjective observation and assessment are all presented and included in this analysis of the farm household, of the institutional and economic environment, and of the socio-cultural environment facing smallholder farmers in Tonga.

CHAPTER 5

ORGANISATION OF TONGAN AGRICULTURE

5.1 Introduction

Agricultural development, in the context of this study, is the improvement in the way farmers and people utilise their land for crops and livestock production so as to improve their living standards. Developing countries seek to improve the performance of the agricultural sector as a means of promoting their overall economic and social development. The causes of poor performance of the agricultural sector are complex. In general, five conditions are essential for satisfactory development progress in the agriculture sector: (a) adequate resources, both physical (land, labour, good weather) and financial; (b) new technology to improve productivity; (c) suitable institutional supports (for research, extension, marketing, credit etc.); (d) appropriate policies, both in the economy as a whole and in the agriculture sector, including marketing systems, in particular; and (d) suitably trained and skilled farm managers. A government can not control all aspects of the agricultural environment that are ideal for development. However, it can have a significant influence on agricultural development through development policies and programs, and the provision of financial and other supporting services.

In this chapter, a review and analysis of the organisation of agriculture in Tonga is presented. The development of the agricultural sector is examined with an emphasis on the economic and institutional environment in which smallholder farmers operate. A detailed discussion on how policies and development plans are formulated in Tonga is presented, and on how supporting services, research and extension, marketing and credits impact. Major problems are also presented. The key policies described were incorporated into the model application.

5.2 Agricultural Policy and Development Planning

Policies to promote development are partly guided by policymakers' conceptions of the behaviour of people. In agricultural development, a better understanding about farm-level behaviour, therefore, is a crucial factor in formulating decisions that could affect the welfare of farmers. Agricultural policy is the specification by government of those laws, regulations and rules under which agriculture and agribusinesses have to operate (Dillon and Hardaker, 1993). Agricultural policy analysts face a challenging task of formulating policy measures, within the framework of national economic policy, which will elicit desired responses from key components of the agricultural sector, the producers, consumers and traders. The range of agricultural policies available include those affecting prices, marketing, input supply, credit, mechanisation, land reform, infrastructure facities, research, extension, and food security. Instruments are, or should be, chosen on the basis of their expected contributions to overcoming critical constraints and to attaining stated objectives. Agricultural policy instruments are often based on adjustments to the production and consumption incentives for rural households, so the responses of these households to changing external conditions are of considerable significance.

The basic ingredient of good policymaking in agricultural development planning is being able to define and classify the development problems that are to be dealt with. Upton and Dixon (1994) noted the need for sectoral policies to be developed with information on, and an understanding of, the way in which rural incomes are generated and, even more critically, of the nature of the rural producers' and consumers' attitudes and responses to constraints, incentives and changes in the policy environment. The responses do vary between different household categories and can be strongly influenced by existing local formal and informal institutions. Dillon and Hardaker (1993) point out an important aspect in policy analysis is the recognition of the differences between farm-level decision-making and aggregate sector-level decision-making. Often their interests do not coincide, leading to difficulty in the achievement of desirable results in the economy. At the farm level, the responsibility for decision making rests on individual farm households, groups or communities who formulate the goals to be achieved and decide on the technology and input levels to be used within the limits of their resources and the prevailing policy environment. They are responsible for making production, consumption, and marketing decisions. Therefore, the aggregate effects of farmers' responses to agricultural policies can lead to significant changes in the economic structure of the agricultural sector.

Government agricultural policies have targeted increases in productivity as well as a diversification of production to improve incomes of rural people. An effort is also being made to promote the use of more productive farm inputs and techniques. In many countries the infrastructure and institutional framework is also being improved and planning for the agricultural sector is aimed at identifying the major constraints on agricultural development. If these government policies are to be effective,

target farm groups must be identified and policy tools developed which are specific to the production possibilities and farm resource bases of the targeted groups.

With reference to Tonga, agricultural development must be viewed in terms of the large proportion of the population who are smallholder farm families. These people have a close affinity to the land and agriculture, and their social, cultural and economic attitudes must be taken into account. The agriculture sector forms a substantial part of the national economy. Development efforts in the agricultural sector have faced several constraints, such as the small land area, varying degrees of internal fragmentation, remoteness, small market size, high per capita costs in the provision of basic physical and socio-economic infrastructures, socio-cultural factors such as land tenure, poverty of resources, and internal and external communication problems. These problems are widely known and well documented (Hardaker, 1975; Sevele, 1973; ADB, 1995). The Tongan economy is inevitably open and vulnerable to both natural disasters and external market shocks. Cyclones and droughts have more impact in smaller developing countries like Tonga, and the ability of the agriculture and other production activities to recover are much lower compared to larger and developed nations. Smallholder producers are price takers and are subject to fluctuations in world market prices because fewer products dominate the composition of their exports. The responsiveness of long run growth to export instability is a matter of debate but the limited production possibilities in small economies reduces their capacity to adjust to external shocks and thus lowers the profitability of this leading sector.

5.3 The Formulation of Government Policy in Tonga

Tongan society is relatively homogenous, with an elaborate and well-established social system. In the latter part of the 19th century a Constitutional Monarchy was established, which still dominates the structure of the socio-political system. The government consists of the Privy Council, the Legislative Assembly, and the Judiciary. The King has constitutional authority to appoint the Privy Council, including all cabinet ministers. The Cabinet consists of a speaker and ministers appointed by the King and the governors of Ha'apai and Vava'u. There are 33 nobles who elect nine representatives on the Legislative Assembly. The remaining nine members are elected from members of the general public in a nation-wide poll every three years. Cabinet-level island development committees have been formed for each island group and, under the direction of these committees, aid packages providing funding for institutional buildings and infrastructures are currently being planned for each respective island group. At the district and village levels, there are elected officers. They serve as a link between the government and the people, passing on government directives, making representations to government on behalf of their communities, and handling official duties. Regular village meetings (*fono*) are held to discuss community and village issues.

The Central Planning Department (CPD) has overall responsibility for co-ordinating the preparation of development plans, in consultation with relevant ministries. CPD also undertakes negotiations with funding sources, prepares project dossiers and monitors their implementation. The Ministry of Agriculture and Forestry (MAF) is responsible for the implementation of Government policy through most aspects of agriculture and forestry, with three exceptions. Land tenure matters are the responsibility of the Ministry of Lands, Survey, Environment and Natural Resources; market development of most export crops is the responsibility of Tonga Trade at the Ministry of Labour, Commerce and Industries; and agricultural credit is largely the responsibility of the Tonga Development Bank. The detailed descriptions of MAF organisation structure and major responsibilities are given in Appendix 1.

The complicated nature of agricultural development in Tonga stems from the fact that government, in an effort to meet the aspirations of its citizens, is compelled to accelerate the pace of agricultural development. If left to natural evolutionary processes they would take far too long. The Government policy formulation process is closely tied to the preparation of formal five-year development planning documents. The recent development objectives and strategies for the economy are outlined in the sixth development plan known as DPVI, which covers the period 1991-95 (Kingdom of Tonga, 1991). The predominant objective of DPVI is the achievement of sustainable growth conducive to a higher and more equitable distribution of income.

Project or program proposals from MAF are submitted to the Development Coordination Committee (DCC) for review prior to being put to Cabinet for approval. Delforce (1990) claimed that given this apparently rigorous selection procedure, projects that are accepted should have a high chance of success. Nevertheless, the results of projects implemented are often disappointing. In some cases, the difficulties stem from a lack of understanding of the objectives of intended beneficiaries, or an overestimation of their ability to commit resources, such as family labour, to the project.

Previous studies (Hardaker, 1975; Delforce, 1990; AGRICO, 1995) noted that despite sporadic attempts to involve target beneficiaries through regional development workshops, policy formulation and implementation is still very much a top-down process. In the agricultural sector in particular, government policies frequently take the form of directives which are relayed, via the ministries concerned, down to the District and Town Officers, who are expected to see they are acted upon by their constituents.

In the area of agricultural development planning, there is evidence of a lack of consistency at a number of levels (Dixon *et al.*, 1994). At the macro level, the emphasis placed on agriculture, and the resources allocated to it, tend not to match the stated objective of promoting the development of the sector. At the level of choice of development programs and projects, there has been confusion about the merits of promoting the smallholder sector and the priorities that need to be followed in

such a promotion. This confusion is reflected in the often diverse opinions encountered among those supposedly involved with agricultural policy formulation. In many cases, it is not clear where policy initiatives originate and how they are linked to each other and to the development objectives set down in planning documents.

Agriculture policy analysis and planning activities in Tonga have been dominated by ad-hoc activities, such as, for example, sectoral reviews by donors, and routine planning and reporting. Although the underlying strategies for the agricultural sector are usually prepared within the context of a five-year plan, they are often strongly modified by changes in budget allocations. Ministerial targets set by the Ministry of Finance fluctuate from year to year, so the budget process is often confrontational, with each sector striving to maximise its share of the available budget allocations. The agriculture sector gets limited government support. In 1996, agriculture received only 6 percent of the total recurrent budget allocation despite the fact that it provided 78 percent of all exports and 53 percent of employment. Unfortunately, the narrow tax base in the rural sector does not assist the limited government revenue base overall, adding to the problems of the limited capacity and recurrent expenditure to support agriculture.

5.4 Government Support Programs and Development Initiatives

The agricultural sector in Tonga is facing considerable challenge which may require Government policies to increase agricultural and forestry production, improve market accessibility and profitability while maintaining sustainability, self sufficiency and agricultural security (MAF, 1995). This direction is expressed in the 1997/1998 Budget Statement which contains the recent government policies and national strategy on agriculture. "*MAF's objective is to facilitate the private sector to:*

(i) improve agricultural and forestry production by (a) actively promoting research into export potential crops such as vanilla, squash, spices, papaya, yam beans and coffee; (b) deregulating the quota system thereby improving the efficiency of resource use through greater competition; and (c) revitalising copra exports, which will greatly benefit outer island farmers.

(ii) diversify the agricultural sector through (a) introduction of new crop varieties such as coffee, aloe vera, rock melons, chilli, peppers and papaya, and (b) development of the organic market.

(iii) improve market opportunities by (a) developing quarantine protocols; (b) exploiting traditional systems of organic horticulture; (c) seeking innovative ploys and niches for products; and (d) using the high temperature forced air treatment facility which provides the opportunity to open overseas markets for Tongan fruits and vegetables previously not considered because of fruit fly and restrictions on ethylene dibromide residues" (Ministry of Finance, 1998).

Over the last 20 years the Government has encouraged entrepreneurial development either directly or indirectly through a number of initiatives. These have included (1) improved credit facilities through the establishment of the Tonga Development Bank (2) establishment of the small industries centre for agro-processing activities, (3) the provision of business incentives under the Industrial Development Incentives Act (1978) which gives tax exemptions on exports, imports and income (4) regulation of export licenses (exporters must be licensed by the Ministry of Labour, Commerce and Industries) (5) and improvements to the infrastructure such as roads, wharves, water supply and improved access to market information and research. The perceptions of the people on these initiatives revealed in the survey varied among the different region and the different farm types. These are discussed at more depth later in this chapter and chapter 6.

Recently, the Government has followed a policy of promoting the expansion of the agriculture sector both for domestic and export production through an export diversification program. The aim was to encourage farmers to increase production and productivity in order to improve the nationai trade balance. Development efforts have been aided by a variety of different schemes in the form of development projects from various donors. Assistance has been provided in a wide range of areas such as crop development, extension support, finance quality control and marketing (Unisearch Ltd, 1991). All these programs involve some financial assistance and have an influence upon the financial situation of farms. Contemporary developmental agricultural policies through the Ministry of Agriculture and Forestry tend to incorporate research and extension education as priority areas, and major strategies for the generation and transfer of improved technologies to smallholder farmers to enhance productivity. A major change in the form of support was given mostly in the form of outright grants or subsidies; later on an increased emphasis was put on credit schemes and institutional support through research and technology development. It is considered that credit programs lead to a better use of money spent as they usually imply a greater selectivity and require more economic considerations on behalf of the user. In recent years, the credit schemes have become more co-ordinated and integrated in view of the long-term adjustment of Tongan agriculture and strict criteria are applied by TDB in the selection of farms benefiting from the various schemes.

An issue for the sustainability of financing agricultural development is the low level of tax taken in the agriculture sector. Agriculture producers pay no income tax, there is no sales tax levied on domestic produce market sales, and agricultural produce exporters can be granted development status. Government policy instruments of price policy have been used in recent times in Tonga. For example, input subsidies on banana rehabilitation and coconut replanting schemes. Another common government action has been to provide subsidies for tractors and agricultural machinery, which encourages farmers to convert from traditional manual to machine cultivation. MAF operated a tractor hire service for farmers, which was subsidised to some extent. Some of the respondents favoured the subsidy and demand continuation. However, the government claimed the lack of fund

to support the scheme is the major constraint. Recently, the machinery pool has been reorganised into full commercialisation and the subsidy abandoned. Other subsidies to the agricultural sector exist in the form of exemptions from customs and import duties as well as port and service tax. Some farm machinery, chemicals and seeds are exempt, but other inputs, such as livestock feed and fishing equipment (boats, engines, freezers), had only partial exemption until recently (Sevele, 1983). The main source of tax revenue from the agricultural sector is the 20 percent Port Services Tax levied on all imported goods. Import tariffs and licensing gives some protection to local agriculture. Import duties ranging from 15 to 25 percent are incurred on items, which can be produced locally, including poultry, pork products, fish, fruit, vegetables and root crops. Importation of eggs is permitted only by license and only when local supplies fall short of demand.

5.5 Past Development Schemes

On a national basis, agriculture is still perceived as being the major source of future foreign exchange, with the greatest scope for improvement. Yet experience to date has been very mixed with regard to agricultural development projects that have targeted export market opportunities. In order to highlight the behaviour of smallholder farmers, it is useful to review the past performance of agricultural development projects. While some development programs were successful, including the squash, kava, and vanilla development programs, a significant proportion of agricultural development projects have been uniformly unsuccessful in achieving their manifested objectives of sustained increases in production and productivity. Examples of these commodity based development schemes are reviewed here.

5.5.1 Banana rehabilitation scheme

The banana industry was a significant export earner in the late 1960s, but has failed to develop in the long term. New Zealand was closely associated with the development of the banana industry through an aid scheme designed to re-establish a New Zealand market for Tongan bananas by improving quality, productivity and consistency of supply. New Zealand funding for the Tonga Banana Rehabilitation Export scheme, which catered for technical assistance, capital equipment, funds for disease control and a price support system, amounted to over NZ$6 million over the period from 1983-1988. The objective was to have 810 hectares under production by 1987 with an average yield of 4 tonnes per ha and a minimum farm size of 0.8 ha. If this target had been achieved it would have amounted to about 40 percent of the New Zealand market.

Input subsidies were a feature of the New Zealand-financed Export Banana Scheme from its inception in 1983. Chemical inputs (fertilisers, insecticides and fungicides) and packaging materials

(cartons) were provided to participant farmers free of charge or at low prices. These subsidies were gradually phased out over the life of the project, which concluded in 1988 (Needs, 1988).

A review by Cessford (1989) showed that, while the scheme made a number of achievements in quality control, post-harvest handling, production, safety, research, commercial attitudes and financial returns, the project fell well short of its major goals. Cessford attributed the failure of the scheme to poor productivity (low yields and poor quality), not only from climate effects but also from poor management. The exceptionally dry (less than two thirds of the long-term average) weather in 1981 to 1987 produced an average yield of 1.5 tonnes per hectare, but when rainfall returned to normal in 1988 the yield doubled. Several tropical cyclones during the project period also devastated most plantations and had a major impact. For instance, in 1989 banana exports dropped significantly from 1316 in 1988 to 445 tonnes in 1989. Exports of banana to New Zealand peaked in 1986 with T$1.5 million and drastically dropped to T$0.2 million dollars in 1989. By 1991, exports of banana to New Zealand ceased. The New Zealand market had opted for different suppliers, as Tonga could not achieved the quantity and the quality required. In addition, the outbreak of black leaf disease intensified the problem.

Needs (1988) has claimed that the project had the effect of increasing economic inequality among farmers in Tonga, and the poorest farmers had the least benefits. The scheme involved about 250 growers and about 462 hectares of land. Twenty growers owned about 32 percent of the land in the scheme, while 70 percent of the growers had an average of one hectare accounting to 35.6 percent of the land. The large growers were almost all involved in other ventures besides banana growing and had the money to increase their landholdings. Many of those in the upper socio-economic level had acquired the land specifically to participate in the banana scheme. The lower socio-economic group, who depended on banana production for most or all of their cash income, were relatively disadvantaged in their access to the scheme.

5.5.2 Coconut replanting scheme

The Coconut Replanting Scheme was financed with British aid and commenced operations in 1967 with the objective of rejuvenating the coconut industry. The scheme involved direct input subsidies to encourage the replanting of coconuts. In this case, growers received a cash grant (T$4 per ha) towards clearing and establishment costs, and seedlings were distributed free of charge. The operation of the scheme was structured around the selection of seed nuts from selected mother palms and propagated in nurseries. The resulting seedlings, after further selection for vigour, were supplied to growers for replanting. Employees of the scheme did part of the land preparation and planting or else subsidies were paid to growers who did the work themselves. A further subsidy was introduced in 1975 to encourage farmers to maintain their trees.

During the 1970s coconut products represented over 70 percent of the exports. The drop in the world market prices of coconut products from an average of T$$500/MT to a low of T$200/MT had a major impact on the coconut industry. The decline in the relative importance of coconut product exports was particularly severe in 1988-1989. The production of coconut products has declined from about 70 percent of the exports in the 1970s to about 41 percent in the 1985 -1988 and to a low of 1.8% in 1990 to 1993. This substantial decline has not only induced a loss in foreign exchange but also affected the employment opportunities created through copra processing, oil mill and desiccated coconut manufacturing. The decline was particularly severe on the outer island economies.

5.5.3 Coffee development project

The Coffee Development Project is an ongoing project supported by French and Australian Aid Programs. Part of the project proposed to fund the planting and development of 8 hectares of coffee in Ha'apai in 1993/1995. The coffee seedlings were raised by MAF and made available to growers at no cost. Farmers' training on the establishment for coffee, management strategies, harvesting and post-harvest operations were conducted by extension officers and research specialists from Tongatapu.

A survey indicated that the project was not successful due to a low adoption rate with only 25 farmers growing coffee. This corresponds to a total area of 2.4 hectares, which represents 30 percent of the target area to be planted (MAF, 1997). The MAF officer in charge in Ha'apai reported that more than 20,000 coffee seedlings were left in the MAF nursery and thus were a waste of project resources. According to the officer, "*the main problems for developing coffee in Ha'apai, according to some respondents, was the unreliability of the market and the technology – referring to the discrepancy of yields of coffee in Ha'apai compared to that of Vaini experimental farm*" ('Anitoni, pers comm. 1998).

5.5.4 Livestock development programs

The livestock industry has developed around the household production of mostly pigs and poultry for social obligations and household consumption. The Tongan government has attempted to initiate and accelerate the process of commercialisation of the livestock industry, mainly for cattle, dairy, pigs and poultry farming to reduce the high importation of mutton, poultry and livestock products. The livestock development schemes involved subsidised capital inputs for construction of pigpens, fenced grazing, troughs for food and water, and the acquisition of stock. Nevertheless, unforeseen problems occurred. The large scale of government plans and policies, which had been drawn up with the assistance of Western experts, failed to correspond to the small scale of traditional Tongan smallholder livestock husbandry.

Reviews of livestock development projects, according to the Head of the MAF Livestock Division, showed the failure to achieve their respective projected outputs. For example, of the 83 farm households involved in a pig development project in 1972, less than 5 percent were successful. Project reviews noted a majority of smallholders did not see much point in fencing pigs if this meant that they were obliged to feed them and clean their accommodation every day. The pink pigs (improved breed) imported from New Zealand, which were larger than the beige, brown and black Tongan pigs, were so seriously affected by sunburn (due to their lack of pigment) that they had to be slaughtered prematurely. Similar results were found in a beef cattle development project in 1982 with a 10 percent success rate. Improved breed stocks were imported from New Zealand for multiplication and distribution to smallholder farmers. The project struggled to achieve its objectives due to the high cost of purchasing animals.

An official, when asked about the reasons for high failure rate, commented: *"There are a number of reasons for these failures. Tongans keep cattle and pigs for social motives, to meet social obligations to church and family, and for home consumption. As far as the pig project is concerned, a household would begin with two sows, say, but that was far too few; it was only enough to meet their obligations. Perhaps they would manage to sell them if they had ten sows"* (Fifita, pers comm. 1998).

The development of the poultry industry has seen the collapse of broiler production due to the local industry's inability to compete with cheaper overseas imports. Thirty households were involved in the poultry development project in 1974; only 10 percent were successful. The high cost of imported feed was the major constraint, and made it impossible for them to sell at the price of imported poultry meat and eggs.

5.5.5 Vanilla development project

Overall, it is hard to point to many concrete examples of success among the agricultural development schemes introduced so far. This is not to disparage the efforts that have been made, but rather to emphasise the difficulties inevitably encountered in the attempts to transform agriculture from a traditional, mainly subsistence oriented system, into a more market-oriented industry (Hardaker, 1975). However, some projects have been successful such as the vanilla, squash and kava development programs. These commodities continue to be the most important cash crops and major contributors to export earnings.

Vanilla has been successfully introduced and commercially established in Vava'u under past FAO, ADB and French assistance starting in 1955. Project support was in the form of technical assistance, research and extension activities, setting up of processing and curing units, and the provision of planting materials. According to Hardaker (1975) the development of the vanilla industry was slow; it

was not until 1966 that any significant quantity of cured vanilla beans was successfully produced. In 1970, there were 723 growers in Vava'u with a total of over 80 hectares of vanilla producing about 2 tons of cured beans. Vanilla production has increased consistently since, 9 tonnes were produced in 1977, and in 1991 the export level reached a high of about 70 tonnes and with a total earning of T$5.5million.

In 1993, the total area under vanilla was 804 hectares of which about 78 percent was in Vava'u and 18 percent in Tongatapu (MAF, 1994a). The average production has been about 110 tons of green vanilla, or 22 tons of cured vanilla, in the last five years. Due to poor management, actual yields averaged around 178 kilograms of green vanilla per hectare per year vis-à-vis yields of about 615 kg per hectare under good management. Fa'anunu (1985) indicated that an average yield of 1400 kilograms of green beans per hectare is potentially attainable under progressive management. However due to the lack of research and poor extension support, MAF input has slowed and contributed to lower yields and post-harvest problems (immature harvesting and poor curing). The relative profitability of vanilla seemed to decline in recent years. Vanilla exports continued to be Tonga's second major export commodity, contributing about 16 percent of the total agricultural export earnings over 1991-1996. The relative stability in the world prices of vanilla has maintained real producer prices sufficiently to stimulate the expansion of farmers' plantations. The performance of the vanilla industry is discussed in depth later in this chapter.

5.5.6 Squash development project

As noted in Chapter 3, the most significant structural change during the last ten years has been the development of the Squash Export Industry in place of banana and copra, which had been dominant in the 70's and early 80's as the country's main export commodities. The squash industry was initiated by private sector interests and has developed with little government intervention compared to other development schemes. The squash export industry was established in 1987 under shipping and marketing arrangements with Group Trade Ltd of New Zealand. Local growers were then organised into the Tongan Growers Association and in 1989 took over the marketing role of squash from the New Zealand company.

The squash development programme, in support of the private sector initiative and aided by the New Zealand Assistance programme, focussed on technical assistance, infrastructure facilities, training programmes on production and post-harvest handling. The Tongan Government also assisted in setting up credit facilities through the TDB to assist the development of the Industry. The major contributions by MAF have been through research and extension for improved technologies and the dissemination of information to growers. The Quarantine division of MAF also handles quality control and the management of export produce.

The development of the industry has been dramatic (discussed in depth later in this Chapter) and farmers have responded in large numbers. This is reflected in significant increases in the area cultivated under squash and the number of farmers involved. For instance, a fourfold increase occurred in the area cultivated (from 80 to 320 ha) and farmers involved (40 to 164) in 1987 to 1989 respectively. The Land Use crop survey in 1993 showed the total area cultivated under squash was about 2115 hectares and the number of growers was estimated to be about 1050 (MAF, 1994b).

5.5.7 Kava development project

The kava development program was initiated under Australian aid (ACIAR). Project support in the form of technical assistance, and research and extension activities with an emphasis on the kava die back disease control, which had hampered the industry in the late 1980s. The project involved setting up a tissue culture laboratory unit at the MAF Research Station for the propagation and provision of disease free planting material. In 1993, the total area under kava was only 250 hectares of which about 70 percent is grown in Vava'u and 18 percent in Tongatapu. The performance of kava in the Tongan economy is outlined later in this chapter.

5.6 Agricultural Marketing

One of the most important supporting services that has a direct impact on land use decisions relates to the marketing of agricultural produce. This section provides an overview of the existing market environment, specifically the domestic market and the access to export markets, marketing organisations and farmers' access to market information.

5.6.1 Domestic marketing

Marketing of agricultural products in rural villages normally begins at the level of the individual smallholder. The marketing of local produce, food and materials, remains largely in private hands under the supervision of the Ministry of Agriculture and Forestry as specified in the Market's Act, 1975. The Government established produce markets in the main islands, and these are managed and controlled by a separate Market Authority for each island group. Each market (except Ha'apai) is administered by a market manager and supporting staff. They are responsible for collecting rent from the stalls and butcheries, collecting marketing data (eg. volume of produce sold through the market, prices received) and overall maintenance of the market place. Private individuals hire stalls and floor space in these markets with the cost ranging from T$1.00/day for open stalls and T$2.00/day for lockup stalls.

The primary local outlet for root crops and fresh produce in Vava'u is the Sailoame Market. Situated in the capital town of Neiafu, the market serves as the centre for market exchange among the growers, retailers, traders and consumers. According to some respondents, the Sailoame Market is presumed to have reached its saturation point, given the low rate of population increase in Vava'u and Neiafu, and the slow build-up of tourist arrivals. The existing market site is too small in physical area (approximately 800 square meters). Over the last ten years, there have not been dramatic changes in the volume and type of commodities traded. However, some congestion was noted on Saturday mornings when market transactions between the sellers and buyers are at its peak. A new market site has been identified, and currently under construction. In contrast, the Ha'apai market is held on an area of open ground in front of the MAF head office in Pangai. The poor market infrastructure was one of the major constraints according to the majority of village respondents in the two Ha'apai villages. The lack of a permanent structure restricted sellers in the quantity they sell and some of the sellers interviewed stated that a permanent structure would allow them to increase their sales by giving them more flexibility over what they could sell and time to sell them.

Talamahu market in Tongatapu is the largest domestic market in the Kingdom. Construction of the new market was completed in 1995. The market is a valuable source of cash for rural people as well as being an important food source for the increasing urban population of Nuku'alofa. Talamahu also provides an outlet for perishable and other commodities that are not allowed to be exported (such as tropical fruits mangoes, etc). Table 5.1 summarises the average quantity and prices for the major agricultural commodities supplied in 1990 to 1996. Trading is heaviest on Saturdays with most of the vendors or buyers only attending once a week. The sale of Tongan handicrafts is also a significant source of domestic cash income. Handicraft items are sold at Talamahu Market, and also through co-operatives like FIMCO, Langafonua, and in special stalls on Government grounds when cruise ships are in port, and at specific tourist resort locations.

The study found that a majority of the households surveyed in Vava'u and Ha'apai sell their produce at their local market. However, despite the small-size and congested nature of the local market only a few farmers, 7 and 12 percent in Vava'u and Ha'apai respectively, shipped some of their market-directed surpluses to the national market in Tongatapu. This is confirmed by information from the Market officials in Tongatapu which revealed that almost 80 per cent of national market (*Talamahu*) sellers are from Tongatapu, 16 percent from 'Eua and less than 5 percent of the market sellers are from Vava'u and Ha'apai Islands. The study showed that produce shipped from Vava'u and Ha'apai were mainly high valued products such as yams, giant taro, kava, handicrafts, mats, processed pandanus, and paper mulberry. Respondents expressed concern about the risks associated with high freight and handling costs, and the strong competition with farmers in Tongatapu and 'Eua giving them lower profit margins.

Table 5.1: Supplies of major agricultural commodities at Talamahu Market (1990 – 1996).

COMMODITY	1990	1991	1992	1993	1994	1995	1996
Yam *(tonnes)*	349.9	136.8	126.0	143.1	490.1	280.4	368.8
Price ($/kg)	1.64	2.82	2.31	2.24	1.53	1.45	1.52
Swamp Taro *(tonnes)*	187.2	35.1	41.8	43.4	45.6	55.6	67.5
Price ($/kg)	0.6	0.9	0.6	0.86	0.89	0.78	0.73
Common Taro *(tonnes)*	887.4	210.7	287.6	285.4	311.9	215.8	293.6
Price ($/kg)	0.44	0.93	0.62	0.54	0.65	0.61	0.52
Giant Taro *(tonnes)*	158.3	76.0	48.8	41.5	183.3	111.6	96.9
Price ($/kg)	0.42	0.64	0.70	0.70	0.64	0.64	0.53
Cassava *(tonnes)*	438.0	817.4	605.7	631.7	969.3	461.4	721
Price ($/kg)	0.34	0.51	0.22	0.18	0.19	0.24	0.24
Sweet Potato *(tonnes)*	1818.3	765.7	767.1	789.6	338.3	598.9	449.6
Price ($/kg)	0.53	0.72	0.34	0.35	0.45	0.41	0.48
Potato *(tonnes)*	6.7	12.9	20.3	26.3	25.1	13.2	15.4
Price ($/kg)	1.4	1.12	1.10	1.10	0.83	1.28	1.23
Banana *(tonnes)*	141.1	65.0	48.9	42.1	92.3	79.8	395.5
Price ($/kg)	0.32	0.54	0.73	0.65	0.49	0.39	0.33
Plantain *(tonnes)*	62.1	73.1	65.1	69.4	196.7	247.1	385.6
Price ($/kg)	0.53	0.81	0.72	0.72	0.58	0.46	0.43
Watermelon *(tonnes)*	843.6	736.2	618.3	573.4	803.1	815.7	1031.9
Price ($/kg)	0.91	0.92	0.80	0.78	0.67	0.69	0.60

Source: MAF, 1994a and 1996b

5.6.2 Export marketing

The contribution of agricultural exports to total foreign exchange earnings is covered in Chapter 3. Marketing methods and the type of produce exported from Tonga have changed over the last decade. AGRICO (1995) note some of the changes which have occurred. They include: (1) development from a commodity base (copra and banana) to a more diversified base (squash, vanilla, kava, vegetables, root crops); (2) restrictions in Government direct involvement in marketing to be more of a facilitator role and emergence of private sector exporters – company, individual; (3) improved quality control systems for export crops, and movement from a production driven approach towards a market driven system.

Tonga's agricultural exports were established around copra, which was sold as a bulk commodity. With the fall in world prices over the last decade, Tonga has attempted to diversify into other agricultural crops such as vegetables and root crops, which, in contrast to copra, have a relatively high unit value. Table 5.2 depicts the country's major export crops and their respective contributions to foreign

exchange over the period 1991 to 1996. The major agricultural export commodities ir vanilla, kava, root crops and watermelon.

5.6.2.1 Squash

The most significant structural change during the last ten years has been the development of the Squash Export Industry, which has contributed significantly to economic growth. Trade figures show significant decreases, or eventual disappearance, in just about all the traditional exports, such as banana and copra, which had been dominant in the 70's and early 80's, (World Bank, 1993). These have been replaced by squash as the main export commodity. The industry was established as a result of the efforts of New Zealand entrepreneurs who identified a seasonal gap in the Japanese market. At that time Tongan farmers were also under great pressure following the collapse of copra prices and disease problems with bananas.

Table 5.2 shows the performance of the squash industry and its significant impact on foreign exchange. The squash export industry was established in 1987 and during the last 6 years the total export earnings from squash has amounted to a total of about T$60 million, which is equivalent to about 63 percent of the agricultural exports and at least 45 percent of the overall export value.

Table 5.2: Major agricultural export crop earnings (1991 – 1996).
(in T$million)

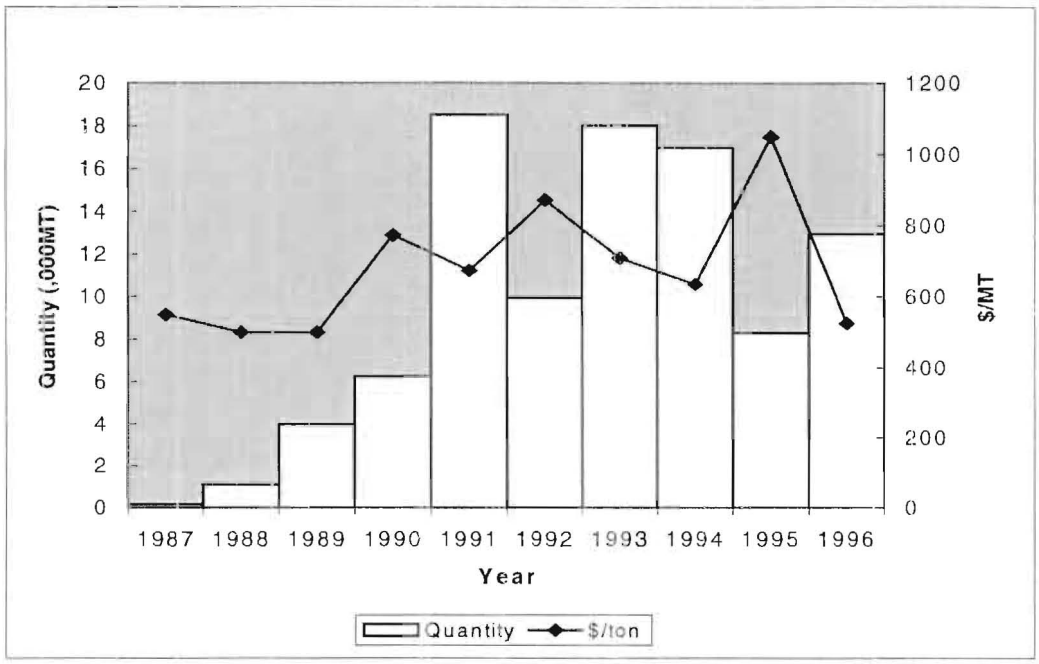
	1991	1992	1993	1994	1995	1996	Total	% of Total
Squash	11.16	7.32	17.56	11.38	5.88	5.44	*58.74*	*63.4%*
Vanilla	5.48	1.51	3.17	1.55	2.44	0.87	*15.02*	*16.2%*
Yams	0.29	0.05	0.07	0.21	0.74	0.5	*1.86*	*2.0%*
Giant Taro	0.06	0.02	0.04	0.03	0.07	0.07	*0.29*	*0.3%*
Cassava	0.4	0.64	1.06	0.52	0.2	0.37	*3.19*	*3.4%*
Swamp taro	0.25	0.03	0.05	0.12	0.05	0.05	*0.55*	*0.6%*
Common taro	0.3	0.05	0.08	0.07	0.79	0.15	*1.44*	*1.6%*
Watermelon	0.18	0.13	0.12	0.08	0.19	0.13	*0.83*	*0.9%*
Kava	0.02	0.04	0.01	0.08	0.41	2.15	*2.71*	*2.9%*
Coconut	0.68	1.05	0.33	0.14	0.16	0.24	*2.6*	*2.8%*
Total Agr. Exp.	**19.53**	**11.35**	**22.93**	**15.53**	**12.19**	**11.16**	**92.69**	

Source: MAF, 1996a

Despite being a successful industry, performance over the years has been characterised by inconsistencies in production and market returns as depicted in Figure 5.2. In 1991 production of more than 18,500 tons was exported to Japan. This exceeded market quotas and a large proportion of the shipment had to be dumped, but despite a drop in market price it still managed to yield an export FOB value of T$12.4 million which represented 50 percent of the country's total export earnings for the year. After an oversupply in 1991, the Tongan Government immediately took

remedial measures to defend the industry through fiscal policy, setting up legislation and a quota system. In 1992 production was limited to 10,000 tonnes and legislation was introduced to control standards and quality, and the number of exporters was limited. As a result squash exports for the following year fell by almost 50 percent. Despite the higher per unit value of about 87c/kg the total export foreign exchange earnings generated was T$8.7 million.

Figure 5.1: Squash export data (1987 - 1996).



Source: NRBT, 1997

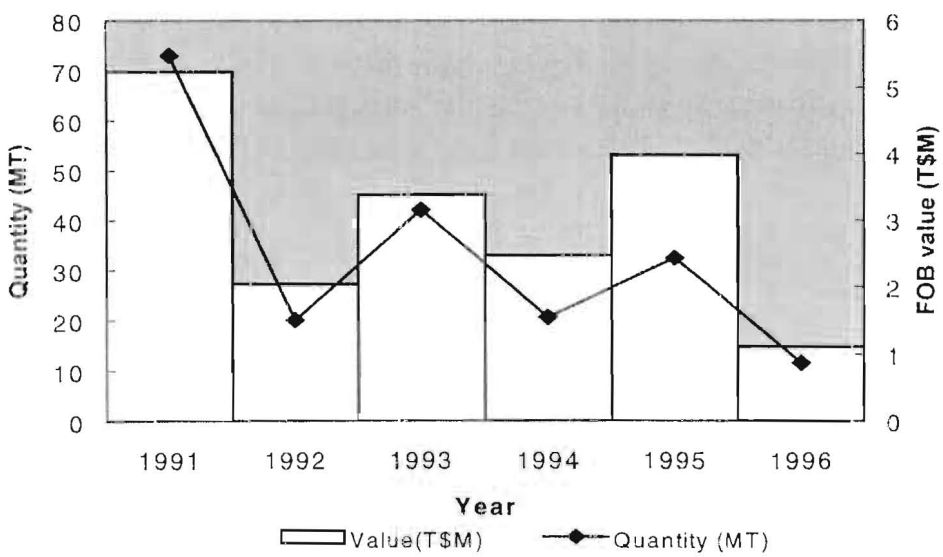
Exports picked up in 1993 when production rose to 18,000 metric tons and total earnings were $12.9 million, or 60 percent of the total export earnings for that year. A price fall in the Japanese market for the 1994 crop led to a decline in export income from squash. This fall impacted heavily on Tonga's foreign reserves. There were several causative factors, one being the fact that shipping was not co-ordinated well with the requirement of the market or the production of the crop. Consequently there was an oversupply of poor quality squash on an already depressed market. The relatively poor returns in 1994 resulted in a high default rate by growers on Development Bank loan repayments. A combination of a dry season and poor 1994 returns lead to a fall in the area planted in 1995 planting to only half that of 1994. The reverse continued in 1996, with an accompanying decline in foreign exchange earnings. The factors that contributed to the downward trend in exports included unfavourable weather conditions, market uncertainties, transportation difficulties, diseases, and a decline in the market price. In 1996, 12789 tons of squash were exported with a record low price of 0.46 cents per kg.

The fluctuation and inconsistencies in market prices has been a key feature of the squash industry over the years as shown in Figure 5.1. Often in good years, there is over production thus exceeding the quota, which lowers the price farmers get and even prevents some farmers selling any of their produce. In years of bad weather, there is often a lower yield and production falls short of the required quotas; then the Japanese market offers higher prices. The price trend over the years indicates inconsistency and price fluctuations which makes it difficult to predict future prices. Some of the growers, especially emergent farmers, considered squash a very high-risk option and left the industry. Some exporters are pressing the Government to remove the quota system to allow a free market arrangement. The future of the squash industry clearly depends on Tonga's ability to consolidate current market and production environments, its ability to sustain market quota and to obtain returns for both exporters and growers, and its ability to maintain a competitive edge over other exporting countries in the Japanese market.

5.6.2.2 Vanilla

Vanilla has important advantages as a cash crop in Tonga. It is a high value, labour intensive crop that requires little capital investment by growers and limited land areas. The final product is non-perishable, has a high value to volume ratio, and can be stored for a considerable length of time. Vanilla exports have continued to be Tonga's second major export commodity, contributing about 16% of the total agricultural export earnings over 1991-1996. Three exporters, PPEL (23%), FIMCO (20%) and South Pacific Processors (50%), export the bulk of Tonga's vanilla. The total production is difficult to access because a certain amount appears to be exported illegally. Figure 5.2 shows the export of vanilla during 1991 – 1996.

Figure 5.2: Fluctuations of vanilla export (1991 - 1996).



Source: MAF, 1996a

Prices for high quality commodity are generally favourable, and vanilla production has provided an attractive return to growers. The main producer in Madagascar dominates world prices, and political uncertainties over the distribution of the present high level of stocks presents the possibility of price destabilisation. Vanilla production increased from a depressed export level of 11 tonnes in 1990 to about 70 tonnes in 1991 with a highest total earning of T$5.5million. The price per kilogram of cured vanilla was T$79. Figure 5.2 shows the cyclic nature of vanilla export production in the last 6 years. The 1996 production showed a significant reduction (72%) with only 15.7 tonnes of vanilla exported compared to 53.1 in 1995. This was attributed to a drop in the world market price and lower yields. Despite the drop in price for cured vanilla from USD $60-70 per kg in the 1970's - 1980s to the more recent experience of $20-40 per kg, vanilla still fetches a higher return than most other crops. It should be noted that average returns for organic vanilla is USD$60 per kg.

5.6.2.3 Kava

Kava is currently Tonga's third major export commodity. Table 5.4 shows the performance of the kava industry during 1991 to 1996. Kava exports were low in the early to mid 1990s with the major attributing factors being a high local demand and the dominance of the squash industry. The FOB price of $17 per kilogram of powdered kava was consistently high. However in 1994, production increased to about 5.5 tonnes from 0.5 tonnes in 1993. This continued in 1995 to 24 tonnes and in 1996 kava exports surged to a record high of 126 tonnes with a total value of more than T$2 million and was ranked second to squash on returns. The potential of kava for export is now much greater. The local demand is consistently high with a reasonable price, and exports to Fiji, New Zealand and the USA are growing. There was also an additional demand from pharmaceutical manufactures in Europe in 1996 and this boosted the production and export of kava as well as the price which doubled to about T$40 per kilogram of powdered kava. The future for kava looks promising and the challenge now is for Tonga to meet the market demand. However, the main constraint lies in the difficulty of obtaining access to areas with suitable soils of deep and moderate fertility, and access to a sufficient quantity of planting materials.

5.6.2.4 Root Crops

Root crops are the major staple crop, and minor cash crops both for domestic and export markets. The export of root crops to migrant communities overseas is a lesser known commodity but one that has performed favourably in recent years. Overseas Tongans and other Pacific islanders provide a continuing stable market for taro, yam, giant taro and cassava especially with the downturn of copra production. Large volumes of frozen cassava, peeled and bagged, are exported in container lots all year round to New Zealand and Australia. Yams, giant taros and taro are also exported in large volumes on a very seasonal basis. The main supply goes to New Zealand and Australia on a private basis through relatives and friends, and target markets are mainly Polynesian communities. Table 5.3 shows the export of root crops in recent years. Significant increases reflect the fact that people lost faith in the squash industry and opted to grow yams, taro, cassava and kava.

Table 5.3: Major root crop exports for 1991-1996.

Crop Type	YEAR	1991	1992	1993	1994	1995	1996
Yams	Quantity (MT)	245.3	31.5	67.8	193	745.3	551.4
	Value (T$M)	0.29	0.05	0.07	0.21	0.74	0.5
	Price ($/kg)	1.2	1.5	1.1	1.1	1	0.9
Giant Taro	Quantity (MT)	125.8	39	61.3	59.5	116	147
	Value (T$M)	0.06	0.02	0.04	0.03	0.07	0.07
	Price ($/kg)	1	1.2	1	1	0.95	0.9
Cassava (frozen)	Quantity (MT)	813.4	1065.7	1768.1	866.7	372.2	815.4
	Value (T$M)	0.4	0.64	1.06	0.52	0.2	0.37
	Price ($/kg)	0.5	0.6	0.6	0.6	0.55	0.45
Common taro	Quantity (MT)	428.1	56.5	90.2	77.2	92.7	219
	Value (T$M)	0.3	0.05	0.08	0.07	0.79	0.15
	Price ($/kg)	0.7	0.9	0.9	0.9	0.85	0.7
Swamp taro	Quantity (MT)	178	15.7	45.8	111	49.8	52.3
	Value (T$M)	0.06	0.02	0.04	0.03	0.07	0.07
	Price ($/kg)	1	1.2	1	1	0.95	0.9
Kava	Quantity (MT)	0.86	2.36	0.64	5.56	24	126.7
	Value (T$M)	0.02	0.04	0.01	0.08	0.41	2.15
	Price ($/kg)	18	17	15	17	17	40

Source: MAF, 1996a

5.6.2.5 Watermelon

There is an established market for watermelons in New Zealand through New Zealand traders, (FIMCO or PPEL). Improved quarantine facilities in Nuku'alofa and Vava'u have resulted in the recommencement of watermelon exports to New Zealand in the mid 1990s. In 1991, 211 tonnes were exported; then production dropped to 127 tonnes in 1992 and to 90 tonnes in 1995. This fall was linked to farmers being attracted to squash production, which proved to be more productive at the time. The problems intensified with a fruitfly infestation on one container load, which led to a temporary ban on exports of watermelon from Tonga imposed by New Zealand Quarantine in 1994. However, the export production picked up in 1995 and 1996 as more squash growers reverted back to watermelon. This indicates that there is still potential to increase exports of watermelon.

5.6.3 Marketing organisations

As noted earlier, one of the major changes that has occurred was the Government phasing out its involvement in the direct export marketing of agricultural produce. The Government is restricting it's role to facilitating market research, quality control, credit and loan facility provision, and marketing policies to assist private sector development. The actual marketing of agricultural produce for export is entirely in the hands of the private sector through exporting companies, groups and individuals. Individual farmers or groups negotiate contracts with exporting companies or organisations and each grower is given a quota to produce. For example in the squash export market, the farmers

have to be registered with one or more of the exporting companies and a quota will be allocated. There are about 14 squash exporting companies operating; however only two of them are involved in exporting other crops and commodities (PPEL (Primary Produce Export Ltd) and FIMCO (Friendly Islands Marketing Co-operatives)). In addition there are a number of private entrepreneurial exporters who export a variety of crops through an informal system that involves either selling through relatives living in other countries or flying to the country to do their own selling.

5.6.4 National market information system

Market information systems for agricultural products exist in a number of agencies. The Marketing Research and Development section of MAF is responsible to the Policy and Planning Division. Activities performed by the marketing unit include industry workshops and liaison, maintenance of databases, technical advice on food processing, collection and collation of market information from Talamahu market, and the preparation of radio broadcasts. The Ministry of Labour Commerce, Trade and Industry has established the Tonga Trade organisation and is responsible for approving export licenses for squash, market research and the promotion of export products in overseas markets. The Tonga Development Bank, exporters, and some NGOs such as the Foundation of the South Pacific (FSP) are also involved in market development, and many individuals and groups act on their advice for export market development (particularly with handicrafts). However, the activities are uncoordinated and tend to be ad hoc.

5.7 Agricultural Credit

A survey of the household's credit source for financing farm activities was included in the household questionnaire. The study found that a majority of surveyed households (about 90%) with agricultural loans identified Tonga Development Bank (TDB) as their main source of credit. The other 10 per cent borrowed from other credit resources such as relatives overseas or in Tonga. The use of credit by households by region was fairly widespread with 43, 52 and 14 per cent of households in Vava'u, Ha'apai, and Tongatapu respectively having an agricultural loan with TDB. The higher percentage of households in the outer islands (Ha'apai and Vava'u) was largely due to a TDB credit line from IFAD (International Fund for Agricultural Development) earmarked for the outer island's development.

In the two villages from Vava'u more than 70 percent of surveyed households with agriculture loans used them for vanilla and root crop development projects and the remaining 30 percent for womens' projects. Crop development loans are often organised through village farmers' groups as working capital for crop establishment labour, vanilla pollination, and crop management. The average loan size was T$1300, and the interest rate on agricultural loans under T$2000 is 10% on a flat rate

basis. In the two villages in Ha'apai, about 70 percent of those with agricultural loans were through womens' groups, or for womens' activities and the remaining 30 percent were for root crop production purposes. In Tongatapu, the few people with agricultural loans had them mainly for squash and watermelon cash crop development purposes.

5.7.1 Tonga Development Bank

The Tonga Development Bank (TDB) finances development investments within the agricultural, industrial and commercial sectors with the majority of lending going to the agriculture sector. For the past eighteen years of the TDB operation, a total of 74,422 loans have been approved by the Bank for a total value of T$135.85 million. Agriculture sector loans dominated the loan portfolio with 83.0 percent in number and 62.7 percent in value (TDB, 1998). In 1998 agricultural loans still dominated representing 59 percent of the total value of the TDB's loan portfolio. However the value of agricultural loans decreased in 1997 to only T$12.6 million compared to T$13.6 million in 1995 and T$18.5 million in 1994. Squash loans still dominated the agricultural loans in 1997 with a total value of T$4.9 million, root crops (T$2.6 million), vanilla (T$2.5 million) and 'Women in development' T$1.1 million. The decline was linked to the performance of the squash and vanilla industry described earlier in this section.

The major proportion of all agricultural loans, 55 percent, was disbursed in Tongatapu, and the rest was spent on the outer island groups with a major share going to Vava'u. In 1997, the total lending to the outer islands amounted to a total value of $5.27 million. The Ha'apai group dominated the number of loan approvals for the outer islands whilst Vava'u still dominates the amount approved. A majority of agricultural loans were provided as working capital.

The majority of TDB clients are small-scale farmers, fishermen and handcraft producers (approximately 70 percent) with the average loan size to this group being $420 with debt servicing being approximately $25 per month. Typically, a small borrower will begin with a loan of less than $200 and over time, if successful, their use of credit could increase to a loan of approximately $2000. One key issue in this process is the difficulty faced by potential rural clients to attain the threshold (and thus the equity) to access the first loan. While the IFAD credit package to outer island borrowers has made considerable improvements in this respect, feedback from farmers, especially young farmers and women (including women's handicraft groups), clearly highlighted this need for training to support these new borrowers. Bank policy is that most potential borrowers must undergo a pre-lending training, but there are not necessarily the resources for this work, especially for follow-up training and the integration of credit training into a small business package.

A UNDP/FAO funded project supplied a base fund (T$23000) to be administered by TDB for women's groups with income-generating projects. A group desirous of obtaining a loan presents a

project proposal to TDB for appraisal. These are normally supported by MAF. Money is released in cash to the group, with interest imposed to cover costs, and repayments are constituted into a revolving fund. The maximum size of a loan is T$1,500 with a maximum repayment period of two years. The fund is fully committed for loans, which have been given for such purposes as vegetable cultivation, for purchasing planting materials, or raw materials for handicrafts and tapa making, sewing material, piggery, poultry requirements and other projects.

Farmers were asked their view of the performance of TDB and credit facilities. Many farmers referred to TDB's loan procedures as cumbersome. In addition, many would like to see the repayment schedules follow more closely the revenue earning peculiarities of each crop. Progressive farmers, being risk-takers, are generally good clients. In contrast, subsistence and emergent farmers are risk-averse and create most of TDB's problem loans. Although problems exist in the dealings of the Tonga Development Bank (TDB) with farmers, it is believed these are not serious. There are no shortages of TDB loan funds for the outer islands. The IFAD credit line is especially suitable for farm loans to smallholder farmers and for income generating activities of women's groups for Ha'apai and Vava'u groups. The credit conditions are not stringent. The interest rate for short-term loans, especially for small scale subsistence agriculture (farming, fishing) loans less than $1000, is 8.5 percent, while for commercial purposes it is 10 per cent. Repayment of loans for short-term crops is due directly after harvest, while repayment for other types of credit varies depending upon the type of project. The poor repayment of credit has been claimed by TDB to be due to the following reasons; (a) failure of farmers to use funds for production; (b) low returns from the technology package for which credit was obtained; (c) losses due to seasonal or unforeseen calamities; (d) unscrupulous borrowers and wilful defaulters; and (e) inadequate efforts at collection by the credit supplying institution. From the TDB's viewpoint, the existing repayment problems could be reduced through a combination of intensive client training, closer monitoring, and loan rescheduling.

The analysis of credit use showed that TDB used different criteria for different farmer types and amongst the different island groups. The credit lines available for more subsistence and semi-subsistence farmers are different to those that progressive farmers would have access to, not only in terms of the total amount but also the interest rates. The available maximum credit is included in the model for each farmer's type. The impact that changes in interest rates has on semi-subsistence farmers and progressive farmers' operating plan was examined in the model analysis and validation.

5.8 Agricultural Input Supply

Agriculture inputs and equipment are available from a number of sources. A commercial company provides a wide range of herbicides, pesticides and fertilisers, farm tools and prerequisites in the three main island groups. In Tongatapu, the major retail stores and some smaller, more specialised retail outlets also supply farmers' need. Farmers are generally well served by these sources that in addition to MAF and other exporters, also provide some advisory services. As an encouragement to the primary sector, agricultural inputs are imported free of duty.

5.9 Conclusion

While the causes for the stagnation of the agriculture sector are varied, it is generally agreed that inadequate sectoral planning capacity is one important reason. For future development, a comprehensive agricultural policy statement is required to guide the activities of the Ministry of Agriculture and Forestry (MAF) and the direction of agricultural development in Tonga. Within the context of such a policy, a sound strategy must be formulated to ensure that the goals and objectives are met. Based on these strategies, agricultural projects and activities undertaken by MAF must be well planned and financially viable for successful implementation. Funded projects and activities must be regularly monitored and evaluated to assure that targets and key indicators of performance are met. Agricultural data for all types of planning and project preparation must be gathered and properly managed.

The capacity to develop and monitor development policies is currently weak, but is a necessary prerequisite for improved performance of the agricultural sector. This project addresses these issues and should make a significant contribution in improving the overall performance of the sector through improved planning techniques. Accelerated agricultural development and growth will have important and significant implications on the quality of life for a large portion of the Tongan population, and on the economy as a whole.

The major focus for the Government effort to develop the agriculture sector should be largely export-based. This is aimed at increasing the incomes of local producers. The Government is turning traditional constraints into development opportunities. Examples include the small size of the domestic market, limited resources and relative isolation all being used to advantage by diversifying production towards new crops for specialised niche markets overseas. It is placing a high priority on quality management and the production of commodities which meet the high standards required by specialised markets. The Government is also trying to increase domestic production of certain commodities, such as livestock products, to replace relatively high levels of imports.

While past development efforts have been largely fragmented and donor driven, the Government is attempting to consolidate and coordinate efforts by developing a program approach to sectoral development. Experience from past performances discussed above have resulted in a noticeable shift in the main thrust of agricultural policy and development innovations from direct interventions to less direct measures affecting the incentives of the smallholder farm-households in Tonga. This change in emphasis includes moving from such instruments as input subsidies and price controls to measures such as support for improved technologies, and better infrastructure and supporting institutions. Currently the majority of the developments involve training, research, extension, market, credits, markets, roads, and wharves. Grants have given way to low-interest or interest-free loans, and donors frequently make their contribution in the form of goods and technical assistance, rather than monetary grants, which had, in the past so strained Tonga's administration.

The need to diversify agricultural production is a major concern to the agricultural sector. Judging from recent development plans, the main motives for the diversification are: (a) to lessen dependence on a single crop; (b) to switch from a crop with weak market prospects to one for which the demand is likely to increase; (c) to encourage the production of crops that have an assured local market; (d) to favour labour intensive crops; and (e) to encourage crops that can be processed by local industries. The current reliance on a homogenous export crop like squash is a high risk to the economy.

The economy urgently needs enlarged foreign exchange earnings from the export of agricultural products. This study revealed that the smallholder agricultural sector in Tonga has unrealised potential to contribute to economic growth. However, efforts to enhance the commercialisation of the smallholder farmers requires effective policies and institutional support in terms of better market access and more efficient marketing services; adequate credit facilities (criteria, and loan repayment), and agricultural extension services. The cash income of farm households needs to be increased to stimulate commercial production, but the restriction of factors such as limited market opportunities, inadequate market access, fluctuating farm output and input prices, and even market failures all need to be counted. As it will be difficult to enlarge the domestic market rapidly, increasing the export of agricultural products will be an important strategy.

The increased commercialisation and introduction of new crops such as squash, requires modern agricultural inputs (fertiliser and chemicals) and thus a considerable increase in expenditure per unit of land. As a result, access to credit plays a major role in the diversification and commercialisation process, allowing smallholder farmers to assume the greater risks associated with commercial crop production. The Tonga Development Bank has an important role in the provision of agricultural credit at reasonable cost for farmers' recurrent seasonal inputs such as fertilisers, pesticides and labour requirements. Suggestions from farmers for improvements include credit must be available

at the time when the inputs are purchased and must be extended until the crop is marketed. Some respondents raised the Bank using land as collateral for credit as unfair especially to landless people who rely on borrowed land for their livelihood.

Tongan farmers have shown a remarkable capacity to adopt and expand the production of new crops, and the private sector marketing system has shown a remarkable ability to move the new products into export. This has been reflected in the success of squash, vanilla, and kava. Many farmers were able to increase their cash income quite significantly by growing vanilla, kava, squash and other export crops, thus overcoming the constraints due to the relatively small size of the domestic market for food crops. Squash, an annual crop, is highly labour intensive, but it is short term, quick to mature and with an assured market and financial support from the government (credit facilities through TDB), and technical support from MAF, it generated a significant source of cash income. Squash has been quickly adopted with minimal government extension effort. Kava and vanilla are perennial long-term cash crops, which blend well with the existing mixed cropping system, and, like squash, have an assured market. The rapid acceptance of these crops in Tongatapu and Vava'u is a clear indication of smallholder's response to economic incentives. 'Akolo (1997) noted that Tongan farmers are hard working, productive and ready to embark on new agricultural ventures, but there is a need to find the right crops to grow, with the best yield, and a ready market. The Government (Tongatrade and MAF) should therefore spend more time finding new crops, their markets and possible distribution channels for the growers.

The second part of the analysis will examine the household's goals and objectives, and how they are related to the national objectives and policies discussed above.

CHAPTER 6

ANALYSIS OF SMALLHOLDERS' GOALS AND OBJECTIVES

6.1 Introduction

This chapter contains a review of the goals and production motives of smallholder farmers, particularly those in Tonga. The main aim of this analysis is to identify and evaluate the goals and objectives of village smallholder farm households, and to derive an objective function suitable for incorporation in the Tongan smallholder goal-programming model.

As identified in Chapter 2, for agricultural development planning to be successful, policy support and development innovations must be based on a detailed understanding of the social and economic realities of farm households. It is important to understand the goals, preferences and values, and the many demands farmers have on their available time and resources. Capillon (1986) argued that farmer's practices reflect their particular goals and constraints and thus the poor application of advice is not due simply to the technical failings of the farmers but as a result of failing to incorporate their goals and intentions. Papy (1994) pointed out one must look at the underlying decision-making processes which act as a driving force for practices. Understanding the whys and wherefores of these practices is a necessary step towards designing new innovations (Gibbon, 1994).

The process of decision-making for land use is exceedingly complex. The decisions depend partly on the farmers' objectives or goals as well as their decision making process. Gasson (1973) defined goals as ends or states that an individual desires. These include economic, lifestyle status, social and other components. Most researchers who study farm management in peasant agriculture recognise the limited resources and smallholder farmers' multiplicity of goals, and appreciate they should be considered when evaluating the relevance of agricultural innovations (Flinn *et al.*, 1980; Patrick and Blake, 1980; Lee *et al.*, 1994). McGregor *et al.*, (1996) highlighted the importance of studying farmer behaviour in order to obtain credible information about the decision making process. These authors studied the performance of Scottish farmers and concluded that they do have multiple objectives, ranking environmental and social concerns ahead of the traditionally accepted objectives of profit maximisation and risk minimisation.

It is important to understand the framework within which farm-household goals are set and the methods by which they are achieved. The overall objective of a Tongan smallholder farmer, as far as the operation of the family farm is concerned, should be to make what he or she regards as efficient sustainable use of the resources available (land, labour, and capital) to achieve their goals. The principles of enterprise choice deal largely with the internal problem of allocation of these resources to those enterprises and activities that will satisfy their goals. The present study focuses on the ***farm-level production objectives***, which in turn influence higher level goals such as improving living standards and the wellbeing of the family.

6.2 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 which the farmer needs to exercise his judgement about the importance of individual goals. In goal programming decision making, the ranking of the various goals is necessary and the criterion for goal ranking is based on the deemed "importance" of the objectives. Data collected in the present study allowed the objectives and priorities of the sample of village households 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 in the study.

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. As discussed in Chapter 4, 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*). Detailed data on the different farm type's goal ranking, and information on the previous cropping year's farm operation were collected from a sub-sample of 16 farmers drawn from the main sample.

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 6.1.

Table 6.1: Importance weighting of objectives by each farm category.

	FARM TYPES	Subsistence	Emergent	Progressive	
Goals		*Weight*	*Weight*	*Weight*	*LSD (5%)*
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*
LSD (5%)		*0.47*	*0.62*	*0.48*	

Importance Scale: 0 = Not important at all; 10 = Extremely important.
Sample data (n = 108) ; LSD values $p < 0.005$)

Source: Field survey, 1998

The weight 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.

The data in Table 6.1 shows that all farm types surveyed ranked the family subsistence food security as the most important objective and their mean weightings were not significantly different. "*The major objective of my farming is firstly to feed my family. I have no income generating opportunity but from my land*" was a common statement. The basic objective, which almost universally applies, is the desire to fulfil biological needs. In more traditional settings this is achieved through producing enough food to feed the family (*food self-sufficiency*). This is also confirmed by the household expenditure, as the majority (90 percent) of households do not purchase staple food. However, 9 percent of the households have profit maximisation as their main objective. As the farm-households become more commercialised the food subsistence objective is likely to be replaced by one relating to producing sufficient products that can either be consumed by the family and/or can be sold and the revenue used for purchasing food for the family (*food security*).

Social objectives include fulfilment of church obligations and social contributions, which imply the need to belong and be accepted. A majority of smallholders (91 percent) identified the fulfilment of obligations to church as their second priority. These obligations take the form of annual commitments both in cash and in food for feasts. However, progressive farmers give profit maximisation a higher priority than either church or social obligations. One progressive farmer put it: "*Cash is top priority because with more cash then I will be able to put more into church donations and obligations to my family and community*". It is inevitable, therefore, that for most households a significant proportion of the cash generated goes back into catering for these obligations.

The means show that food for home consumption is very important in all three farm types and seems to follow the same ranking as in Table 6.1. The main difference relates to the profit maximisation objective, which progressive farmers regard as more important than other objectives. Subsistence oriented farmers rarely aim to maximise production, rather the goal is to maximise the chance of survival. Social contributions to the church rank highly in subsistence and emergent households, which indicates social objectives are apparently more important than economic objectives of maximising profits. For progressive farmers, who represent about 9 percent of households surveyed, social objectives are not as important as economic objectives.

This result confirms that the majority of village smallholders in Tonga are semi-subsistence farmers, and their objectives and priorities are different from farmers in more developed countries. The latter produce for sale and profit, and if there is no profit they go out of business. In Tonga, there are no social welfare or unemployment benefits available. Therefore farm households have to rely on agriculture and off-farm employment for living. It is evident from this study that, for village smallholders in Tonga, continuous production of food for daily livelihood is essential, even when it is commercially unprofitable and uneconomic. As some smallholder farmers put it: *"If we stop producing, our family will starve; therefore we have to plant food crops every year".*

This also has major implications for production methods and strategies. Some smallholders (especially subsistence farmers) are not able to take risks with new export crops, like squash and coffee for instance. They tend to rely more on traditional food and root crops, and on technologies or production methods that have developed over the past based on the accumulated experience of their forefathers. Some of these methods often result in lower but stable yields, but the methods are ecologically sound and safe. For example, fewer than 10 percent of the farmers interviewed used agrochemicals and fertilisers in root crop productions. The implication of this needs exploring with a possible progressive entry into the expanding niche market for organically grown products which command premium prices (such as vanilla and vegetables).

6.3 Achievement of Goals

Smallholders were asked how successful they were in achieving their goals in their present operation. Farmers were also asked to rate their level of satisfaction with the achievement of each objective on a "very dissatisfied" (0) and "very satisfied" (10) scale. Table 6.2 provides the goal achievement status among the three main farm categories.

Table 6.2: Goal achievement satisfaction levels for each farm category.

Farm Types	Subsistence	Emergent	Progressive	
Goals	***Mean***	***Mean***	***Mean***	***LSD (5%)***
Home sustenance	6.90	8.50	9.1	*0.71*
Risk minimisation	5.80	5.00	5.40	*0.75*
Religious Obligation	4.70	6.40	6.20	*0.97*
Social obligations	3.40	4.70	5.40	*0.73*
Leisure time	6.70	4.60	2.40	*0.73*
Profit maximisation	1.30	3.00	8.60	*0.67*

Satisfaction scale: 0 = Very dissatisfied; 10 = Very satisfied

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

Source: Field survey, 1998

A majority (about 95 percent) were satisfied to varying degrees with the level of achievement in meeting their subsistence requirements. Subsistence farmers expressed satisfaction only with regard to the home consumption goal but were dissatisfied with achievement of other goals. Emergent and progressive farmers were satisfied with their achievements of religious and social goals. With respect to the cash generation and profit maximisation, only progressive farmers were satisfied with their goal achievement. It is inevitable that only a small percentage of the population can be considered progressive farmers. From general observation there are some farmers who have good access to land resources and labour but who fail to utilise them efficiently to fulfil their goals and aspirations as they lack the motivation. As Sevele (1973) points out, the desires of the

Tongan for an improved level of living are not sufficiently strong to elicit the required effort given the existing incentive structure.

The failure to achieve higher goals and aspirations should also be considered in relation to the values and the way of life of smallholder farmer which, it is often argued, hamper development efforts. It was evident that there is little spending on purchasing agricultural equipment and home repairs and maintenance compared to the large spending on church and social occasions such as funerals and weddings. With regard to the latter, Tongans are still prone to expenditure on a scale that is lavish in relation to income. This tends to be more common with older farmers.

There is also the question of prestige and status. As one key informant stated, in the Tongan context "*Wealth of a man is identified not by what he owns but by his contributions for the church, and social obligations*". Thus, large donations to the church and/or contribution to some public or community fundraising are often made at the expense of greater material well being, due largely to the prestige and status contributions bring to the donor. This is discussed at greater depth in Chapter 9.

6.4 Major Constraints to Achieving Objectives

Farmers were asked to indicate the major constraints and agricultural problems they faced. These are considered to influence their attitude, behaviour and overall production decisions. The nature of their problems varies with location, physical environment, farm size and structure. Nevertheless, the basic concern of the farmers was that their land was not realising its full potential. One of the most interesting issues that emerged from the discussions was that all the farmers associated increased productivity with cash cropping. The majority stated that achieving sustained food production for family consumption was not a constraint, and catering for social and religious obligations is to some extent satisfied (Table 6.2). But the main constraint lay in achieving a surplus for cash generation. Therefore, the problems discussed mainly referred to cash production. The major problems and constraints to improve smallholder agricultural production revealed in the survey are discussed below.

6.4.1 Inadequate marketing opportunities

Farmer respondents and key informants (exporters, traders, shippers, bankers, etc.) identified inadequate marketing and marketing opportunities as the most serious and critical constraint. Poor market access was seen as the most serious impediment. A majority of the household surveyed expressed that they have enough land and sufficient labour to produce a surplus, "*There is no incentive for us to produce, prices are too low. What's the use of having high yields of yams and taro, but all left unsold and rotting at the market*". Some of the farmers from the six surveyed

villages succinctly summarised the issues by saying that *"No matter what improvements in farming we make, they are always nullified by marketing problems"*. They indicated that they could easily double their output with the existing resources if there was a market for it. Most respondents stressed the need for a market information system that allowed them to make informed choices about the allocation of land, and the production of family food, crafts, medicines, firewood, etc, as well as the use of capital and labour.

Among the factors that hinder accelerated agricultural production in the Vava'u and Ha'apai regions are the small-size and over-supplied nature of their local market. Some Vava'u and Ha'apai farmers and traders shipped their market-directed surpluses to and/or through Tongatapu Island particularly to the Talamahu Market and overseas markets. Marketing costs are high (transport, handling, transaction costs, etc) and there is strong competition offered by Tongatapu farmers and traders giving them lower profit margins. They need, however, to continue with such outshipment arrangements because better local marketing options are not available. There is a consensus that Talamahu Market, however, like the local market, has reached its peak except during lean production periods resulting from seasonal shortages.

Some farmers suggested that the Government needs to improve the economic environment in which they operate through better incentives to produce more. In general, this could occur by reducing the risk to farmers through better price policies and higher efficiency, particularly in marketing. This would require not only a higher price *per se* paid to farmers but also a higher farm price as a percentage of the market price. In other words, the farmers should receive a larger proportion of the price paid by final consumers. This was the main problem for people who were once engaged in squash production and have switched back to root crop production. One squash grower noted "*Squash exporting companies are getting the lion's share of what we get for our produce and that is not fair*". The inconsistency in farm-gate prices and the lower percentage paid out to farmers by exporters was discouraging. Many of the farmers from the two villages in Ha'apai, for example, referred to the coffee development project that was initiated by the Ministry of Agriculture in it's recent development programs for Ha'apai. Many farmers registered and committed to the project but later withdraw due to low prices and a limited market opportunity for their crops. Squash growers in Tongatapu and Vava'u raised similar concerns regarding the instability of market export prices for their squash.

If new policies and strategies are to be successful, their introduction will have to be accompanied by conducive pricing policies. Policies within the agricultural sector, such as trade duties and subsidies, can mitigate the implicit taxation caused by general economic policies. Sectorial trade taxes and subsidies in various developing countries are measured as the difference between farm-gate prices and border prices at official exchange rates, after adjustments for internal transport and marketing

margins (Ellis, 1988). In Tonga, squash and vanilla exporters received more than half of the border prices.

There were, however, many cases in which the obstacles were, in fact, more apparent than real. A considerable number of farmers, for instance, could, with a little more effort, have easily improved their current output of cash crops. In the two villages in Vava'u, for example, marketing of kava for both domestic and export use is not a constraint. The study revealed that some households with similar existing resources in terms of land and labour had different outputs; some are still marginal farmers, while others are average or even progressive farmers. Strong evidence suggests that, although inadequate marketing opportunities constituted a very important constraint to increased productivity, factors such as lack of motivation and inability or reluctance to do sustained work were also determining the level of household production.

6.4.2 Limited access to credit/capital

Some of the respondents regarded the inadequate access to credit as a major constraint. They found difficulties in complying with alleged stringent Tonga Development Bank (TDB) loan terms and conditions. One grower described the situation as "*I have borrowed T$1000 from TDB for land preparation and purchase of planting materials for yam plot. Yam take a year to mature and harvest, but the bank wants repayments straight away. I would appreciate it if they would let me defer the repayments until my yams are ready to harvest and sell*". The TDB, on the other hand, raised the problems of people misusing loan proceeds for unproductive or consumption purpose; "*They come and make a loan for crop development but end up paying for their church donation*".

6.4.3 Ineffective MAF research and extension services

The Research and Extension Division of MAF is responsible for providing technology development and technical advice to farmers. Advisory activities are carried out on a district basis by district extension officers. To make the best use of resources, the extension service also provides back-up support and assistance to the extension component of livestock and forestry development. Reports from district extension officers indicate that progressive farmers increasingly play an important role in disseminating improved agricultural technology to the community. Their farms are commonly used as venues for field days for average and marginal farmers. Progressive farmers increasingly share their knowledge and experience with other farmers in all categories in discussion groups. They also commonly provide improved planting material to other growers at little or no cost. Common issues and constraints to extension work reported by the district extension officers include lack of confidence, lack of qualification or experience to advise farmers; limited resources such as vehicles, fuel for transport; and poor extension information materials and services.

Some of the respondents were concerned about the inappropriate technology package for cash crops (eg. squash, pineapple, vanilla, kava, etc.). There is a lack of confidence in some of the technologies that MAF recommend. The discrepancy in yields from experimental farm trials by MAF and what the farmers obtained is quite significant. For example, there was a 30 percent difference in yield for coffee in Ha'apai compared to that in the Research Station. This may account for the low response rate to coffee planting in Ha'apai ('Anitoni, pers comm. 1998).

In response to the question on what is their most important source of technical information, Table 6.4 illustrates the variation amongst the three categories. A most important source of production information is experience, both that of the grower himself and that of the peers with whom he is in most frequent and trusted communication (*father, progressive farmers, friends*). Subsistence farmers often rely on their own experience and of other growers and do not seek advice from MAF extension workers and other sources. District agricultural extension officers constitute a major source of agricultural advice and information to emergent farmers and progressive farmers who have commercial interests. Marketing companies, especially squash exporters, also offer advice and technical information to growers. Thirty percent of smallholder farmers in this study seem to mistrust technical information given by extension officers, especially on traditional root crops. In explanation they frequently cite the lessons of their years of farming experience: "*Those extension officers are teaching book stuff or from what they learn from school. I've been spending my entire life growing yam, kava and taro and I have learnt a lot. What else do I need to learn? I don't need advice from anybody*".

Table 6.3: Main source of technical information for each farm category (column percentages).

Source	Subsistence	Emergent	Progressive
Own experience	45	40	60
Experience of other growers	40	30	5
MAF extension	15	20	25
Marketing companies	0	10	10

Source: Field survey, 1998

6.4.4 Socio-cultural values and beliefs as constraints

The significance of social cultural and religious values on Tongan smallholders' household production decisions is discussed at greater depth in Chapter 8. The evidence gathered in the course of the fieldwork indicates that fulfilling traditional obligations is among the higher ranked goals of smallholder farmers, although they do have conflicting effects on other goals. A majority of respondents regard the demands for social and religious obligations as priority objectives rather than constraints. Less than 10 percent of the respondents perceived them as a constraint and impediment to increased productivity. This seems surprisingly low in view of the often-expressed

opinion that excessive contributions of labour, cash, and goods to religious and socio-cultural organisations divert resources away from farming and thus are a deterrent to increased output. Maude (1965), for example, has noted that the majority of those interviewed considered the burden of obligations to be the major factor retarding their progress.

However, many observations made, and discussions held, in the course of the fieldwork suggested that traditional obligations to church and society can, and do serve, as they did in the past, as incentives to produce more than day to day household requirements. One household head put it: "*We have to produce more food and livestock than we actually need to cater for the many obligations we have. It would be shameful if we cannot meet our obligation to church, family and community. This is something that my forefathers believed in and passed on to me, and now I keep telling my children*".

Religious beliefs and values do affect decisions on production enterprises. For example, respondents who belong to the Seventh Day Adventist church said, "*Our church does not allow us to grow kava and raise pigs, which are the most cash generating enterprises in the Tongan farming system. We accept that and focus on other crops and livestock*".

6.4.5 Absence, or inadequacy of infrastructures

The poor state of agricultural roads was identified as a major constraint to further development of agriculture, especially in the Vava'u region. Most of the village agricultural activities in Tefisi take place on steep sloping areas and access to agricultural land is mainly on clay surface roads or poorly sealed roads, which are impassible in wet weather. Some squash growers reported that they were unable to transport their produce to market in one season as no vehicle was able to get through.

Some respondents raised the issue of inadequate mechanical services, or insufficient machinery and appropriate implements, which leads to inadequate land preparation. This problem was highly significant in the Ha'apai region with only two working tractors, operated by the MAF machinery pool. The effects of the unavailability of such services in Ha'ano village was described by some villagers; "*We have no choice but rely on manual labour for cultivation of our land. That's why we have smaller crop size, that is what we could afford*".

The absence of boundary fences in villages to avoid damage to crops by livestock was also a concern to some households, especially to those with tax allotments close to the village boundary. The problems with free ranging pigs posed a threat to farming activities: "*If you want to grow any crops you need to fence the plot to keep the pigs out, and we could not afford to purchase fencing materials*". The only option left for them is to grow the crops not affected by pigs like fruit trees such as breadfruit, coconut, mangoes, mulberry and pandanus.

6.5 Farm Household Decision Making

A key issue addressed during this study was to understand the decision-making strategy of farm households. Such information is invaluable for policy makers in ensuring that any changes required will be determined by the decision makers at the farm level. Therefore extension, education and training required have to be targeted at those that are directly involved in decision making. Respondents were asked, who makes decisions on farm production and who influences them? The responses are summarised in Table 6.4.

Table 6.4: The main decision maker and decision influencers.

	Main Decision Maker	Distribution of Decision Influence				
	(Row percentage)	*(Row percentage)*				
Village	***D1***	***D2***	***D3***	***D4***	***D5***	***D6***
Feletoa	100	28	0	33	39	0
Ha'ano	100	17	22	0	56	6
Koulo	94	12	24	24	47	0
Masilamea	95	17	0	22	50	17
Navutoka	100	32	0	11	47	5
Tefisi	100	33	0	11	50	6

Key: D1 - Head of household (normally the father) D2 – Son, D3 - Wife, D4 - Farmer's group, D5 - Village or district committee, D6 - Marketing agencies

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

Source: Field survey, 1998

It was evident from the study, as shown in Table 6.4, that farm decision making is mainly the responsibility of the head of the household. This person (D1) is traditionally the father or the most senior male member; he receives the land through inheritance and he has the responsibility of ensuring that family food requirements are met. In some households, where the head of household is either too old, no longer able to do any work in the garden, or not present, the decision making is the responsibility of his son(s) or son in law (D2), as shown by the 5 percent and 6 percent recorded in Koulo and Masilamea respectively.

The study also revealed that other people influence the decision making, including members of the household (son and/or wife), the local farmers group, the village committee, or District Agricultural Committees (DAC), and Marketing agencies. There were slight variations among the different villages as described below.

6.5.1 Farmers' group

The evidence gathered in the course of this fieldwork indicates that about 40 percent of the surveyed sample were involved in informal farmers' groups or *kautaha.* Respondents involved in such groups claimed the main motivation from working as a group is the encouragement from other group members, and they are able to share labour activities within the group and help each other to ensure that their plots are weed free and well managed. In such situations, land use decisions of members are influenced by the group (D4) decisions. The group sets targets of what crops to grow and how much for each associated member to produce. The group then conducts monthly inspections to monitor the progress. For example, in the village of Tefisi, one group of 27 members was focussed on the intensification of vanilla and kava plantings. The group agreed that every member must plant no less than 200 kava and 200 vanilla plants for every month during the growing season, or a total of 1000 plants a year. After the growing season, the group followed up with a weed management inspections plus monitoring of other crops that the group agreed to grow.

6.5.2 Village committees

Decisions on the use of land are to some extent affected by village or district agricultural committee policies (discussed in greater depth in Chapter 8). In all villages, there is a food security enhancement program, which includes ensuring root crop production by every household. The district officers and village officers are responsible for conducting quarterly inspections and monitoring of the farm allotments of every household to ensure that every household has crops growing in their allotment for home consumption. The village and district agricultural committees are also responsible for organising village involvement in the national agricultural shows that are conducted every three years.

6.5.3 Other factors

Social factors, like anticipated religious and ceremonial needs, also play an important role. These are described in greater detail in Chapter 8. As noted by Delforce (1990), cropping decisions are directly linked to forthcoming religious, social and cultural events and obligations. The importance of religion and obligations to the church are significant. Most of the households make fixed contributions for their church throughout the year, and annually in the form of annual fund raising activities (*misinale)* and feastings (*fakaafe).* As one respondent described, "*We have got one church feast on Christmas day and our misinale in November. I am planning to plant yam, sweet potatoes and watermelon to harvest around December".* Most households consider these obligations in deciding what crops to grow and they time the harvest to coincide with these obligations and events. Preparations include food crops (especially yam) and livestock raising that are earmarked for these obligations or *kavenga.* Farmers generally plant crops in excess of their subsistence needs in order to contribute to wider social projects through ceremonial activities; bare subsistence is considered deplorable. Marketable surpluses of

traditional crops are sometimes a result of conscious over-production, but are more often the result of a particularly good growing season that leaves a surplus over and above subsistence and social requirements.

Some respondents stated that decisions on the use of their land are also influenced by the tenure status of land. Generally speaking, the amount of land and the form of their tenure are important determinants of the level of living that the household can attain. Equally important, of course, is the way the land is used. Among the many factors influencing the type and amount of crops planted are material concerns like access to planting materials, access to land with the appropriate soil types and available household labour. These factors are discussed in more detail in the next two Chapters.

6.6 Risk Assessment

Risks are more easily defined than measured. While the ability to define and measure risk is of assistance to policy makers, the most important aspect is being able to predict the response to different policy measures. This response is closely related to the farmer's perception of, and attitude to, the risk in question. An individual farmer's response will change over time, with experience, and with changes in the goals set. Attitudes to risk appear to vary between smallholder farmers' categories and geographical locations.

Risk arises when a farmer, embarking on any productive activity, is uncertain about what the actual outcome will be. Yield risk is particularly significant in Tonga with the unreliable climatic conditions, natural disasters, droughts, possible major pests and disease outbreaks. Also of crucial importance are the fluctuating crop prices. Risk assessments in smallholder farming is a complex undertaking as Ruthenberg (1985) described.

In this study the two major sources of risks identified by farmers to be most significant were market or price risk, and production or technical risks. Market risk included the variability of commodity prices featured in most cash crops like squash, vanilla and coffee. The price fluctuation of export squash during the last 10 years was discussed in Chapter 5.

In the course of this study, farmers were asked for their response to the risks identified and to describe the means used for avoiding or reducing their impact. The responses seem to vary with risk type.

6.6.1 Crops and enterprise diversification

The ability to diversify and intensify production was rated as an important strategy to reduce the risk by a majority of the farmers that increased the enterprise mix. "*Because the market prices is inconsistent and unpredictable, rather than putting all my eggs in one basket - I have to grow a wide range of crops instead. When one crop fails others could stand in*". The survey results indicated that every household grew a diverse range of crops (4 to 10) thus reducing risks of disease incidence and total crop failure. About 75 percent of the total adjusted cultivated area was devoted to food crops, including yam, plantain, taro, and cassava. Almost all farmers grew these crops, which reflects the high value placed on assuring the family food supply is maintained.

6.6.2 Modify planting times

Some farmers counter weather variability and price fluctuation effects on production by phased planting techniques, which involve broadening the planting times for their crops to enable them to lengthen the harvest periods. For example, one farmer in Navutoka who specialises in sweet potatoes as a major cash crop described how he is now using block plantings of sweet potatoes every two months to reduce market price risks. Rather than having a 0.8 hectares plot of sweet potatoes planted and harvested at once, he now has four (0.2 hectares) plots each planted in June, August, October and December. This would allow him to harvest from September to March. He is doing the same with cassava and that has proved to be successful. He asserted "*Even though I have lower yield per unit area, I am able to supply my family throughout the year and get better prices from the market at off-season times*".

6.6.3 Diversify production practices or technology

Some farmers avoid risk or reduce the consequences through diversification and/or modification of production practices to mitigate weather variability and drought effects. Some growers use live mulching or ground cover for kava and vanilla, rather than a weed free bare soil, to reduce moisture loss from the soil. This seems to work well with kava and vanilla, and also with squash where weeds help to provide shade to the fruit reducing sunburn effects. Some of the respondents also referred to their limited use of machine cultivation on their land in favour of direct drilling techniques. In response to this, "*There is less disturbance to soil, reducing moisture loss*".

6.6.4 Market information

Some of the respondents, especially larger or progressive farmers, indicated the importance of regularly seeking appropriate information. They are aware of price and market risks and value flows of updated market and financial information that improve their expectations of future events.

6.7 Summary

One of the most distinctive features of Tongan smallholders is the strong influence, if not dominance, of socio-cultural considerations in the process of land use or production, labour use and in the exchange of agricultural output. Economic factors are important but only partially determine farmers' choices. In contemporary farming systems it was found that economic and socio-cultural factors are mutual determinants of farming decisions in the Tongan smallholder household. The study confirmed that the majority of village smallholder farmers have multiple goals that make them more of semi-subsistence or semi-commercial producers. That is, the majority of smallholder farmers produce primarily for their home consumption and social exchange, and commercial production is very much an adjunct to subsistence production. Self-sufficiency at farm level implies a high level of diversification, since smallholders have to produce a greater proportion of their direct needs in terms of staple - root crops. The concept of food security is defined as the desire to provide enough food for home consumption. The system also provides for fulfilment of social and religious obligations. Food crops are normally grown for home consumption and social purposes with the surplus being sold. Cash crops are grown to purchase goods that cannot be produced. Thus, resources (land, labour, capital assets and savings) are combined in such a way to produce outputs, which satisfy first the farm household basic needs - home food consumption then education, church and social obligations.

Further, farming activities are still submerged in social and cultural relationships and demands, which invariably take precedence over profit maximisation. For example, the particular crops chosen may need to meet certain anticipated kinship or religious obligations, and the subsequent distribution of the product is made along societally or culturally determined lines rather than on purely economic ones. The whole economic decision making and action complex is thus affected significantly by non-economic forces - social, cultural, and religious. As our understanding of this interrelationship deepens, we will increasingly be able to avoid attributing observed differences in farming practices to individual or group irrationality. We will also be better equipped to distinguish between courses of action that reflect farmers' values and those that are situational adaptations to particular contexts of resource mobilisation.

This implies that development of agriculture in Tonga is not purely a technological or economic problem. Its success is frequently dependent on an understanding of the socio-cultural environment, knowledge of the social and cultural factors that condition farmers' responsiveness to development change and innovation, and the ability to obtain willing co-operation of the people involved. Gillmor (1986) noted the existence of two opposing schools of thought regarding the motivation, attitudes and values of traditional subsistence or peasant farmers. One, described by Schultz (1964), assumes a miniature economic man acting within the bounds of economic rationality[1] and striving to improve his economic position. According to this view, socio-cultural factors only have a marginal role; subsistence farmers live and work in a physical, economic and cultural environment that is relatively static. He asserted that traditional farmers would respond quickly, normally and efficiently to economic incentives in adopting new innovation. The second school considers that in subsistence agriculture, non-economic forces generally outweigh purely economic forces, leading to behaviour that is not within the bounds of monetary economic rationality. However, it appears reasonable to assume that both extreme points of view do not reflect the real situation in Tonga, and the individual farmers and groups fall on different points of a continuous scale.

The identification and ranking of the goals and priorities of Tongan smallholder farm households allows them to be incorporated into a mathematical model. Given the inherent difficulties of formulating farm household models, in which all the farmer's goals can be summarised as a single utility maximisation problem, a more practical approach is to treat the farmer's goal as a series of separate objectives or constraints. This approach opens up the possibility of including a variety of other goals preferred by the farm household in addition to income and social obligations. Such goals include family preferences to ensure survival in risk situations, leisure, social standing (obligations to church and society). The simplest way to handle multiple goals is to select one goal that will be maximised or minimised in the model, and to specify the remaining goals as inequality constraints. Hardaker (1975) and Delforce (1990) used an example of this in setting up a model to maximise cash income subject to minimum constraints on food production. A limitation of this approach is that the goals included in the constraint set must be rigidly enforced and where they cannot be met the problem will be infeasible. One form of alternative approach, known as goal programming, establishes a target for each goal but rather than forcing compliance seeks instead to minimise the deviations between the achievement of the goals and their target levels.

Increasing attention is being given to the fact that subsistence and emergent smallholder farmers view risk differently than progressive farmers. For example, the adoption of a new farm technology (eg. growing squash) often means a greater risk in an objective sense to small farmers than larger farmers because small farmers cannot count on obtaining the necessary inputs when needed. In

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[1] *Economic rationality : behaviour that seeks to maximise economic returns or income*

addition, marketing services (eg. transport) are frequently not as certain for small farmers. Even if the risk to large and small farmers is the same in terms of the expected probability of a crop loss, there are often other reasons why smaller farmers would be less likely to adopt a new production approach. Further, the small farmers may be more subject to group and community norms.

This study has confirmed that a majority of village smallholders do respond to new economic opportunities but within their realistic economic capacities and with their own understanding of the likely risks and outcomes. Marginal farmers tend to be more risk averse than average and progressive farmers. Long experienced with crop failures and with price fluctuations, and not yet directly affected by expanding economies, these village farmers do not think like development planners in terms of expanding horizons. Some indication of risk avoidance is indicated by the following survey findings: (a) All the households grew a diverse mixture of root crops, fruit trees and vegetables, thus reducing risks of disease incidence and total crop failure, (b) A large proportion of the cultivated land is devoted to food crops, including yam, taro, cassava and sweet potatoes (almost all farmers grew this crop indicating the high value placed on assuring the family food supply), and (c) 20 percent of farmers indicated they had tried growing squash and coffee for a few years but decided against it due to inconsistent market returns. Because even traditional activities carry some risks, the subsistence farmers tend not to put their savings into long term fixed capital investments such as machinery and land improvements. They cannot turn these investments into cash in the event of bad seasons or prices and so prefer to keep savings in liquid assets such as cattle, pigs, mats and handicrafts. These can be readily converted into cash.

The next two chapters analyse not only the resource endowment of farm households but describe how the land, labour and capital resources are being utilised to achieve household's goals and objectives described.

CHAPTER 7

ANALYSIS OF HOUSEHOLD LAND RESOURCES AND PRODUCTION

7.1 Introduction

Land is the most important productive asset in Tonga and reflects the economic conditions of smallholder farmers. The livelihood of most Tongans is intimately tied to the land as it is the basis of not merely their immediate subsistence but their cash transactions (Hardaker *et al.*, 1988). With about 80 percent of the population relying on land for an existence, consequently land distribution is fundamental to the organisation of social relations in Tonga (ADB, 1995). Tonga's tenure system has undoubtedly provided many benefits to its people, but pressures are now increasing for some adjustment to meet the needs of changing social and economic circumstances (ADB, 1995). The land tenure system increasingly impacts on the extent of farming as well as on how farming is carried out. Access to land is crucial to the economic situation, power, prestige and security of any individual or family. The amount of land to which a household has access and the terms on which it utilises that land are factors that influence, if not determine, its decisions about the strategies adopted in utilising land resources to earn a living.

In this chapter the way in which a household acquires rights to land, the nature of those rights and the obligations they imply are discussed, as well as the distribution of land ownership and the pattern of holdings in Tonga. This analysis provides an understanding of the land resource endowments of different smallholder household types in terms of access to land, and how land resources are being utilised. Particular attention is given to the farming system enterprises in terms of their cropping patterns and livestock components. This analysis will allow decision variables and resource constraints to be derived.

7.2 Access to Land

Smallholder farmers may have their own allotment as well as access to land registered to a relative or friend, or to land under a formal lease agreement. In the course of this study, farmers were requested to indicate whether they were farming exclusively their own tax allotment or whether they were farming land belonging to others. The Land Use Crop Survey (MAF, 1993) showed that in 1992 a total of 14,846 tax allotments existed, of which 5422 were farmed at the time of the survey.

The total number of tax allotments, and farmer allotments for the different island groups is presented in Table 7.1.

Table 7.1: 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 7.2 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 7.2: Land tenure status and access.

ISLAND GROUP	Tongatapu		Vava'u		Ha'apai	
VILLAGE	Navutoka	Masilamea	Tefisi	Feletoa	Koulo	Ha'ano
Number of Households	*131*	*36*	*100*	*58*	*38*	*34*
Number of HH Surveyed	*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. Farming on other people's land, through short-term informal arrangements with relatives, friends, villagers and estate-holders, is common throughout Tonga and has its basis in the customary,

although now weakened, obligations that exist between kin, friends and a chief and his people. Individuals may be given rights by landowners to use the land for a specific time and are normally known as a caretaker of tax allotments. It is clear from Table 7.2 that a majority (about 70 percent) of the villages households, with the exception of Navutoka, farm on borrowed land. It is fairly easy to borrow land for growing short-term subsistence crops, even in Tongatapu, although many villagers claimed that it has become more difficult in recent years. This is also reflected in the fact that very few people formally lease land. For example, in Ha'ano village there was no leased land but a majority of the households within the village had access, at no cost, to other people's land, especially from those who are residing overseas, or in Tongatapu or other areas. The figures also point to absentee land ownership. This is partly due to overseas migration (which is higher in the outer islands than in Tongatapu) and the dangers of losing the land title if the tax allotment is not properly maintained and/or cropped. It should be noted that the degree of absentee land ownership is lower in Tongatapu, where the economic opportunities in both the agriculture and non-agricultural sectors is higher than in the outer islands. In the outer lying islands, including Vava'u and Ha'apai, access to land is less of a problem.

A recent development in the transfer of land is the use of cash payments. The land legislation prohibits the sale of land in Tonga. However, the survey showed it is increasingly common for people who want land to make a gift (of cash) to an aristocratic landholder. He returns the favour by making a gift of land and by giving his permission for the plot of land concerned to be officially registered in the name of the direct user. This is the only guarantee of legal security. The parties involved do not view the transactions as a sale, and there is no contract. Prices vary with land quality and demand levels. In the village of Tefisi respondents reported that a 3.34 hectare allotment costs from T$5000 to T$10000. For a town allotment, or *'api kolo*, the prices vary more widely depending on place and region. The standard size of a town allotment plot is 0.16 hectare. The information from the Ministry of Land and Survey revealed that for a town allotment on Ha'apai and Vava'u the 'price' ranged from T$500 - T$2000, while in Tongatapu the range is from T$1000 in rural area to as high as T$4000 in the Nuku'alofa area.

The survey revealed that when land is borrowed for short-term use from a relative no direct payment is usually made, but in borrowing land from others it is customary to give a small part of the crop to the landholder. In Tongatapu, where the land constraint is more significant, such transactions involve paying the landowner, in cash or in kind, for a few years' use of his land. In these situations the contracts are not binding and the landowner could (and sometimes does) renege on the agreement. Some respondents indicated that obtaining land for cash cropping is more difficult. The demand for such land has increased with the growth of population and the increasing commercialisation of Tongan agriculture, especially with the growing squash industry. More people are borrowing land with higher cash rentals imposed. As one squash grower described it "*people are raising the rent for their land, from hundreds to thousands per season*". In Vava'u and

Ha'apai access to agricultural land is less of a problem and most farmers access other relatives' or friends' land without charge. There is also a significant use of land under short term gardening rights by co-operative gardening groups, known as *toutu'u*. These informal groups are often church, or farmers' group, based.

Higher prices are charged for land used for export crops that fetch consistently high returns, such as squash, kava and vanilla. In Vava'u, one informant paid T$3000 as a donation to the estate holder for the registration of a 2 hectare tax allotment to grow kava for a period of 5 years. In 1996, a squash grower paid T$2000 to register 1.5 hectares of land for one season. In Tongatapu, where most of the squash is grown, and land is most limited, squash growers are paying between T$2500 to T$4000 per hectare to lease fertile land for one season.

The insecurity of land farmed under these circumstances, or under short-term formal leases, often results in farming practices that degrade the land. This is highly significant in Tongatapu, where squash cultivation is predominant, with an increased clearance of coconut trees, and fallow periods reduced to six months. In addition, farmers with insecure land tenure normally do not invest in long-term improvements to their farms. In the two villages in Vava'u this problem was often raised, especially with respect to farming long term perennial crops like vanilla and kava. Some landowners are reluctant to offer their land for kava and vanilla plantings as they have to wait for another 5 to 10 years respectively before their land is free. Some respondents also reported that the security of land acquired from the Government, particularly those that are choice sites for public infrastructures, has proven to be dubious. The Government sometimes requires immediate removal of all crops and structures to allow public infrastructure development to go ahead.

The data in Table 7.2 also shows that land distributions in noble estate villages (Navutoka, Ha'ano and Tefisi) are more evenly distributed than in Government estate villages (Masilamea, Koulo and Feletoa). This is indicated in the lower percentages of households without tax allotments. Some key informants in these villages noted that the Government is still holding on to land which should be distributed to those with no land. In noble estate villages the noble has authority over the land distribution and in most cases can subdivide to smaller plots of 1.5 hectares instead of the 3.4 hectares plot in normal legislation. Some of the village respondents suggested that the Government should review the existing land policies and reduce the quota to allow a better distribution of land.

7.2.1 Cropping pattern

The way in which farmers use their land can be described as a sophisticated and balanced mixed cropping pattern, a type of organic farming which includes a diversity of crop species and tree crops which supply food regularly throughout the year. The 1993 land use and crop survey (MAF, 1994b) showed the major food and cash crops include the following species.

(i) Yam (Dioscorea spp.). Known in Tonga as *'ufi,* is the most valued and prestigious of the root crops. Yam is considered to be best tasting and normally reserved for presentations to the royalty, nobility, ministers and other high-ranking people in the community, and for ceremonial and religious functions and feasts. Yam is also as a valuable cash crop for the domestic and export markets. The 1993 Land Use Crop Survey showed that yam was grown by 83 per cent of households surveyed, with a total of 3454 hectares being planted.

Yam is generally given pride of place as the first crop to be planted on new cultivated areas after a fallow period. It is commonly grown as an intercrop with giant taro, plantain or American taro, kava and vanilla. Yam comes in two varieties, early and late yam. Early yam is planted from May and July and harvested in March and April. Late yam is planted from August to October and harvested around May to July. Early yams usually grow for 9 to 12 months and late yams 8 to 12 months. Yam has the important advantage among other tropical root and tuber crops of storing well after harvest for up to 3 to 6 months if kept in a well-ventilated cool store. Yam production is highly specialised and requires high capital investment. This is in terms of land preparation through tractor hire, labour and the purchase of planting materials. Input costs are high, but so are the returns, both for local and export sale to overseas Tongans and other Polynesians. Details of yam production and a gross margin analysis is presented in Appendix 4.

(ii) Giant taro (Alocasia macrorrhiza). Known locally as *kape,* it is another prestigious traditional crop found on a majority of bush allotments. Giant taro is an important subsistence crop and is also produced for the domestic and export markets. The two common varieties are *kape hina* (white) and *kape fohenga* (dark). Giant taro is commonly interplanted in yams and other crops. Kape takes approximately 12 to 14 months to mature and is harvested from August through November.

(iii) American taro (*Xanthosoma spp).* Known as *Talo Futuna,* it is one of Tonga's most important staple crops and the most frequently grown crop, and is of primary importance in the household food consumption basket. This aroid of tropical American origin was probably introduced into Tonga during the nineteenth century (Thaman, 1976). Farmers like American taro because it can be planted all the year round provided the rainfall does not drop below 1000 mm, although most planting occurs between June and September. The tubers take about one year to mature, and because they store well in the ground they can be left unharvested for up to two years without the cormels rotting. The young green leaves, *lu,* of the American and common taro plants can be eaten as a green vegetable after cooking.

(iv) Colocasia taro, or *Talo Tonga,* is an ancient introduction to Tonga and is cultivated as one of the staple foods throughout the country and has good export potential. The popularity of the crop has increased in the last 10 years due to the increasing demand for fresh corms from migrant communities overseas. A cyclone in Western Samoa in 1991, followed by the Taro blight disease in

1993, virtually destroyed Samoan production, the major supplier of colocasia taro, and provided the opportunity for Tonga to pick up the temporary reduction in supply. Colocasia taro is best planted from March to April to synchronise harvest periods with the export demand to New Zealand, which is greatest in December to January. The other planting period is between August and October, during the wet season, which provides optimum yields. Colocasia can be grown both as a monocrop and as an intercrop. Colocasia taro does not store well after harvest (2 weeks).

(v) Cassava (*Manihot esculenta).* Known as *manioke*, constitutes an important staple crop, as well as a minor export crop. In the 1993 Land Use and Crop Survey, it was found that cassava was the most widely planted staple crop with ninety percent of households growing, on average, 0.5 hectares per household. Cassava ranks low in consumer preferences, reflected in low prices for cassava in the domestic market relative to other staples. Cassava has the advantage of being able to be planted all year round and generally requires much less care and grows well on less fertile soils. Cassava is commonly grown as a monocrop, is generally the last crop in the cropping cycle following yam and subsequent taro and sweet potato. It is frequently planted twice in succession in the same plot, after which the land is left fallow. Cassava can be harvested after 8-15 months, or left unharvested for up to 2 years.

(vi) Sweet Potato is the third most important staple food crop. As a cash crop sweet potato is attractive since it has a much shorter production period than other root crops, with some varieties being ready to harvest four months after planting. In the traditional cropping cycle, sweet potato is planted second to either yam or taro. Sweet potato is used as a feast food. The leaves are frequently used as pig feed.

(vii) Buttercup squash (*Cucurbita maxima D.*) is the Tonga's most important export commercial crop grown chiefly for the Japanese market. Squash, cultivated commercially, does not fit into the mixed cropping system like kava and vanilla so it is commonly grown as a monocrop. The main export variety grown is *Delica* and the planting season is around July to August during the drier part of the year. Squash takes about three months to mature with harvest occurring in November.

(viii) Kava (*Piper methysticum*) is commonly cultivated, especially in Vava'u, mainly for local sale but also for the export market. Kava is the source of an important ceremonial and social beverage. Kava grows best after a long period of fallow and is commonly planted in January to April. Intercrops can be planted once the kava is 3 months old; common intercrops are yam, taro and bananas. Intercrops will provide food and/or cash in the period while the kava is not productive. Kava used to be harvested after 5 to 10 or more years of growth. It is now harvested as early as 3 to 4 years after planting. In recent years, the increasing high demand of kava, plus the ideal growing conditions in Vava'u, has made it become a high cash earning crop similar to vanilla. The trend for kava production is increasing, mainly due to better market returns.

(ix) Vanilla (*Vanilla planifolia*) is the second most important cash crop in Tonga. Vanilla production is concentrated in Vava'u, where soil and climate are particularly suited to the crop.

Vanilla fits well into the traditional mixed cropping system, and is commonly grown as an intercrop in the first 2 years of production with root crops, pineapples and vegetables. Intercrops will not only provide food and cash for the farm family to offset accumulating development expenditure, but also help shade the young vanilla plants and reduce the need for extra mulch and weeding. The first vanilla fruiting is in the third year of growth which is harvested in the fourth year. Well-managed vanilla plantations should produce for 12 to 15 years. The price of vanilla beans is dependent upon the world market for vanilla with a current price of T$10 per kilogram of green beans.

The importance of root crop production in Tonga, not only for home consumption but also for cash, is obvious. Table 7.3 contains details of households' current land use and the acreage devoted to the major crop types in the six villages. The average farm size was smallest in the villages of Ha'ano and Navutoka at about 0.85 hectares. Tables 7.4 and 7.5 show the crop types produced in the six village and distribution of farm size. The study showed that farmers in the six villages have largely been conservative in the farming systems and practices they adopt, as shown by their preference to stick closely to the traditional farming system of mixed food cropping. Some argued that it is still an efficient agricultural production system that is self sustaining, relying on rotations and fallows to build fertility and provide a wide resource base.

Table 7.3: Crops grown in the six villages.

ISLAND GROUP	Tongatapu		Vava'u		Ha'apai	
VILLAGE	**Navutoka**	**Masilamea**	**Tefisi**	**Feletoa**	**Koulo**	**Ha'ano**
Number of HH surveyed	*19*	*19*	*18*	*18*	*18*	*18*
Crop Area (ha) per HH	0.85	2.2	2.2	1.6	1.0	0.85
Total Land Area per HH	4.5	4.8	5.4	4.0	3.9	4.2
Percentage Cropped (%)	20	46	44	41	28	19
Crop Composition						
Mixed Crop[1] (%)	33.3	18.2	30.9	28.2	27.9	23.8
Xanthosoma (%)	19.0	18.2	14.5	12.8	15.3	14.2
Cassava (%)	23.8	32.7	7.2	10.3	34.6	23.8
Sweet potatoes (%)	14.3	18.2			7.7	
Kava (mono) (%)			30.9	38.5		
Vanilla (%)			7.3	5.1		
Pandanus (mixed)						19.0
Others (%)	9.5	12.7	9.1	5.1	15.4	19.2

Mixed Crop[1] - Yam, giant taro, colcasia taro and plantain

Source: Field survey, 1998

Amongst the three island groups the study found little variation in the range of crops grown. With the exception of vanilla and kava which is grown most exclusively in Vava'u, all the crops listed in

Table 7.3 were grown by most households. The main leading crops in area were yam, giant taro, common taro, american taro, sweet potatoes and cassava, which provide the main staple food for most households. There were some variations, however, in the area devoted to the individual crops amongst the three main farm categories. The introduction of perennial cash crops like vanilla and kava, with initiative and advice from MAF, have been successfully incorporated into mixed-food-cash-crop-intercropping.

Table 7.4: Crop types produced in the six villages.

ISLAND GROUP	Vava'u		Ha'apai		Tongatapu	
VILLAGE	Tefisi	Feletoa	Ha'ano	Koulo	Navutoka	Masilamea
No. of HH surveyed	*18*	*18*	*18*	*19*	*19*	*18*
%HH growing yam	94	100	94	84	79	100
%HH growing cassava	94	78	94	95	74	100
%HH growing xanth.taro	67	50	67	47	68	61
%HH growing colcas.taro	83	78	0	11	68	44
%HH growing vanilla	66	78	0	0	5	17
%HH growing pandanus	0	0	94	95	0	0
%HH growing kumara	11	6	6	42	63	100
%HH growing plantain	72	94	94	95	90	100
%HH growing gian taro	83	94	94	84	68	100
%HH growing kava	83	83	0	0	0	0
%HH growing mulberry	6	6	17	5	21	6
%HH growing coffee	0	0	22	5	0	0

Source: Field survey, 1998

Table 7.5: Distribution of farmers by crop area size (%).

ISLAND GROUP	Vava'u		Ha'apai		Tongatapu	
VILLAGE	Navutoka	Masilamea	Tefisi	Feletoa	Koulo	Ha'ano
Number of HH surveyed	*19*	*19*	*18*	*18*	*18*	*18*
0 – 2.0 acres	63	21	5	33	67	89
2.1 – 4.0 acres	21	32	39	33	22	11
4.1 – 8.0 acres	16	26	44	28	6	0
> 8.0	0	21	11	5	5	0

Source: Field survey, 1998

The variations in the cropping pattern and farm size among the different villages are summarised in Tables 7.4 and 7.5 respectively. The cultivation and rotation pattern of different plots seems to depend on the individual preference of farmers. Nevertheless some common practices and crop sequences were found and are shown below in order of importance:

Pattern 1: fallow ----> yam + giant taro + plantain + colcasia taro ---→ xanthosoma taro + plantain ----→ sweet potatoes ------→ cassava ----→ fallow

Pattern 2: fallow ---→ kava + yam + giant taro + plantain + colcasia taro -----→ kava + xanthosoma taro + plantain ---→ kava ----→ fallow

Pattern 3: fallow ---→ vanilla + yam + giant taro + plantain + colcasia taro ----→ vanilla + xanthosoma taro + plantain ----→ vanilla + cassava ---→ vanilla -----→ fallow

Pattern 4: fallow ---→ squash ---→ fallow -----→ squash --→ fallow

The basic principle behind rotations is that the land should be used to produce food all year round with a minimum of storage. Root crops dominate the production cycle, with plantain and banana interplanted under a coconut canopy that has been brought under cultivation. Many tuberous plants do not have a fixed harvest time, and after a minimal growing period they can be harvested over a long time span whenever they are needed. In Ha'apai and Tongatapu rotation pattern No.1 was used in about 85 percent and 70 percent of the surveyed households respectively. Figure 7.1 shows the typical rotation cycle take five to six years.

Figure 7.1: A typical mixed cropping rotation pattern in Tongatapu and Ha'apai.

MONTH	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Year 1	MX1 – Mixed Crop : Yam, Giant taro, Colcasia Taro, Plantain											
Year 2							MX2 - Xanthosoma Taro, Plantain					
Year 3							Sweet Potatoes – **Monocrop**					
Year 4	Cassava - Monocrop									Harvest → Fallow		

Source: Field survey, 1998

Fallow lands are first cleared and planted with yam, intercropped with giant taro, colcasia taro and plantain. Plantain and banana are often used as garden borders and for blocking plots. The yams and colcasia taro are harvested after 9 months to one year of planting, then replanted with *xanthosoma taro* often mixed with giant taro and plantain. Giant taros are harvested after 12 to 16 months. *Xanthosoma taro* is harvested at the end of the second year and then planted with sweet potatoes. When the sweet potatoes are harvested after six months, a fourth crop of cassava is often planted which occupies the next two years. Once cassava is harvested at the end of the fifth year the land is allowed to return to fallow for 3 years.

There are some variations and modifications to this traditional pattern. Other crops can be added into the mixed cropping pattern, the most common ones being sweet corn, vegetables, mulberry, and pandanus. Monocropping of any sort is uncommon except in the third year of cropping with kava, vanilla, sweet potatoes, cassava, paper mulberry and squash. Other tree crops and fruit trees

are also found in most allotments such as coconuts, breadfruits, mangoes, papaya, citrus and medicinal plants. In Vava'u the kava and vanilla intercropping are the dominant pattern where kava and vanilla are intercropped with yams and other crops at the first year. Figure 7.2 shows a typical kava mixed cropping with traditional root crops.

Figure 7.2: A typical kava mixed cropping rotation pattern in Vava'u.

MONTH	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Year 1	***MX1 – Mixed Crop : Kava, Yam, Giant taro, Colcasia Taro, Plantain***											
Year 2							MX2 - Kava, Xanthosoma Taro, Plantain					
Year 3											**Kava – Monocrop**	
Year 4	Kava - Monocrop											
Year 5	Kava - Monocrop						Harvest Kava -→ Fallow					

Source: Field survey, 1998

Figure 7.3 shows the seasonal calendar for a mixed root crop system based on yam. Early yam is normally planted between May and July and harvested from December up to June. Farmers noted the main reason for early planting in May was to make it possible to harvest tubers in the December-January period for the Christmas and New Year festivities. There is a lot of prestige to have freshly harvested early yams which taste better than stored yams.

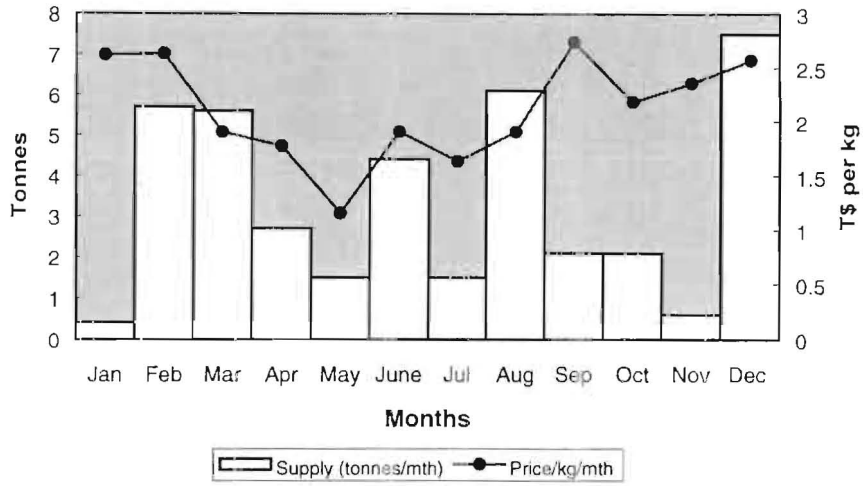
Figure 7.3: Seasonal sequence of traditional root crops in Tonga.

SEASON	**HOT/WET SEASON**		WARM AND DRY SEASON						**HOT AND WET SEASON**			
ACTIVITY												
Land Preparation	Cultivation											
Planting			Kava, G.Taro, yam, plantain plantings									
Weeding						Hand hoeing						
Harvesting										Harvesting early yam		
	Harvesting Yam, Giant taro											
MONTH	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**

Source: Field survey, 1998

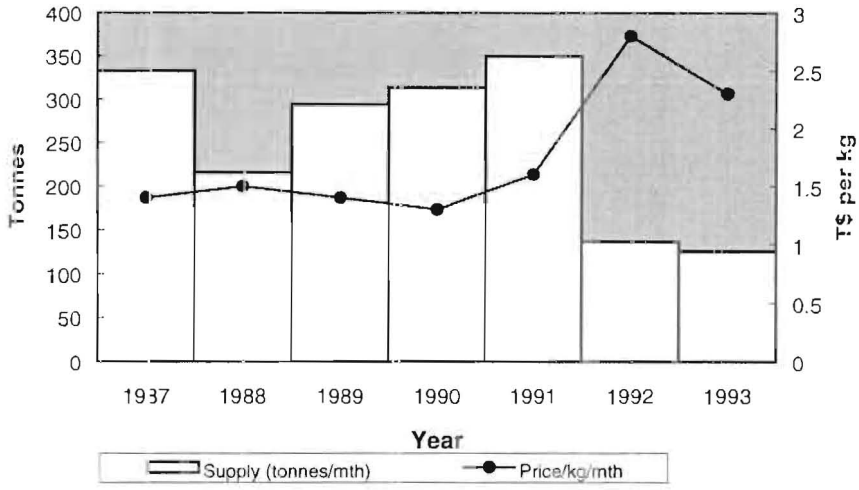
Figure 7.4 demonstrates that demand for early yam tubers is highest at the festivity time around December (more than 7000kg), and this corresponds with the high price of about T$2.30 per kilogram. Figure 7.5 shows the total yam (early and late varieties) supplied at Talamahu market over 1987-93. The severe drought in 1992 caused a significant reduction in production and the quantity sold was below 150 metric tonnes with a corresponding price of about 90 cents/kg.

Figure 7.4: **Supply and price of yam at Talamahu market in 1996.**



Source: MAF, 1997

Figure 7.5: **Annual supply and price of yam at Talamahu market (1987-93).**



Source: MAF, 1996b

The data on the cropping pattern suggests that while most farmers maintain a traditional farming base with fallows and rotations, this system is gradually changing with more emphasis and incentives to produce cash crops. Over the past eight years squash production has increased and squash is now seen as the most important cash crop. Its production has enabled more farmers to develop the production and planning skills required for producing an export crop. The associated technology has introduced farmers to agri-chemicals that could be used to short cut the traditional fallow, possibly with long term negative effects on the soil environment. Other crops with potential include watermelon, peanuts and coffee for Ha'apai. Tongatapu and Vava'u have more opportunities

for improved agricultural productivity than Ha'apai. These opportunities mainly arise out of a rainfall pattern that is more favourable for growth, less exploited and thus less abused soils, more available and accessible arable land, and a conservation-conscious farming community.

7.2.2 Agricultural technology

One of the most important aspects of land use decisions is the technology used. The type of village agriculture commonly practised in Tonga requires no special skills that could not be easily acquired by a village smallholder. The bulk of the agricultural work is performed using simple hand tools such as a spade, digging fork, axe, machete and hoe. However, the use of machine cultivation and ploughing is now common in all villages except Ha'ano, which does not have access to a plough. Among small land holders only some progressive farmers can afford to individually own a tractor with a majority of farmers relying on the service of the machinery pool operated by the Ministry of Agriculture and Forestry. This is available in the three main regions and costs T$30 per hour. The main use of the service is for ploughing and disc harrowing during the initial land preparation stage following the fallow period.

To explore the interaction of factors in the adoption of new innovations and improved technology it is important to consider farmers' perceptions of the important technological changes they have incorporated. The farmers were asked what major changes in farm practices or techniques had been made over the years. About 70 percent noted mechanisation using a tractor and machine cultivation for land preparation in place of manual land clearance and cultivation was the most important change. Although the government encourages the use of commercial fertilisers, out of the 110 sample households, only 15 percent had used commercial fertiliser on their bush allotment. In a vast majority of cases these were used in commercial cropping, especially squash, watermelon and vegetables rather than in the traditional subsistence crops. In terms of crop composition, only 15 percent reported using fertiliser. Of particular interest were farmers' reasons for not using more high cost technology, such as fertiliser. Four areas of concern emerged: the high cost of fertiliser, low potential increase in yield, lack of knowledge on use, and lack of faith or confidence in the technology.

In maintaining soil fertility, farmers have considerable empirical knowledge and understanding of the necessity for crop rotations and a sufficient fallow period. In the past they have normally fallowed land for more than 3 years. However, with an increasing demand on the limited land resource, the fallow period has reduced from between five and three years to two or even just one year in some cases.

7.2.3 Indigenous knowledge

Despite the success of modern techniques, it is important to consider the indigenous knowledge of smallholder farmers which affects some of the decisions. Thrupp (1989) noted the increasing

attention given to the indigenous knowledge and capabilities of smallholder farmers in developing countries as a potential basis for sustainable agricultural development. Rural people have a good understanding of their resources and often are adept at experimenting and adapting to changes over time. Numerous analysts have discussed the knowledge, practices, indigenous skills and beliefs of rural farming people in developing countries. These insights and adaptive skills of farmers are often derived from many years of experience and may be called cultural traditions. They often have been communicated and learned through family members over generations. Obviously, decisions to use these ideas are not based on empirical measurement or cost benefit analyses as in conventional, modern science. Farmers in many parts of the world use their knowledge of the moon cycles as a basis for farming, fishing and cultural practices. The specific activities vary in different regions, but some aspects and principles are similar cross culturally (Thrupp, 1989).

In ancient times Tongan smallholders had their own calendar around which farm activities revolved. As days looked the same, the nights were used to mark time through the phase of the moon, its time of rising, and the change of phases. The year comprised 13 months or phases and each phase was reckoned to consist of 28 days. The moon cycle within the month was divided into 3 main phases as shown in Figure 7.6. The month began when the thin crescent of the new moon was first visible at sunset. It took 12 days from moonrise to full moon and another 12 days to moon set. The moon disappeared for a period of 4-5 days before rising again.

Figure 7.6: The three main phases of the moon.

PHASE 1	PHASE 2	PHASE 3	PHASE 1
Moon rise	Full moon	Moon set	Moon rise
(Tu'u 'ae mahina)	*(Katoa 'ae mahina)*	*(Mate 'ae mahina)*	*(Tu'u 'ae mahina)*
12 days	*12 days*	*4 days*	*12 days*
Planting	*Weeding*	*Preparation.*	*Planting*

Source: Havea, pers comm. 1998; Field survey, 1998

The Tongan calendar is significant in agricultural activities and decisions that the smallholder makes in terms of timing and productivity. Figure 7.7 shows the passage of the year being generally marked by reference to the months; two main seasons and the names were based on the relative growth and development of yam cultivation.

Broadly it states that there are naturally advantageous times to plant certain crops, and to weed and prepare land. A key informant pointed out that "*the principle of achieving maximum results with minimum effort is still reflected in our lunar calendar*", which stressed that the importance of doing the right thing at the right time saved effort and time (Havea, (1998) pers. comm). The best time of the month to plant crops is determined by the phase of the moon. Crops are said to grow best if planted between moonrise (*tu'u*) and full moon (*katoa*) and weeding is best when the moon starts to

phase out (*mate*). The period of 4 to 5 days between set and moon rise, normally known as the "disappearing moon", is considered the best time for land or seedbed preparation, and preparation of planting materials. Smallholder farmers normally set out their farm work program accordingly. As some asserted: "*we never plant our root crops beyond full moon or when the moon is weak, we will be getting low yields, and we never weed before full moon when the moon is strong, as it is hard to kill weeds during this time*".

Figure 7.7: Tongan lunar months and key activities.

Season	Months	Tongan calendar	Features and activities
Hot and Wet Season	January	*Lihamui*	Rainy season start s(First Rain) Weeding for most root crops Mulching and looping for vanilla Planting of banana, plantain
	February	*Vaimu'a*	
	March	*Vaimui*	Latter rains Weeding for root crops Land preparation for next season plantings Planting peanuts
	April	*Faka'afumo'ui*	Early Spring Weed management Thinning vanilla beans Planting vegetables
Warm and Dry season	May	*Faka'afumate*	End of Spring Planting sweet potatoes Weeding
	June	*Hilinga kelekele*	Harvesting of yam Land preparation (plough and disc) Planting sweet potatoes Weeding
	July	*Hilingame'aa*	Drying of yam planting material Early yam planting Weeding
	August	*'Ao'ao*	Yam planting Vanilla harvesting Squash planting
	September	*Fufunekinanga*	Squash fertiliser and insecticide application Staking of yam Planting sweet potatoes
		'O'oamofangongo	Vanilla drying, pollination, looping Planting watermelon Late yam plantings
	October	*'Uluenga*	Vanilla pollination Vegetable planting Taro planting
	November	*Tanumanga*	Yam start growing Harvesting sweet potatoes Planting banana and plantain
	December	*Lihamu'a*	Yam tubers start to develop Harvesting watermelon Harvesting vegetables
		Lihamui	

Source: Havea, pers comm. 1998; Field survey, 1998

It was evident from this study that some rural farmers know the basic calendar and still operate accordingly, although some young farmers are discarding it with the increasing modernisation of agriculture with new crops, varieties, fertilisers, chemicals, and technologies available. There is a

lack of information from MAF research to back up the indigenous ideas. Some of the traditional farmers suggested that MAF should conduct more adaptive research on some of the traditional methods and compare them to the modern methods they wish to promote.

7.3 Significance of Domesticated Livestock

As noted in Chapter 3, livestock plays a significant role in the Tongan agriculture system. Livestock development in Tonga has been aimed at back-yard semi-commercialised operations performed by smallholders to meet family goals of self-sufficiency in food and protein production and, to a greater extent, to cater for religious and social obligations. As a cash product, livestock is sold almost exclusively for the domestic markets with an active local demand for live animals, and very little of this produce is exported to neighbouring nations. In addition, the domestic role of livestock is complex and complicated by tradition. On ceremonial occasions, such as a funeral, wedding, birthdays and church feasts, herds are often slaughtered. Very few people sell them for cash. Survey results summarised in Table 7.6 indicate that every household surveyed owned pigs, poultry and a minority of farmers own a few cattle, horses and goats.

7.3.1 Pigs

Pigs are the most prestigious livestock raised in Tonga, and are owned by more than 90 percent of the survey sample (Table 7.6). As noted, domestic pigs play an important role in social obligations, mainly for gifts and exchange at feasts, weddings and funerals. Most of the respondents described the pig raising purposes as social and religious obligations, home consumption and cash, in that order of importance. Pork is not included in the average Tongan weekly diet, being consumed primarily during special occasions.

The study found the pig population per household to be much higher in the two villages at Ha'apai than in Vava'u and Tongatapu. Table 7.7 shows the total number of pigs raised per household which comprised boars, sows, porkers and weaners. While there are 15 pigs per household in Ha'apai, there are only about 9 in Vava'u and Tongatapu. This may be a reflection of the lower amount of cropping in this region compared to the other two sub-regions. As vanilla, kava, squash and root crops provide high receipts in Vava'u and Tongatapu, raising pigs is a comparatively low priority activity. In Tongatapu, some respondents also claimed that the high cost and limited availability of pig feed is the major constraint. In contrast, the high production of cassava and the excess of coconuts in the Ha'apai region provides adequate feed to support the higher pig population.

Table 7.6: Distribution of livestock among the six different villages.

ISLAND GROUP	Vava'u		Ha'apai		Tongatapu	
VILLAGE	Feletoa	Tefisi	Ha'ano	Koulo	Masilamea	Navutoka
No. of HH surveyed	*18*	*18*	*18*	*18*	*19*	*19*
HH keeping pigs (%)	94	94	94	94	95	95
No. of pigs per HH	8	10	13	16	9	9
HH keeping chickens (%)	94	100	89	83	37	42
No. of chickens per HH	14	13	16	14	6	6
HH keeping cows (%)	28	33	0	28	11	37
No. of cows per HH	1	1	0	1	1	2
HH keeping horses (%)	61	56	50	22	0	5
No. of horses per HH	1	1	2	0	0	0
HH keeping goats (%)	6	11	39	17	0	11
No. of goats per HH	0	1	2	1	0	0

Source: Field survey, 1998

Table 7.7: Composition of household pig herds among the six different villages.

ISLAND	Village	No. Pigs	Sows	Boars	Porkers	Weaners
Vava'u	Tefisi	9.8	3.4	0.6	3.1	2.7
	Feletoa	8.3	2.6	0.4	3.1	2.4
Ha'apai	Ha'ano	13.2	3.1	0.4	4.1	5.6
	Koulo	16.3	4.0	0.4	3.3	8.6
Tongatapu	Masilamea	8.8	2.2	0.3	1.1	5.6
	Navutoka	9.3	2.5	0.2	1.8	4.6

Source: Field survey, 1998

Table 7.8 shows the three main forms of pig rearing in each village (free range, fenced or a combination of the two). The most common allows pigs to scavenge with little or no feed and other inputs provided. A majority of the households used partial fencing where the pigs are fed in the evenings and contained in a pigpen overnight. When asked about the feedstock given to pigs, most farmers generally reported 3-4 coconuts per day for adult pigs and one for piglets, and some farmers mentioned occasionally giving raw cassava in addition. Aside from coconuts and cassava, pigs are sometimes kept around houses and are occasionally fed on kitchen scraps, cassava roots, coconut and other crop residues. Most households identified the feed problem as the main reason for the free ranging system. The pigs are allowed to forage on grass and plants around the village, and are sometimes fed on coconut and cassava on a daily basis. Due to the communal system only a few need to raise boars.

Table 7.8: Pig management systems at different villages.

ISLAND GROUP	Vava'u		Ha'apai		Tongatapu	
VILLAGE	**Tefisi**	**Feletoa**	**Ha'ano**	**Koulo**	**Navutoka**	**Masilamea**
No. of HH surveyed	*18*	*18*	*18*	*19*	*19*	*18*
Management of Pigs						
Free range (%)	41	41	12	12	39	44
Free range and Fenced (%)	59	59	88	65	56	50
Fenced (%)	0	0	0	23	5	6

Source: Field survey, 1998

Livestock present a number of problems and appear to cause a great deal of damage to crops. Some farmers maintained that free-ranging pigs are a nuisance to crops. The conflict between roaming livestock and crop production seems solvable by fencing off areas in crop. This proved to be a major constraint to people with tax allotments close to the village boundary with the extra cost for fencing materials. Some farmers prefer these areas to be used for fruit trees and pandanus if fencing is not available.

7.3.2 Poultry

Villages have an abundant number of scavenging fowls, chiefly used for home consumption. Eggs are used mainly for infant nutrition. Table 7.6 shows more than 90 percent of surveyed households in the four villages in Ha'apai and Vava'u region raises chickens, while less than 50% of the households in the two villages in Tongatapu raise chickens. The average number of fowls raised per household is given in Table 7.6.

A significant proportion of the chicken population scavenges for an existence though some households provide some feed, mainly household scraps and coconuts. Usually chickens are only fed when they are hatching or brooding as they are around the house. Since all chickens are free-ranging, most of the farmers interviewed did not know their actual stock numbers. They had difficulty locating the nesting places, and reported cases of widespread losses, particularly of young chickens, to dogs and cats. The meat of free-ranging chickens is highly valued compared to commercially raised broilers. In contrast to pork and beef, its consumption is not restricted to special occasions' and social festivities.

7.3.3 Cattle

The survey showed about 20 percent of the surveyed farm households are keeping cattle. The average number of head per household in the six villages is shown in Table 7.6. Generally, these households had access to more land than average, and therefore could allot land for pasture in

addition to agricultural cultivation. Occasionally, cattle are tethered on garden fallow lands in tax allotments where they live on the natural vegetation grazing grass and weeds under coconuts. No fenced or improved pasture was found. The water supply of the animals is also far from secure. Several farmers expound the belief that cattle have no need for supplementary water since the animals have adequate access to rain water and to water-rich vegetation like banana stems. The problem is mainly the lack of transport facilities to carry water from the village to the bush.

Cattle have entered the social system as most are traded, or exchanged, and butchered for feasts. The study found that a majority kept cattle as a source of meat for very special occasions, mainly religious obligations and social feasting such as funerals, weddings and birthdays. Similarly, some households purchased cows for these obligations, and most sales are for urgent matters such as school fees and church donations (*misinale*).

7.3.4 Goats

Goats were owned by 15 percent of the total survey sample, with the average number per household being 2 to 3. The local goat breed is a mixture based on the Saanen, a breed that has a large mature size. However, due to the incidence of inbreeding, the adult is now medium to small. Goat raising was found to be more dominant in Ha'apai. Goats are shepherded in village herds or tethered in small lots on the fallow land, or sometimes free ranging or tethered within the village or its nearby surroundings. Their feed consists of natural vegetation.

Goats are not milked. As a general rule goats are not rated very highly and only members of the Seventh Day Adventist Church, who abstain from eating pig meat for religious reasons, rate goats more highly and keep small herds numbering up to seven head. Goat meat is not usually reserved for special occasions and goats are slaughtered for the less important festivals, or when there is insufficient pig meat. In addition, because of the low status ascribed to goats, use of goat's milk is avoided. Thus, the role of the goat in the Tongan agriculture is expected to remain one of little significance.

Informants complained of extensive damage to crops caused by roaming goats. This problem is complicated by the fact that tethering can lead to increased attacks by dogs and to foot rot. The inhabitants of the outer-islands suggested increasing the number of goats in uninhabited islands since goats tolerate drinking-water shortages, a situation that would also contribute to a reduction of foot rot.

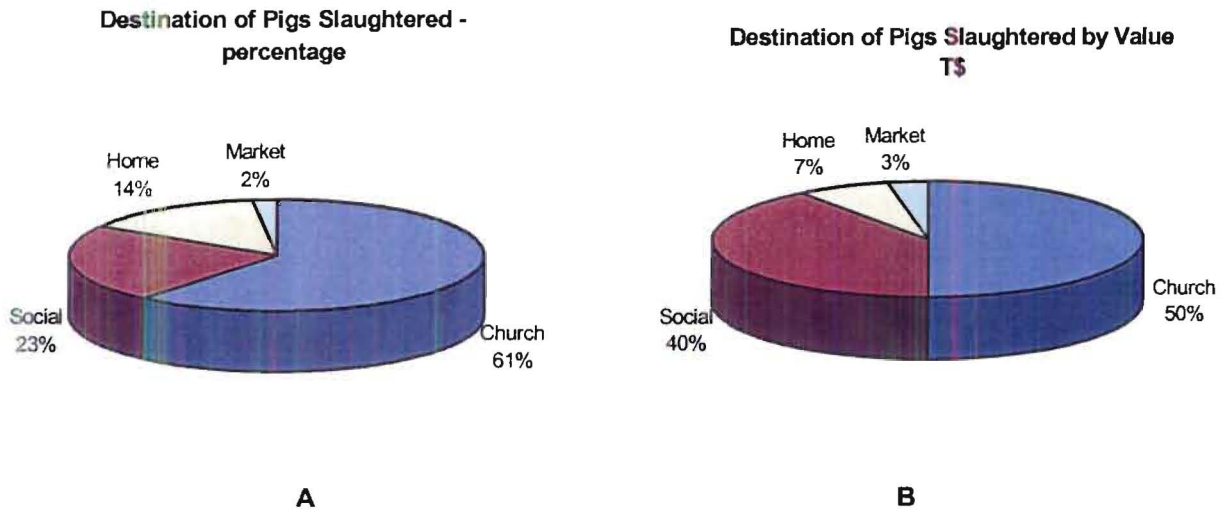
7.3.5 Horses

Horses are very common in the villages and are mainly kept for transportation and meat. Until recently, horse drawn carts were common in Tonga, though very few horse drawn carts can now be found in Ha'apai and Vava'u, possibly due to the increased importation of vehicles. This is highly significant in the two villages in Tongatapu where only about 5 percent of the households had horses. The common method of keeping horses is tethering on the fallow part of the tax allotment. The water supply for horses is not a problem since the animals are brought to the villages at least every other day.

7.3.6 Disposition of livestock

A vast majority of the households stated the main objective of raising livestock is to fulfil church and social obligations: "We keep our pigs for our *kavenga* and *fakaafe*". Survey results showed very few (less than 20%) of the surveyed households reported selling any livestock. One farmer in Koulo, who owns about 60 pigs and 13 cows, claimed he never sells his pigs for cash; they are kept for church and social obligations. At the funeral of his mother he slaughtered 7 cows and 6 choppers and 12 other small pigs, estimated at a gross value of T$15,000. This is also reflected in the fact that livestock numbers fluctuate with the frequency of festivities, declining noticeably after an important occasion such as a funeral, wedding or birthday. Pigs may also be slaughtered at less than their optimum weight in order to provide meat for a festivity. Figure 7.8 shows the use of pigs slaughtered both by numbers and by total value.

Figure 7.8: Destination of pigs slaughtered in 1997.



Source: Field survey, 1998

Table 7.9: Disposal of pigs among the six different villages.

ISLAND	Vava'u		Ha'apai		Tongatapu	
VILLAGE	**Feletoa**	**Tefisi**	**Ha'ano**	**Koulo**	**Masilamea**	**Navutoka**
No. of HH surveyed	*18*	*18*	*18*	*18*	*19*	*19*
HH with pigs (%)	94	94	94	94	95	95
Pigs for church use	93	109	97	140	114	74
Value ***(T$)***	7830	9450	8650	13330	10530	7365
Pigs for social use	58	22	51	53	20	33
Value ***(T$)***	9170	5650	6130	10500	5550	9050
Pigs for home use	5	4	38	60	15	20
Value ***(T$)***	230	210	1950	3200	920	1120
Pigs for market sale	4	0	0	1	11	6
Value ***(T$)***	500	0	0	500	1180	1180
Total no. disposed	***160***	***135***	***186***	***254***	***160***	***133***
Total Values (T$)	***17730***	***15310***	***16730***	***27530***	***18180***	***18715***

Source: Field survey, 1998

Sixty one percent of the total number, or 50 percent of the total value, are disposed for church functions, followed by 23 percent for social obligations such as birthdays, funerals and weddings. Pigs for home food consumption accounted for only 14 percent of the number disposed and 7 percent of total value, while pigs sold at the market for cash were only 2 percent of the total number and 3 percent of total value.

Survey results also revealed subtle differences between marginal, average and the progressive crop farmers. In general, livestock raising in Tonga is mainly associated with the farm operations of average and marginal crop farmers, where livestock ownership is mostly viewed as savings or insurance against times of critical need, as well as improvement in their ability to fulfil obligations. For the more wealthy and progressive crop farmers, they tend to be averse to the free-ranging system because of livestock damage on crops. The study found that they devote most of their labour, land and capital to crop production and spend little if any, effort on livestock production. They prefer cropping as a more productive use of the land than raising cattle or pigs. Some respondents raised only a small number of pigs for religious and social obligations and relied on their relatives and members of their family to provide additional pigs while in return they provide them with crops or cash, or they purchase livestock from the market.

7.3.7 Marketing livestock

Live sale is the normal method of marketing pigs and cattle, which are then used for slaughter in social and church obligations. Prices are based on the characteristics demanded by the occasion. For pigs intended for presentation in traditional ceremonies, the size of the animal may not be as important as the size of the tusks. A live back fatter, or "*puaka toho*" could sell for T$600-T$800 while a sow would sell for T$150-$250, weaners sell at an average price of T$30-T$60. For cattle, size and condition are the main determinants. A three-year-old steer in good condition could fetch T$600-T$1000 on the hoof. Market prices for a horse range from: T$350-T$600 per head and goats (T$30-45 per head).

The domestic market for livestock products is not a problem for producers. Demand for pigs and cattle is still high and good prices are obtained. Village pigs supply most of the pork consumed locally. A few commercial producers - individuals and college institutions, supply the bulk of the local beef that enters the market. The same applies to the milk supply. The local broiler and layer chicken industry is reasonably well established and supplies most of the chicken meat and eggs consumed in Tonga. High imported feed costs are the major difficulty facing commercial producers. Attempts at intensive pig raising have not been successful, with only five such units now in operation. The main constraints have been the high costs of establishment and imported feeds, lack of appropriate technical and management skills, and an inadequate market infrastructure.

Tonga relies more on imported meat product for daily home consumption needs. It is estimated that local production only accounts for about 26 percent of meat consumed in the country ('Akolo, 1997). The balance is made up of imported mutton flaps, corned beef, poultry and other types of meat. As indicated in Table 7.10, Tonga imported over T$6 million per annum of meat of various types during the 1990s.

Table 7.10: Value of meat imported to Tonga in 1990 –1996.

	YEAR						
Commodity	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
			Value in T$'000				
Poultry products	1325.4	1199.1	1261.4	1389.7	1587.3	1678.3	1950.4
Mutton flaps	2611	2547.6	2936.5	2785.4	2569.2	2736.2	2601.5
Beef	140	189.3	113.8	198.3	219.3	246.7	312.4
Corned Beef	2313.9	1995.7	2113.6	2058.3	2105.4	2068.9	2207.8
Other	427.9	157.3	94.5	287.6	402.6	389.3	464.8
Total meat	***6818.2***	***6089***	***6519.8***	***6719.3***	***6883.8***	***7119.4***	***7536.9***
% of Total food	***20.2***	***20.6***	***21.9***	***25.5***	***26.8***	***27.3***	***29.1***

Source: MAF, 1996a

Altogether livestock products account for approximately 28 percent of the total food imports between 1991-1997. Such very large amounts of meat imports provide considerable scope for import substitution through expanding all existing forms of livestock production. The development of livestock should move towards self-sufficiency in fresh and frozen livestock products.

7.4 Conclusions

In addition to the farmers' goals and priorities, household decisions concerning land use are likely to be influenced by several factors including land tenure, climate, soil types and fertility. The increase in population has made it impossible for every Tongan male to acquire his constitutional right to land from the limited land resource base. It was evident from this study that land use competition is much more intense than a decade ago as the amount of people with no land is increasing. Until the present, land development and an increase in the number of farmers has been seen as a process of bringing virgin land into production. The availability of such land is now limited. If policies aimed at increasing smallholder development are to succeed, they need to be based on intensification of land use rather than development of new areas. The emerging forms of land use competition all indicate that future land use planning and strategies for increasing smallholder production will have to be directed towards achieving higher productivity from the land already in use. The study also confirmed previous studies by Thaman (1976); Sevele (1973); Hardaker (1975); Menz (1988) and Delforce (1990) that households with only temporary access to land were often precluded from planting relatively long-term crops due to the terms under which land was borrowed.

The study showed that all villages normally adopt a farming system characterised by a broad mix of traditional food crops, cash crops, tree crops and livestock, to provide for household food requirement and to fulfil social and religious obligations and market surpluses. The outstanding socio-economic characteristic of the intercropping mixed system is its space-saving attribute. Land is a vital resource and is especially important to a smallholder farm that occupies a few hectares of land. To achieve optimum use of the resources available, intensive use of all forms of space is essential, as shown by the cropping pattern adopted. In these villages the small area of land available necessitated their planting a mix of crops (annual, perennial and trees) thereby getting as much as possible out of the land. Some farmers, however, indicated that the system strikes a balance between the shortage of land and the labour requirements. They argued that the intercropping system allows the efficient use of the farm family labour available by spreading the labour resources among a wide range of crops. Mixed cropping also allows crops to suppress weeds and also results in the reduction of risk: a most important economic objective for any smallholder farmer. The chances of all-staple subsistence food crops and major cash crops being destroyed or seriously damaged by hurricane, drought, disease and pest infestation are greatly

reduced by intensive mixing. The diversity has the potential to provide a more balanced diet, as well as a regular and adequate food supply.

Crop and livestock interactions are important in analysing any mixed farming systems. With subsistence and commercial livestock raised by almost 80 percent of the village households, livestock are an integral part of the traditional farming system. Livestock provide rural households with many important benefits such as a supply of animal protein, income flows and capital reserves, social status, weed control in fallow land, and transport. Pigs, which are fenced or free ranged in villages and fed on crop byproducts, do not compete with crops for the use of land so these are supplementary activities in the use of land. However, the interaction may be complementary or mutually beneficial. Producing livestock in small to medium scale enterprises with the aim of obtaining regular cash income has yet to be successfully adopted in Tonga. Overall, the contribution of livestock to agricultural output is small, in comparison to crop production, being mainly a way of meeting obligatory social contributions on important occasions. Livestock is expected to retain its traditional role in the agricultural system of Tonga. The potential upgrading of stock, as well as the full utilization of this agricultural component, is directly determined by Tongan farming traditions.

One of the outstanding characteristics of smallholding agriculture is the remarkable uniformity and similarity of farm units which produce the same crop in the same way year after year. Mixed farming predominates, with root crops, yam, taro, cassava, plantain and pigs being the most important enterprises. There is empirical evidence that the variation in climate and soil conditions between the three regions has influenced the cropping pattern. Some farmers said that their decision on which crops to grow is based on the soil fertility status. For instance, the farmers in Ha'apai could not grow kava and vanilla well because of their low fertility sandy loam soil. Variations are also attributed to government policies, for example, the decision to allocate quota for squash export to only two regions in 1997, with 80 percent for Tongatapu and 20 percent for Vava'u and none to Ha'apai. This also affects farm size as well as the enterprise combination.

Three major features characterise Tongan agriculture: that is, a subsistence base, social orientation and smallness in scale. Over the past century, with the addition of commercial elements, these have become mixed subsistence cash-cropping systems, but the three major features persist indicating the compatibility of these features with the situation within which they operate and their resistance to change. Thus, while cash cropping has been practised for decades by smallholder farmers, it represents largely an extension of the traditional subsistence system in which crops were produced for subsistence, social exchange and ceremonial purposes. Some external changes have been imposed upon, or incorporated into, the traditional system over the years. These have not yet succeeded in markedly altering the agricultural systems from this essentially subsistence and social reprocity system, nor have they substantially altered attitudes to and /or habits of work.

The next chapter contains an analysis of the farm household utilisation of labour and capital resources, relative to smallholder farmers' land use practices.

CHAPTER 8

ANALYSIS OF HOUSEHOLD INCOME AND LABOUR USE

8.1 Introduction

The purpose of this chapter is to provide background information on the pattern of income distribution and labour utilisation in rural households of the different villages. This analysis provides an understanding of the resource endowments of different smallholder household types in terms of the capital and labour resources available, their use and disposal. In farming systems analysis it is important to gather information on a farm household basis for cash income, its sources and disposal. Data on household consumption patterns, including food consumption and whether home grown or purchased, and other household cash expenditure, was collected. The analysis also includes the supply of agricultural labour, both family and hired. This allows further decision variables and resource constraints to be derived and incorporated in the model.

8.2 Household Cash Income

Table 8.1 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. While it is hazardous to estimate household cash income based on an interview at one point in time, the data provides an indication of villagers' income received during the last 12 months.

8.2.1 Source 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 8.1 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 8.1: 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[1] (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

8.2.1.1 Sales of Agricultural Produce

Agriculture is the key sector for generating household income. The study reveals that more than 85 percent of the sampled households generate income from the agriculture sector. This includes revenue from selling agricultural produce from the farm such as food crops, livestock, tapa products, weaving and handicraft resources and other crops such as vanilla, kava, squash and coffee that are produced for sale. Among the sources, the crop sub-sector was the major source of agricultural income contributing no less than 75 percent of total agricultural income.

In the two villages from Vava'u (*Tefisi and Feletoa*), all of the households surveyed received income from sales of agricultural produce which accounted for about 50 percent of total household income. A large proportion of the agricultural income was derived from vanilla and *kava* which are the predominant cash crops in Vava'u. Of the other income, about 25 percent came from wage employment, 15 percent from remittances, and the remaining 10 percent from business and exchange. A similar trend was found for Masilamea village in Tongatapu with 80 percent of households deriving income from agriculture which corresponded to 38 percent of the total income. The major cash crops are the root crop, yam, taro, sweet potatoes, and cassava, both for domestic use and export. The average household cash income in these three villages was significantly higher than in Navutoka (Tongatapu),and the two villages in Ha'apai (Koulo and Ha'ano).

[1] *Fisher's Least Significant Difference*

In Ha'ano village (Ha'apai), cash income is largely derived from the sale of pandanus (*kie*), root crops, plantain, mangoes, *tava* and copra. There is some planting of coffee but, due to production and marketing problems, many plantings are now neglected. *Kie* is perceived by many of the farmers in Ha'ano as an important cash crop with future potential and some farmers are increasing planting of pandanus. They regarded its advantages as being easy to plant and manage, easy to market in terms of transportation, non-perishable and high value returns. Most of it is being marketed in Tongatapu while processed pandanus in the form of mats and handicrafts is exported. The development of fruit and vegetable crops has been retarded by a general lack of expertise, the lack of a support infrastructure including available inputs and local market facilities, and the ravages of pigs (which necessitates fences and covering).

8.2.1.2 Wages and Salary Earnings

Income derived from off-farm employment made up a considerable amount of the total household average income in all the six villages. A majority of the households had educated their children most of who are now working as civil servants or in other employment opportunities that provide cash for the household. Between 20 and 50 percent of the village households received a permanent wage or salary either from the head of the household or from other members within the household. Paid employment, as a contributor to total average income, provided 15 to 22 percent, except in Navutoka village, which was significantly less with 10 percent. This implies households diversify human labour use into paid employment opportunities. In Feletoa and Koulo, group agricultural labourers are prominent, earning an hourly rate of T$2.50 to T$3 per hour. All other wage earning positions are connected to the Government. In each village, the village or town officer ('ofisa kolo) and District Officer (Pule fakavahe) received about T$30 and T$40 per fortnight respectively. Four of the villages have agricultural extension officers earning a salary rate of T$2000 to T$6000 per year. A number of primary school teachers have salary rates ranging from T$3000 to T$7000 per annum. Several church positions were paid in each village. Ministers and stewards received about T$1000 and T$250 per annum respectively. The significance of the off-farm income on potential agricultural development earnings of different farm types will be explored in the model experiments.

Table 8.2: Wage employment incomes.

Occupation	Annual Salary Range (T$)
Civil servants	2000 – 7000
Church Ministers	800 – 2000
Agricultural Labour	1000 – 2000

Source: Field survey, 1998

8.2.1.3 Gifts and Remittances

Cash remittances from overseas migrants are an important part of the Tongan economy. It has been estimated that private remittances, including those that are from both family and church sources, contribute approximately 40 percent of Tonga's foreign exchange (National Reserve

Bank, 1997). In the present study, unearned income accruing from remittances from outside the island was difficult to estimate as some are not in cash but in goods. However, at the level of village economy, the data collected indicates that remittances (from overseas and in country migrants) are the second most important source of household cash income.

More than 85 percent of the households in all the villages, except Tefisi, received cash remittances. A majority of the households have adult members of their families living and working overseas who frequently send help in the form of cash and goods. The most common sources of remittances were from the United States, New Zealand and Australia, while Tongatapu was also a source for villages in the Ha'apai and Vava'u groups. The amount of money remitted varied both within and between villages. One informant stated that he had to provide only food for the builders of his T$24,000 new house; his sons had sent all the material and the money to pay for the builders. A majority of the households (95 percent) indicated most of the household remittances were from children to parents or vice versa. The importance of private remittances reflects the strong ties within the nuclear family and, to some extent, within extended families.

It has been argued that remittances take away the motivation of locals to increase commercial production. However, the results of this study showed that in fact locals market large consignments of root crops and local produce overseas through their relatives and friends. For example in Vava'u, an increasing number of people send kava, yams and root crops directly to their relatives in New Zealand to sell. In Feletoa village, about 45 percent of households reported regularly sending kava, food crops (yam, taro) and mats direct to their relatives overseas. These findings support 'Akolo (1997) who noted the large unrecorded exports of root crops to relatives in Australia, New Zealand and the United States in return for remittances of proceeds and other cash resources as well as goods for sale at the local fairs and flea markets.

8.2.1.4 Business

The cash income from business derives primarily from small retail stores, fishing, and transportation services such as taxis, boats, and buses. As a source of household cash income, the sale of fish was most significant in Navutoka; 68 percent of the household surveyed reported receiving income from this source and the income accounted for 30 percent of the total average household income. This was followed by Koulo with 12 percent while the other villages were about 5 percent. The data indicated that the comparatively higher earnings and greater significance of this source resulted largely from the better access to market opportunities and facilities in Tongatapu than in outer islands. A majority of the households in the other five villages fish for home consumption and very little for cash. The major problem with fishing includes the lack of refrigeration facilities and inadequate markets.

8.2.1.5 Exchange of Handicrafts

Another source of household income is derived from the exchange of products (*mats, tapa, ta'ovala*) for cash, furniture, and other goods, particularly between women's groups. In absolute

values, household cash income from the exchange of mats and handicrafts was highest in Ha'apai and Vava'u and accounted for an average of 10 to 15 percent of the total income and 30 to 60 percent of the households' derived income from this source. This reflects the fact that women's groups are significantly more active in these two regions compared to Tongatapu. Exchange is mainly organised by women's groups. Some argued that Ha'apai and Vava'u have better access to raw materials, especially pandanus and mulberry. The declining performance of the Tourism industry has a major impact on the marketing of handicrafts.

8.2.2 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 8.3 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.

Table 8.3: 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

8.3 Household Cash Expenditure

Utilization of household cash income is a major element in farm household decision making and is of particular interest in smallholder farm production. With increased monetisation of the economy, decisions regarding the earning and disposal of farm outputs and cash income is an important factor. These decisions are primarily concerned with the disposal of cash income to meet consumption requirements, purchase production inputs and capital, items, service loan repayments and to meet social and church obligations. The intention was to collect information concerning these factors.

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 8.4.

Table 8.4: 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

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. In proportional terms, the

percentages of total expenditure on food differed very little between the villages. The amount of cash spent depended largely on the household's cash income, size, and on the proportion of its food needs which the household produced itself.

Figure 8.1 shows the percentage distribution of household expenditure in all the six villages. The variations in total expenditure among the three main island group was statistically significant ($P<0.005$) for the two villages in Ha'apai compared to Vava'u and Tongatapu. Food and home consumption was the most important in all villages (about 39%). The next most important was expenditure on church obligations, constituting cash donations and cash expenditure on feastings, which corresponded to 25 percent.

8.3.1 Home Consumption

The bulk of the food expenditure, according to most of the respondents, was incurred on purchases of imported foodstuff such as flour, sugar, tea, frozen meat, tinned meat and bread. Purchases in village retail shops were generally on credit and paid for when the cash was obtained. The weekly credit figures were used as the basis for estimating expenditure on food and household items. Expenditure on locally produced foodstuff (including staple food and livestock) was low, and only involved households that did very little farming at all, and occasions when the household did not produce the required crop.

Remittances in the form of imported goods and foodstuff is common. Most of the villagers revealed that, with the fall in exchange rate, their relatives overseas send foodstuff and household goods instead of cash. The purchase of locally caught fish is most common in Masilamea, and the two villages in Vava'u, while Navutoka and the two villages in Ha'apai have good access to the sea and most fish for their own consumption.

The study revealed that household expenditure on food (indicated in Table 8.4) varied from T$710 per annum in Ha'ano to T$1930 in Masilamea, Tongatapu. In proportional terms, the percentage of total expenditure on food differed very little amongst the six villages ranging from 34 percent in Koulo to 45 percent in Masilamea, with the other four villages averaging 37 percent. The amount of cash income spent on food and home consumption depended largely on the household's cash income and on the amount of its food needs which the household produced itself. The correlation between the food expenditure and total income was relatively high. For all the six villages the average correlation co-efficient[2] was 0.809, which indicates a high propensity to consume amongst village households.

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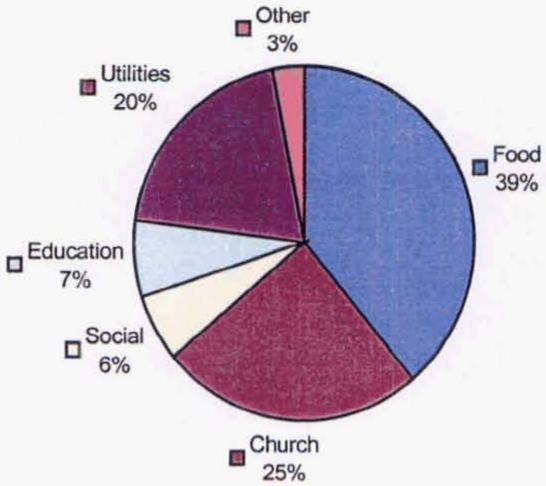
[2] *Calculated using Spearman's Rank Correlation Method*

Figure 8.1: The major household expenditure across all villages.



Source: Field survey, 1998

8.3.2 Church obligations

A considerable proportion of cash income is contributed as gifts toward the church in the form of annual donations and cash expenditure on feasts. In proportional terms, the percentage of cash income spent differs slightly between the villages. It accounted for about 32 percent of that in the two villages in Ha'apai (Ha'ano and Koulo), 24 percent of Tefisi and Feletoa in Vava'u, and about 22 percent for the two villages in Tongatapu. The correlation co-efficient between total income and church expenditure was relatively high (0.755). This indicates that as income goes up so does the church contribution.

8.3.3 Social obligations

A large proportion of social obligation expenditure was incurred on family and relatives, particularly in relation to funerals, weddings, birthdays and other ceremonial occasions. Although most of these occasions are somewhat irregular and unpredictable, when they occurred they often involved considerable expense. A respondent from Feletoa reported that his son in law's funeral in 1997 cost him about T$1200 in cash, five porkers and a cattle. About 70 percent of the cash expenditure for the funeral was contributed by relatives overseas. Village and community obligations were quite insignificant compared to family and relatives. The study showed that the average for the six villages was less than 10 percent of the total income. The correlation of total income to social expenditure was less than for the church expenditure, with a co-efficient of 0.538.

8.3.4 Education

Proportional expenditure on education ranged from 5 percent in Tefisi to as high as 11 percent in Ha'ano village (Table 8.4). The perception that a good education provides an assurance of a good job drives many parents to spend a significant proportion of their cash income to support their children's education. Table 8.4 shows that the expenditure on education ranged from $156 in Tefisi to $327 in Navutoka.

8.3.5 Utilities

This category includes expenditure on electricity, telephone, water, kava and tobacco. The village in Tongatapu and Vava'u spent more than the two villages in Ha'apai, due to the differences in availability of these services between the three different regions. In Ha'ano, for instance, they do not have access to electricity, public water, nor telephones. Tobacco is a major item and absorbs a significant proportion of household expenditure. Kava expenses are mainly incurred when adult male members of the household attend a kava party as weekend entertainment. Each person pays a concession fee of about $2 - $3 per night to attend.

8.3.6 Other

'Other' covers a number of different items including capital items, the purchase of inputs and expenditure on home maintenance. Some respondents asserted that home improvements require a larger lump of income, such as a big remittance, or sale of a large mat or large quantity of root crops, or a loan.

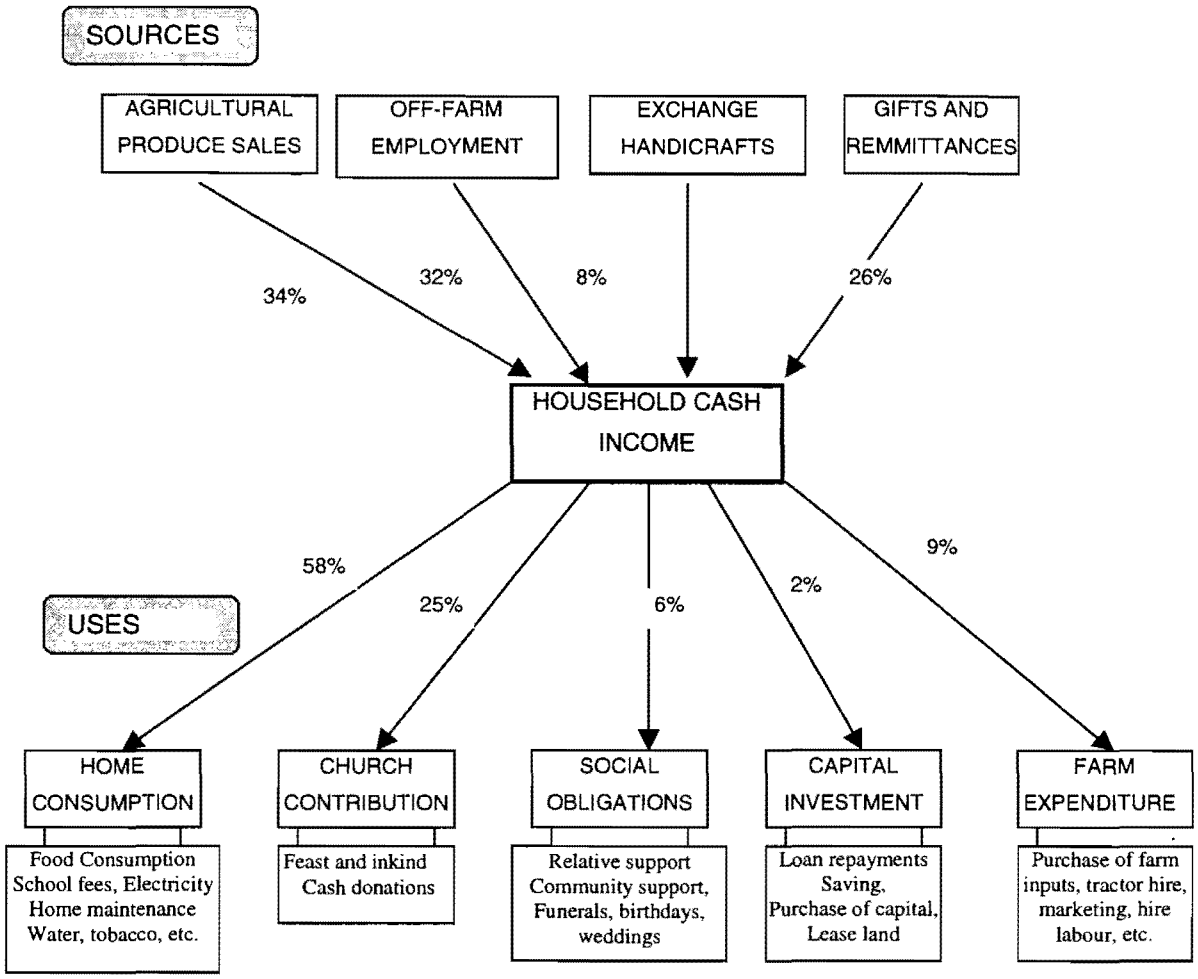
8.3.7 Cash savings

It was difficult to estimate accurately the extent of cash savings of the village households. Cash savings of the surveyed households for the period under study ranged from $16.70 in Ha'ano to $205 in Feletoa. The regional averages were $21 for Ha'apai, $45 for Tongatapu, and $180 for Vava'u. As might be expected, not all of the households had savings, in fact, the majority (70 percent) had no savings at all.

8.3.8 Cashflow

The information obtained allows a simple diagrammatic view of a village farm household cashflow. Figure 8.2 depicts the major sources of household income and expenditure in a typical Tongan village.

Figure 8.2: Cash flow in a Tongan smallholder farm.



Source: Field survey, 1998

8.4 Household Labour Utilisation

Labour is one of the most essential inputs required for crop production. Alternatively, labour is the single most important resource for generating income in smallholder farm households both from agricultural and non-farm work. In this section, the pattern of labour utilisation among different farm types and villages is analysed.

8.4.1 Occupation of household heads

Table 8.5 shows the five major occupations involving household heads. The result of the survey shows that by far the majority of household heads were engaged directly with agricultural production as their main occupation. In the two villages from Vava'u and Masilamea (Tongatapu) more than 75 percent of the heads of household have agriculture as their main occupation, while the rest are either in wage or self employment. The latter category includes such occupational groups as shopkeepers, fishing, farm labourer and self employed tradesman.

Table 8.5: Percentage distribution of household heads by occupations.

ISLAND GROUP	Village	Agriculture	Farm labour	Civil servant	Business	Fishing
Vava'u	Tefisi	78%		11%	11%	
	Feletoa	78%	6%	6%	4%	6%
Ha'apai	Ha'ano	67%		16%		17%
	Koulo	50%		28%	6%	17%
Tongatapu	Masilamea	79%		11%	5%	5%
	Navutoka	42%		5%	0%	53%

Source: Field survey, 1998

In contrast, in Navutoka only 42 percent are farmers as a primary occupation. More than 50 percent are engaged in fishing as their main occupation and 5 percent on wage earning employment. However, the villagers indicated their minor occupation is still agriculture. In Koulo village 50 percent have agriculture as their main occupation, while 28 percent are wage earners and the rest are engaged in fishing. In Ha'ano, 67 percent were agriculturists, and the remaining 34 percent were divided equally as fisherman and wage earners.

8.4.2 Agricultural labour

In most cases, single households provide all the necessary labour for agricultural work. A major factor of farm household decision making is the availability of household labour to work the land, satisfy social and church obligations, ensure leisure and earn off-farm income. Work on the smallholder family farm is the predominant activity but there has been little quantitative measurement of this activity. There are no fixed hours or days of work or fixed payments. Family members combine their farm work with domestic activities, and the distinction between the two is not clear. Nor is it clear how to treat the subsistence cost of labour: as a fixed cost on the family budget or as a function of the contribution to farm work.

In comparison with the inputs of family labour, the numbers, hours and cost of hired labour are usually easy to compute, particularly when that labour is employed to perform a specific agricultural operation or a set of agricultural operations. Hired labourers are rewarded with a specific amount of cash and kind on a piece rate basis. The seasonality of work in Tongan agriculture is not marked, with most crops able to be planted almost all year round, weeding is required regularly throughout the year, and plantation crops producing continually. However, often the busiest time of the agricultural work year is from May to December during the squash season and yam harvesting.

The division of labour by sex is well defined. It was evident from the study that men dominate subsistence activities such as farming and fishing. The field-work indicated that the women's main responsibility not only includes housework, cooking, washing and babysitting, but also an important role in agricultural production. Agricultural work is usually carried out exclusively by the

men, but women are enlisted to help in the labour intensive pollination of vanilla flowers in Vava'u, squash harvesting and grading in Tongatapu, and the harvesting, and processing of pandanus and mulberry, and the selling of farm produce at the market. More than 35 percent of the females in Vava'u and Ha'apai are involved in home industries like tapa making, mat weaving and handicrafts. The cost of female labour is about T$1.50 per hour.

Every active male household member normally contributes labour to the household's farming activities. In this survey of 110 sample households, an average of 2 males per household was primarily engaged in agriculture production. However, in terms of time spent working on the land, it was estimated at 30 hours per man per week including time spent working as members of organised communal groups. This compares with Maude's (1965) and Sevele's (1973) conclusion that the average farmer spends 20 to 30 hours per week on agricultural work.

Table 8.6 shows the main sources of farm labour amongst the selected villages. The head of households, or father, is the main source, in more than 80 percent of village households. The hours spent on the farm vary with different farm categories and household head occupation. Part time farmers and subsistence farmers spend an average of 12 to 15 hours, while emergent and progressive farmers spent 20 to 35 hours a week on farm work.

Table 8.6: Percentage of farms with farm labour from various sources.

ISLAND GROUP	Village	Father	Sons	Group	Hired
Vava'u	Tefisi	100	72	39	22
	Feletoa	100	50	33	17
Ha'apai	Ha'ano	100	22	0	11
	Koulo	100	11	33	11
Tongatapu	Navutoka	84	42	0	16
	Masilamea	89	42	0	26

Source: Field survey, 1998

The data also revealed the significant contribution of sons to farm labour, ranging from 11 percent in Koulo to as high as 72 percent in Tefisi village in Vava'u. Table 8.6 shows the sons' contribution to labour was less significant in Ha'apai compared to the other two regions. In Vava'u and Tongatapu they have good access to education facilities. Most of the children are staying in the villages with their parents and, therefore, are able to help out. In Ha'apai most of the children seek secondary education in Nuku'alofa and have to leave their families and villages. Their absence reduces the family labour available to assist in the garden. This was one of the major problems raised by households in the two villages in Ha'apai; in other words, land is not a major constraint but family labour to work on the land is the limitation. *"Our kids are going over to Tongatapu for secondary education, there is no one else to help us, rather we have to rely on whatever we can do".* The problems seem to be getting worse in Ha'ano as they do not have access to tractors or ploughs for cultivation.

The study also revealed the significance of working as a group within villages. Some respondents claimed the benefits of group working gives them more motivation in comparison to working alone. The most common shared labour working group, the *kautaha*, usually consists of 4 to 20 members, often based on a village. They normally work on the allotments of members in rotation. Group labour is predominant in Tefisi, Feletoa and Koulo as more than 30 percent of the household in each village indicated they use group labour. In Masilamea, farmer's groups do exist but they do not share labour; while in Navutoka and Ha'ano there were no farmer's groups operating during the time of the survey.

Another temporary working group, similar to a *kautaha* but mainly on a "shared land" basis, is *toutu'u ma'ala* which is usually formed for planting yams and other subsistence crops on rented land. This form is an advantage to landless people. A majority of these groups were church based members and the objectives of setting up the group related to church obligations. One group in Masilamea, for instance, set up a *toutu'u* in preparation for a church conference in May. Similarly, in a village in Ha'apai the church planned to send a container load of yams and root crops to Australia to sell for a new church hall construction. The study found that 20 percent of surveyed households participated in *toutu'u ma'ala*.

Hired labour in Tonga is mainly casual labour which can be divided into two main types – individual casual labour and group labour (*kautaha*). The most common form is through working groups or *toungaue*. However, in Ha'ano, it is mainly individuals. Progressive farmers hire labour mainly on a seasonal basis, although a few employ permanent labour all the year round. Squash growers heavily depend on farm tractors for land preparation and they hire labour mainly for planting, fertiliser application, harvesting and packing. Hired farm-labour for specific activities is normally available from *kautaha*[3] groups. The wage rate of farm-labour is T$12.00 per man-day or T$2.00 per man-hour in Ha'apai, but $2.50 - $3.00 in Vava'u and Tongatapu. Alternatively, at the discretion of the labourers, farmers may pay at the rate of T$10.00 per man-day plus meals, cigarettes and transportation. The majority of the respondents reported that access to hired labour is not a constraint.

The survey results indicated that subsistence farmers do not use hired labour. Emergent and progressive farmers occasionally use hired labour, but only for specific activities such as during land preparation and planting of yam and squash, and for vanilla pollination between May to October. Subsistence, and some emergent, farmers often use the services of a few individuals or friends for land preparation especially yam cultivation. Instead of paying cash, they prepare food, drinks and cigarettes for the labourers.

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[3] *Kautaha means a group of men who employ themselves to work collectively on each-other's farm for no pay or for cash on non-members' farms.*

8.5 Conclusions

The analysis of household components provide an understanding of important resource endowments of the different smallholder household types in Tonga in terms of access to capital and labour. The information gathered on farm households consists of data related to the source and uses of household cash income and labour resources, both of which are important components of the model. This data allows decision variables and resource constraints which directly influence farm operating plans to be derived and incorporated in the goal programming model.

An important feature of the households studied was the diversity of income sources, as almost all obtained income from more than one source during the period under consideration. The significance of agriculture, off-farm employment (ranging from earnings from full time or casual employment), remittances from overseas, gifts (cash and in kind received within Tonga), handicraft making, fishing, and other business venture has been made clear. However, the limited opportunities for wage employment in rural villages has resulted in families relying on agricultural production for food and generating income.

Household's utilisation of cash income is a major element in farm household decision making and has a major impact on smallholder production decisions. The Tongan smallholder household's expenditure pattern shows similar patterns to those found in most developing countries. Despite a low cost of living, the average household income level is far from adequate. With the increasing monetisation of the Tongan economy, decisions regarding the earning and disposal of farm outputs and cash income are very important as the quantity of surplus produced for sale determines the level of cash income generated. The amount of cash generated will also influence further agricultural investments. The family cash expenditure reflects the goals and priorities of Tongan smallholders and comprise family cash expenditure on home consumption requirements, other household demands (education, utilities, etc), social and church obligations, purchase of production inputs, and capital and land loan repayments.

The analysis of labour showed that the main source for agricultural work consists of family and community labour, and to a lesser extent, hired labour. Farm work is normally done by more than one person, such as the head of the household helped by one of his sons or a relative. An average of 2 labour units on each farm provides the family labour supply in the model. Labour requirements can be supplemented by hiring casual labour at a rate of T$3.00 per hour. Selling of surplus family labour at a rate of $2.50 is included but constrained by the limited opportunities for off-farm employment.

CHAPTER 9

ANALYSIS OF THE SOCIO-CULTURAL ENVIRONMENT

9.1 Introduction

Tradition and cultural norms influence economic behaviour in any society. In societies where the social and production units largely coincide, and production is largely for direct consumption, this becomes particularly apparent. Successful development of agriculture in Tonga requires not only technological and economic strategies but also a better understanding of the society in which it is to take place. A knowledge of the social and cultural factors that condition farmers' responsiveness to change and the ability to obtain willing co-operation of the people involved are all pre-requisite to development.

This chapter analyses the influence of village or community groups, and other organisations, on individual household decision making. The study identified several socio-cultural factors that have a significant impact on household farming decisions. These include the church, District Agricultural Committees, social organisation and leadership, social and cultural values, and systems of reciprocity and redistribution which provide basic economic security to the great majority of Tongans as well as a sense of identity and self-worth. Others include access to support services; an increasing mode of dependency among communities; high propensity to spend; a tendency of farmers to change the emphasis on commodities farmed; out-migration; the increasing role of women in agriculture, and macroeconomic issues.

9.2 Christian Church Activities

The people of Tonga have generally accepted Christianity with enthusiasm, and the Christian religion in its various forms has made a deep and permanent impact upon village smallholders. The church is an extremely important and powerful institution in Tongan society (Thaman, 1976; Hardaker, 1975; Sevele, 1973). Evans (1996) pointed out that the integration of Christianity into Tongan values and social practices is profound; "*No ceremony or public event, even if it is not directly undertaken by a church, is without some overtly religious elements and the involvement of a cleric of some types; all marriages, funerals, birthdays and civil ceremonies, involve God and church through some earthly representative*". Most village and household ceremonial activities are organised through churches and it is common in all village and government

meetings to start with a prayer. Therefore, no treatment of Tongan society can ignore the significance of the various churches at all levels of Tongan culture.

While there are more than ten different denominations in Tonga, the five main denominations are the Free Wesleyan Church of Tonga, Roman Catholic, Mormon, Free Church of Tonga, and the Church of Tonga. Each denomination has its own separate organisation, administration and leaders, and has different approaches to donations, fund raising and obligations. Table 9.1 shows the distribution of village population to the different denominations amongst the selected villages in the 1996 population census.

Table 9.1: Distribution of religious affiliation among the population.

ISLAND	Tongatapu		Vava'u		Ha'apai	
VILLAGE	Navutoka	Masilamea	Tefisi	Feletoa	Koulo	Ha'ano
Total No. of People	*798*	*267*	*624*	*383*	*258*	*162*
Free Wesleyan	34%	55%	27%	27%	52%	39%
Catholic	2%	0%	11%	14%	2%	0%
Mormon	18%	17%	17%	17%	16%	18%
Free Church Tonga	14%	5%	19%	39%	9%	17%
Church of Tonga	13%	16%	9%	1%	18%	23%
New Light	9%	3%	10%	0%	0%	0%
Bahai	1%	0%	2%	0%	0%	0%
Constitution	0%	0%	3%	0%	0%	0%
Seventh Day Adv.	9%	4%	1%	0%	4%	4%

Source: Statistics Department, 1997

The main influence of churches has been in taxing their adherents in order to finance the church operation and activities. Fleming and Hardaker (1995) notes the willingness and eagerness of Polynesians to support church activities and the construction of religious infrastructures such as large and imposing places of worship, and it may be argued that the rent seeking behaviour of the churches has been counter-developmental. Evidence from this survey showed that church activities are still a dominant feature of everyday life in Tongan villages and this reflects in the significant demands on household 's cash, farm produce and time.

9.2.1 Cash donations

The annual public gifting (*misinale*) or cash donation for the different churches creates a substantial demand for cash. The significance of obligations to church in the average household cash expenditure is discussed in Chapter 7. Cash donations to the churches accounted for 22 percent of the total household cash expenditure in Tongatapu, 30 percent of that in Ha'apai and 25 percent of that in Vava'u. Other occasions over the year, such as quarterly collections and annual church conferences add to this demand. An indication of the high value people give to church contribution can be derived from the *misinale,* or the annual donation of Free Wesleyan Church (FWC) in the six villages for 1997 as shown in Table 9.2.

The annual donations are organised by each village congregation. The Free Wesleyan Church's headquarter sets a budget forecast, or target levels, and specific dates for each. The targets are normally calculated to correspond to the number of people registered in the congregation, with an average of T$45 to T$50 per head. These donations help finance church administration and activities. A minister reported that in 1997, the 9 families of the Free Wesleyan Church in Ha'ano raised T$7,124 for their *misinale.* One third of the money went to the central administration in Nuku'alofa, one third to church education and the remaining one third returned to the local congregation for its disposal.

Certainly, peoples' willingness to contribute varied a great deal. Table 9.2 shows the targets and the actual donations for 1997. Every church donation exceeded the targets by a significant margin as showed by donations per head. Donations are commonly organised by individual households and usually in the name of the most senior person in the family. All donations are publicly made and the amounts contributed by each household within the congregation are announced (Evans, 1996). The donation by each household reflects on the individual household within the church. Greater prestige is associated with large donations.

Table 9.2: Annual donation to the Free Wesleyan Churches in the studied villages.

ISLAND	Tongatapu		Vava'u		Ha'apai	
Village	Navutoka	Masilamea	Tefisi	Feletoa	Koulo	Ha'ano
FWC adherents	271	147	168	103	134	63
Budget Forecast (T$)	13,550	7,350	8,064	4,944	6,030	2,835
Actual Donation (T$)	29,872	10,021	12,139	8,721	20,355	7,124
$ per adherent	***110***	***68***	***72***	***85***	***151***	***113***

Source: Field survey, 1998

9.2.2 Feasting

Feasts follow most important religious occasions. During the year a number of church ceremonies and events are marked with feasts, such as special Sundays for education, Easter, children's, mothers and father's Sundays. Each household also prepares feasts, or *fakaafe,* every year with an average of two per household per year. Most of the farm households supplied pigs and other animals and the food crops required, supplemented by purchased non-farm produce. These can be lavish feasts of a full range of meats and special foods, or simply teas consisting of hot and cold drinks, cookies, and sweet flour dumplings (Evans, 1996).

Most village respondents indicated that church based events are most intense during December and January. On New Years Eve each church holds a long, multi-sermon service that ends at midnight. In Feletoa village, for example, the FWC has nine members conducting the service; another nine households in the congregation each prepare a feast for each of the preachers during the day. This is followed by a prayer week, or *uikelotu,* in which services are conducted every

morning and afternoon for the whole week, followed by either a feast or a tea. During these weeks, there is little work done but worship, food preparation and feasts.

9.2.3 Contributed labour and time

Besides donations of cash and kind, the church and its members also receive gifts of unpaid labour. Members of the congregation carry out repairs and maintenance of the church in turn. They also assist in carrying out unpaid work in the minister's garden when required. The church not only benefits from labour in the strict sense of the word, but considerable time and effort are devoted to church functions. For example, one respondent, who is a steward in one of churches, asserted "*I have to attend every service, program, and meeting. It is my duty to lead and set a good example*". This includes 3 services on Sundays, three services during the week, and choir practices (twice a week).

9.2.4 Leadership role

Results of the study strongly indicated that church leaders have a major significant leadership role compared to other traditional leaders (nobles, district officers and town officers and *matapules*[4]) in the village community life. Obligations of traditional, national and religious nature are more likely to be fulfilled by the community if directives come from church ministers rather than from other leaders in other forums (Sisifa *et al.*, 1993). Some villagers described this as one of the major cultural changes that has occurred in Tonga over the years. Major reasons include the local and constant presence of church ministers. A village district officer noted that "*most of the nobles are no longer staying with their people in the villages or islands but have moved to Nuku'alofa and overseas and only visit them occasionally, while church leaders are the ones who live with the people and so take the honour and respect of villagers*". Some reported that the recent change in the land tenure system with regards to the noble's authority over land is no longer valid once a villager registers the land. So most households are free to do whatever they want with their land.

9.2.5 Motives

One of the key question puts to a number of village respondents was "*What motives drive you to devote so much of your time, material produce and cash to the church?*". Their responses can be summarised as follows. Ultimately, village people see that their offering and gifts are not to the church or the ministers but to God and are part of keeping their relationship with God intact. Ministers are perceived as messengers from God, and people have the idea that God witnesses acts of giving and notes this in their favour in the form of blessings. Many of them said "*We are fortunate that God blesses our family in many ways, we get good yields for our crops, our children are doing well at school, our family is well and healthy, etc*". The belief is thus a

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[4] A *matapule* means a spokesman of the King or a noble.

discourse of reciprocity; it is a question of giving and receiving, and gifts are given precisely in order to receive. The size of a particular household's contribution is perceived to reflect the vitality and viability of their relationship to God. A larger contribution implies more blessings, and more blessings imply a larger contribution. A majority of the respondents in this study said that they were happy and felt great satisfaction to be able to give. They also indicated that they would donate more when they have more money and produce from their farm.

9.3 Cultural Values – wealth, prestige and respect

9.3.1 Social and kinship ties

In addition to their striving to acquire adequate land in order to achieve economic security, village farmers also attach great importance to achieving social security within family units, groups and within the whole village. Thaman (1976) noted the Tongan agricultural system provides a direct and indirect means of fulfilling social obligations, both to relatives and to the society as a whole. These obligations are important in understanding the influence of social and cultural obligations on smallholder farmer's decisions on utilising land resources (Sisifa *et al.*, 1993). Generally these obligations fall into two main classes: kinship ties and social ties. These ties are significant in Tonga and farmers place a strong value on recognising their obligations and debts to their parents and to their relatives.

Kinship ties are commonly known as the *kainga* system which mainly refers to kinship relationships, including families and relatives. The larger unit, the kainga, not only includes the individual household but also those bilateral kindred who reside in other households, villages, or island groups. The size of this broader kin group, and the closeness of ties within the group, depend primarily on the individual's knowledge of his consanguine relatives and their whereabouts (Thaman, 1976). Kinship ties provide a major impetus for the redistribution of product from the agricultural system within the kin group. The most salient exchanges are those which take place during ceremonial occasions, such as births, baptisms, marriages, and funerals, where different kinsmen contribute labour, food, or make presentations of fine mats, tapa, kava, and other traditional goods of high social value. Apart from ceremonial exchanges, there is a constant flow of labour, food and commodities throughout the kin group. This mutual assistance is not only in farm produce but also reciprocal help in assisting cultivation, planting and management. Although the direction is often from lower ranking members to higher-ranking members, there is also a considerable flow in the opposite direction.

Villagers also value harmony and unity assuring security within the village and this is indicated by the significant support given to village and district agricultural committee activities. This tends to reflect on the utilisation of household farm produce, so that only a small proportion of produce is usually for sale while the largest proportion of the surpluses from home consumption is to cater for relatives and other households. It was evident from the study, especially in Ha'apai and Vava'u

and to a little extent in Tongatapu, that regardless of who plants a garden, the rights to harvest from it can extend quite widely. Sisters and their families still maintain the right to harvest from the lands of their brothers. One respondent asserted "*The land is not mine but our father's land, so my sisters and her children can help themselves. It is my duty though*". Although it was not possible to quantify the frequency with which this right is exercised, it was common for a man's sister's children to go to their uncle's garden and help themselves to what they wanted. Brothers are also generally held to have the right to harvest from each other's gardens. So people sharing food crops are still common in village communities.

Field observations revealed that the importance placed by communities on religious and traditional/cultural obligations appears to have led to an increasing mode of dependence in society. The negative effects of "social taxation" on productivity have become apparent not only among progressive farmers from whom the bulk of contributions are expected, but also among those who choose to become dependent (largely the subsistence farmers) through the reduction of an already meagre effort. Farmers who manage to significantly increase their production of crops or agricultural profits are under social pressure to supply loans and miscellaneous obligations to close relatives and friends. "*Relatives always visit me at harvest time expecting a share of yams and taro, even cash*". Several informants asserted that this practice severely reduces not only farmers' independence but also the incentive for increased production: *"They would not increase crop production because neighbours and relatives subsequently borrow all extra produce*". Although lending is a tradition, which increases the social status of the lender, resentment toward this social obligation is increasingly expressed among younger landholders, who place a higher value on cash than tradition.

9.3.2 Perception of wealth

The village people in Tonga have gradually formed their values of what is significant and desirable to them in life. Their own experience and understanding of the environment they are in has influenced their conclusion. Their values also reflect their understanding of the opportunities to develop, given their resources and technology, social institutions and beliefs. The current values held by most of the rural smallholders are influential in determining the outcomes and social rewards they can expect from their choices and achievements. Those values are thus an important element in their capacity to take on risky choices and to make the commitments required in agricultural development programs.

A smallholder's production is consistent with the demands and social reward system, and this relationship is necessary for a meaningful life. With regards to their relationship to agricultural development, it is important to examine the value positions of smallholder farmers regarding security, wealth, and prestige, at the same time as keeping in mind the differences between the three main farmer categories which relate to the specific goals and means of attaining them. Respondents in the six villages regarded wealth as desirable and one of the higher goals they hope to achieve. They have been influenced by the increasing influx of consumer and luxury goods, for

example vehicles, TVs and videos. Some villagers have made great efforts in agriculture and other off-farm employment opportunities to acquire wealth. However, although the material needs and desires of farmers are increasing, marginal farmers are still realistically modest in their expectations of their future economic opportunities.

The desire of Tongan smallholders for wealth is principally a search for security and prestige; that is, enough land to produce adequate crops for subsistence, meet church and social obligations and a surplus for cash sale. For smallholders, who have recently engaged in commercial agriculture, wealth in the form of land is the most important key to security. The family household is the unit that controls land, and the household head normally makes decisions regarding use of land. Land tenure patterns are thus a major element of security.

9.3.3 Prestige and respect

One of the major social features of Tongan society is the high value given to prestige and respect. Individual achievement is a lesser consideration. Elaborate contributions to church and social obligations through family celebrations and the associated publicity are part of a prestige-conferring pattern of conspicuous goods distribution within village society. As people in villages acquire prestige from to each other, they tend to make judgements of people's worth based on status-centred considerations more than on individual achievements. A member of a prominent family can be highly regarded whether or not he contributes greatly to the family's position (Havea, 1998 *pers.comm*). People gain respect and prestige largely on the basis of their relationships with the village as a whole and to family and relatives. For instance, a district officer in Ha'ano described that for every funeral occasion in the village and district he had to make a contribution either in the form of food, pigs, kava, and or cash. "*That's what the village people expect someone in this position to do. To have the respect of the community and the village you have to involve and commit in many ways. However, it will in return give you more power and people will listen and respond to any request you to make in future*".

9.4 Village Organisations

9.4.1 District agricultural committee (DAC)

At the village and district levels respectively there are district committees and officers who link the traditional structure to the system of public administration and have significant impact on farm households' agricultural decisions. Village communities within each district are linked to the Government through the District Officer (DO). The DO is a salaried post, elected every three years by the community, and responsible directly to the Prime Minister through quarterly reports concerning the welfare, activities and general order in the district. Traditionally, District and Town Officers carried out their functions through informal meetings. Now the formal occasion, the "*fono*" is normally held once a month and it involves the District and Town Officers of that

village, sometimes in conjunction with the Noble if one is present, giving directives from Government, or from the District Officer/ Noble, to the people.

The District and Town Officers, farmers' representatives and a MAF extension officer make up the District Agricultural Committee which has the aim of ensuring food crop security of district households (Delforce, 1990). Each village has a Village Development Committee (VDC) which comprises the Town Officer and community representatives. It plays a key role in the implementation of DAC directives and policies (in the case of food security enhancement) in each village. An important element is carrying out physical inspections to determine if goals (minimum subsistence) set by DACs have been achieved. DAC inspections occur every six months and village committees and groups inspect more frequently.

The DAC have developed into a natural focus for decision making and a forum for technology transfer at the district level. Locally expressed needs, agricultural priorities and government authority are all represented within their membership. In addition, at least for subsistence production, the goals of DACs are supported by legislation and farmers have been brought before District Court Magistrates when, without reasonable cause, they have not met DAC targets. Magistrates have supported the District Officer, and people concerned have been required to plant food gardens as specified by the DAC.

Village and district officers revealed that the DAC's operate with different degrees of effectiveness in the three regions. In contrast to their counterparts in Tongatapu, and Ha'apai island groups, Vava'u DAC's have contributed significantly not only to food-security but also to commercial agricultural activities. Through their directives on what crops to grow, and how much, through their follow-up field inspections, DAC's also encourage and foster new commercial crops such as vanilla and kava. The effectiveness of a DAC largely depends on how active district extension and district officers are and how well they are working together with the rest of village communities. DAC's have proven to be one of the most effective means for agricultural extension in Tonga used by MAF. However, much more remains to be done in the dissemination and adoption of highly productive and environment-friendly technologies at the farmer level.

9.4.2 Women's role in Agriculture

The traditional Tongan view that agriculture is not part of the role of women is still strongly held. However, there is no doubt that over time a unique role has evolved for women, who now play an important supporting role to men in agricultural development. Interviews with womens' groups revealed that they are directly involved in the planting and maintenance of pandanus and paper mulberry. As well, they increasingly involve themselves in agro-forestry development, particularly in the cultivation of "cultural" and medicinal plants and trees. Women play a significant part in the pollination, trading and curing of vanilla in Vava'u. In Tongatapu women are also highly involved in squash cultivation, harvesting and processing. Overall, women on Tongatapu and Vava'u do not play the pivotal role in household cash income that they do in Ha'apai. Nonetheless, their craftwork

is an important economic and social activity. The main handicraft production is tapa, which is made from paper mulberry.

Women have traditionally worked in-groups to produce mats and tapa, and each village has one or more such groups. Handicrafts have traditionally been produced for home use, ceremonial purposes and traditional exchange, but these products have increasingly taken on a monetary value, and become an important source of income (in both cash and kind) for some families. Handicrafts are most important to the two villages from Ha'apai. Womens' groups also organise sales, or exchange of their products, with overseas groups, or within Tonga. These are commonly known as "*katoanga*". The usual approach is to negotiate sales with other groups for cash or kind (such as furniture, linen, and kitchen equipment). For example, a womens' group in Feletoa village exchanged mats for T$1200 with a womens' group in the USA. There is generally plenty of paper mulberry and pandanus being available but there are some seasonal shortages, and shortages for some individuals. Planting material can be scarce at times and some husbands are reluctant to have *tutu* planted on their *'api* because of the conflict with other crops. The village groups encourage planting *tutu* in particular. However, most women interviewed identified a disease problem on paper mulberry, and there can also be wind damage during storms.

9.5 Major Support Services

9.5.1 Isolation from Support Services

Some farmers and key-informants reported that the Health and Education services in Ha'apai and Vava'u, although having well developed infrastructures, fall short in their maintenance and staffing (both in number and in qualifications). Most problems described by respondent farmers concerning the MAF Extension Service related mainly to inadequate contact between the extension officers and farmers, and inadequate supporting services such as tractors in Ha'ano. Interviews with District Extension Officers revealed that their activities are shackled by an acute lack of transport and operating funds. In numbers, there are adequate extension officers, but many do not possess sufficient qualifications and technical knowledge. There are also very limited activities and inadequately focused farmers' training, programmes, on-farm trials and little extension information material (posters, leaflets, video, radio broadcasts, etc.).

Major infrastructure development in sea and air transport in the Kingdom has provided the main island groups of Vava'u and Ha'apai with easy access to services available in Tongatapu. Yet the isolation of the outer-islands from support services that are available in the mainland is a major obstacle to development. They expressed their priority needs as health support, water supply, electric power, road building/maintenance, wharves, shipping, farm inputs and improved marketing. Their needs are simple because island life is, of necessity, simple. It is in the more remote outer-islands of the group like Ha'ano that problems of isolation from support services are acute.

9.5.2 Urban migration

Migration is a widespread and important phenomenon in the Tongan economy and society, both in terms of internal migration between the island groups and in migration overseas (Kingdom of Tonga, 1991). There is an increasing movement of people from the rural to the urban areas, or overseas, or from the outer islands to the main island of Vava'u, Tongatapu. This is reflected by the decreasing number of households residing in the rural villages and the increasing numbers of outer homes left unoccupied. It was found that a major reason for the increasing migration from the Vava'u, and to a greater extent from the Ha'apai subregions, was the severe inadequacy of support services in terms of education, health and income generating opportunities. The migration from both the distant villages and the outer islands to the main island is made in search of employment opportunities, better education, and a range of public services such as electricity, water supplies, and transport, none of which are generally available in outlying villages and islands. Sisifa *et al.*, (1993) note that in Vava'u the younger population, many at secondary school age, and others at middle age, are the age-groups most affected.

Migrations also have an important influence on the agricultural sector. In Ha'apai and Vava'u it was evident that about half of the village population is now living abroard. The number of people who have opted to migrate is definitely more important in the outer islands and particularly in the more remote islands like Ha'ano. This is due to the fact that there are very few employment opportunities and, in general, the limited economic opportunities in these secluded islands. At the moment land is not a scarce factor in any of these island groups but shortage of family labour is a constraint. This may explain why in the remote villages of Ha'ano, without access to tractor hire services, farm sizes are much smaller and those is little cash cropping occurs compared to other villages.

On the other hand, migration normally brings economic advantages to families through the remittances sent by relatives. The impact of migrant remittances on the economy is significant in that over 1995 private remittances, contributed approximately 40 per cent of Tonga's foreign exchange (Ministry of Finance, 1996). The value of remittances is practically double the value of the gross agricultural product and 79 percent of the value of the gross domestic production. This flow of remittances meets most of the liquidity requirements of an average farm family and creates another disincentive for switching the farm system from self-sufficiency to commercial forms of agriculture.

9.5.3 Input supplies

Continuous access to reasonably cheap farm inputs such as planting material, fertilisers, pesticides, herbicides and farm equipment is essential to agricultural development. The survey showed that the supply of planting material, especially vegetable seeds, is a constraint although this is not a problem for most root and cash crops. In Vava'u, for example, village farmers noted

that access to planting material of kava is limited by its high cost, as are vegetable seeds, particularly squash.

9.6 Other key issues

9.6.1 Macro-economic issues

Farmers' perceptions of how Government policies at the macro-economic level impact on their farming activities and their life were sought during the interviews and interactions over kava sessions. The study revealed they understood some of these issues, but had little confidence that most of those, which they believe should be changed, have a place in the Government's agenda. Compared to subsistence and emergent farmers, many progressive farmers, who are involved in exports of their produce, have a better understanding of these issues, and were especially clear on how policies could be changed for the benefit of communities. They were generally more positive in their attitudes towards the likelihood of policy improvements.

Most progressive farmers comprehend the relationship between the value of the Tongan *pa'anga* and the revenues they receive for their exports. Some believe that the Tongan *pa'anga* is over-valued, and suggested this is why it is becoming common for some progressive farmers to retain revenue from crop-exports in overseas countries. A few subsistence and emergent farmers expressed the same sentiments but in terms of the reduced value of remittances.

Some respondents made reference to the lack of policies that support the establishment of industries to substitute imported foodstuffs, particularly animal products. They were concerned about the increasing consumption of imported foodstuffs in preference to locally produced substitutes. One respondent pointed out "*The Government is charging no, or too little, tariff on mutton flaps, and this facilitates the succumbment by the poorer of society to nutritionally related diseases, and as well discourages the development of local industries including fishing*". Past experience of Government import substitution policies through imposed tariffs to protect the local production of poultry products is not good. This has resulted not only in a dramatic increase in the prices of local produce (eggs and chicken), but local production failed to meet the domestic demand, therefore these tariff policies were abolished in favour of the consumers.

Issues that negatively impact on the marketing of produce were the most mentioned problems. Different categories of farmers tended to emphasise different issues. Marginal and emergent farmers generally stressed basic problems related to limited, or lack of, access to certain markets. In particular, they expressed the desire to produce for export, the need for established exporters to take more interest in marketing of their produce, and the need to increase market through-put of their food-crops (excess over consumption and obligations) in the local and national markets. In addition, in relation to the export marketing of squash, vanilla and kava, they expressed a desire for more involvement in the decision-making relating to the marketing of their produce.

Compared to marginal and emergent farmers, progressive farmers were more critical of the Government's intervention, or lack of intervention, in marketing. Most progressive farmers are involved in the marketing of their own produce, locally and overseas. Some members of the Vava'u Vanilla and Spices Association (VVSA), for instance, welcomed the involvement of the MAF in the management and in the activities of the association. Others, particularly VVSA-non-members, believed that by being involved directly in the marketing activities of VVSA, MAF intrudes into the role of private enterprise, faces conflicts of interest, and can mis-use Government resources in favour of the association. A progressive vanilla farmer in Tefisi clearly expressed this sentiment, "*At present, Government tries to do too much, but in reality, does little to enhance the marketing of our produce (vanilla). What you people should do is work together with us to establish policies like quality standards, make those standards binding, and ensure everyone adheres to them. Then you should research markets continuously and keep us informed. Let us and private exporters look after the rest without further interference*". It raises important issues not only the need to restrict the role of Government to more facilitating role, but to allow private sector to have the direct marketing responsibilities.

9.6.2 Willingness to try new crops and new technology

Information from the field discussions suggested that some smallholder farmers have proven they are willing to try and adopt new ideas. When vanilla production soared in the 1970's, Vava'u took the lead and today remains the vanguard of the Kingdom's vanilla-based foreign exchange earnings. In this instance, Vava'u farmers were able, within a very short time, to adopt MAF recommended technologies and its calendar of activities for looping, pollination and curing of vanilla. Also kava has in the last 8 years taken over quite significantly and with an assured market and good profits. A similar trend was experienced in the recent development of the squash industry. The assured market and a good profit meant large numbers of farmers became involved within a short period despite it being a new crop.

New, successful crops, however, have a downside where farmers are irrational. The extraordinary interest aroused by introduction of export squash is an example. In Tefisi, for instance, some successful vanilla growers discarded their vanilla plots and took on squash. They have now given up squash growing and returned to vanilla. "*We had been attracted by the quick cash potential of squash cultivation, but we could not cope with the inconsistency and low prices we got*". In another case, one of the largest growers of kava in Vava'u recently started off-season production of pineapples. He showed his intention to give up kava in favour of pineapples. Diversification of the agricultural base is desirable, but not at the expense of already proven stable industries and/or the environment and the ecological balance.

9.7 Conclusions

The field study sought to provide an understanding of how smallholder farmers' behaviour and production decisions are related to the socio-cultural environment. One of the most distinctive features of the Tongan smallholder farm household revealed in this study is the strong influence, if not dominance, of socio-cultural considerations on household farming decisions and activities. There is a strict observance of social norms and customs, including religious beliefs and practices. These established customs, laws and relationships make up the traditional institutions which govern the allocation and use of resources and the distribution of agricultural products. Delforce (1990) noted that family, church, national government and the community in general have considerable influence on the production and consumption among Tongan village smallholder farmers. The crops chosen may need to meet certain anticipated kinship obligations, and the subsequent distribution of the product is made along societally or culturally determined lines rather than on purely economic ones. An example is in the planting of feast foods such as yam and raising pigs for church obligations, or social purposes such as funerals, weddings and birthdays.

Socio-cultural factors are a source of both strength and contemporary weakness of Tonga's development. The elements of the social structure most likely to complicate and affect economic choices are neighbourhood ties, family and household ties, ties of kinship, status and class difference, local political roles, and patterns of religious offering. Thaman (1976) claimed that the Tongan social structure is permeated by countless social and kinship relationships and institutionalised procedures which, if not fulfilled or adhered to in the strictest Tongan sense, can result in a loss of prestige, favour, or effectiveness within one's social or economic sphere. Sevele (1973) also stated that by fulfilling one's social obligations (considered to be the Tongan way - *Fakatonga)*, an individual keeps on good terms with his or her family, village, religious leader, the traditional ruling class, and the rest of the community group. Consequently when a Tongan needs assistance in the form of labour, money, food for ceremonial occasions, or even land, other parties will be willing to fulfil their obligation to that person. Evans (1996) also claimed that everyday interaction as well as ceremonial exchange rests on the conviction that social life would go awry if people neglect sharing, kindness, obligation and religion. These social relationships are particularly important in Tonga, where European institutions such as life insurance, worker's compensation, social security, and freehold land are not available.

The social context within which the greater proportion of Tongan smallholder farmers still operate was largely developed to meet the need of an integral subsistence system. In such systems, people's behaviour is controlled by food security and by social and religious obligations. This is significant to agriculture in attitudes to commercialisation, labour allocation and distribution of farm produce and cash. It is often argued that smallholder farmers are frequently unable to meet the requirements of successful commercial agriculture because of the obligations and values whose origins lie in the older system. Conflicts arise in the allocation of

time, capital, labour, and in the disposal of produce or the distribution of financial return. Yet they contain aspects perceived as constraints, given the high and rising economic expectations of Tongans. All these factors tend to weaken the incentives for smallholder farmers to save and invest. The lack of savings and leakage of funds and stock to kin has doomed many small family business ventures to failure. People desire the fruits of modernisation while wishing to retain the time-honoured traditions, which may impede these aspirations. However, it reflects the importance and value that Tongan smallholder farm households place on these factors. As shown by the significance of non-economic objectives (Chapter 5), the whole economic decision making and action complex is significantly affected by non-economic forces such as social, cultural, and religious factors. Therefore, no treatment of smallholder farmers' development can ignore the significance of these in planning and implementing development programs.

The system analysis conducted in Part II of this study provides the basis for modelling the Tongan smallholder farming system. The Part III of this study provides a conceptual framework of farmer's decisions and a complete description of the model and the analysis. This is followed by validation of the model and application for policy analysis in Chapter 10 and 11, respectively.

PART 3: SYSTEM SYNTHESIS AND MODEL EVALUATION

System synthesis involves integrating the results of the systems analysis into a coherent and logical conceptual framework and the implementation of the framework into a working computer model. In this case it involves explicit consideration of the smallholders' multiple objectives and the characteristics of the farming and household systems to allow development of appropriate procedures for representing these aspects.

CHAPTER 10

CONCEPTUAL FRAMEWORK AND MODEL DESCRIPTION

10.1 Introduction

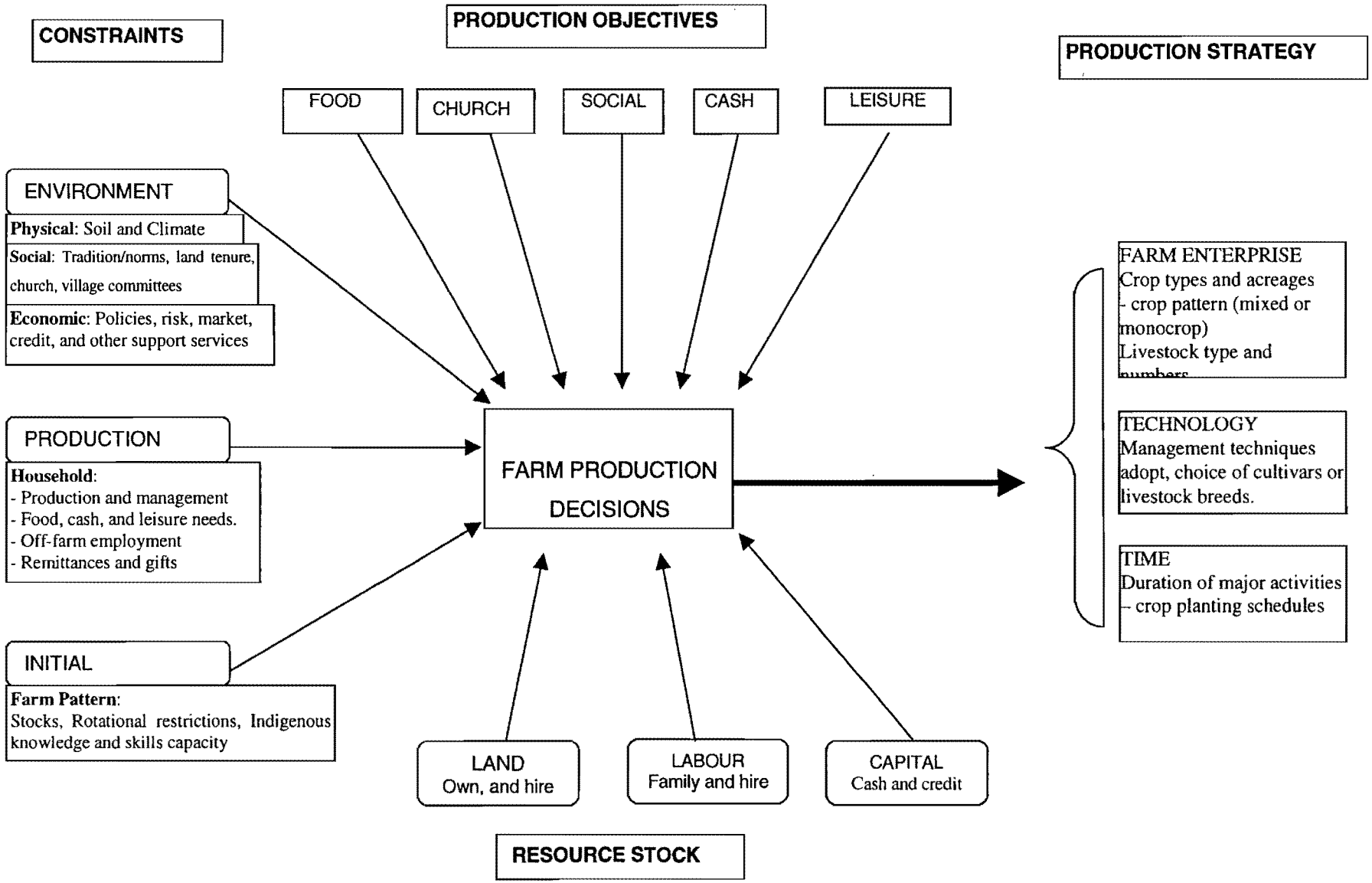
In the first section of this chapter, a conceptual framework of Tongan smallholder farmers' production decision making process is presented. Section 2 presents a discussion of the model development phase including a detailed description of the multiple goal programming model structure, the main components of the production model together with a description of data requirements. The model, as constructed, is described and the model's operation outlined.

10.2 Decision-Making Conceptual Framework

The framework at the farm household level was based on the premise that land is the most critical resource in Tongan agriculture, and therefore attention was focussed on land use decision making.

Based on the literature and the analysis of the Tongan farming system (Chapters 4 to 8), a representation of a smallholder farm household's decision matrix was developed (see Figure 10.1). It indicates the interdependent household decisions as constraints which, together with a range of exogenous factors, will impact on both the resources available for production and the farm objectives. The factors that are considered important include the availability and access to land, the physical factors (soil, climate, etc); the social and cultural factors; and the institutional factors. They will all influence the choice of crop and the production technology, these being the central areas of decision making.

Figure 10.1: A conceptual framework of decision making in a Tongan smallholder farm (Fakava, 1998).



From the preceding chapters it is clear that the fundamental nature of decision making in the Tongan smallholder farm household is analytically similar to decision making anywhere. The smallholder farmer has control over a number of factors or resources, which he or she can define quantitatively and qualitatively and the use of which is subject to a series of constraints and influences. Thus, Tongan smallholder decision-makers have choices in the use of these factors to achieve identifiable objectives.

10.2.1 Production objectives

The production objective is to make efficient sustainable use of land, labour, and capital. The problem is to allocate resources to those enterprises and activities that will satisfy the objectives. It is recognised that smallholder farmers in Tonga have multiple goals that often compete with one another. The more frequently identified goals include having a secured supply of staple food; an ability to meet social and religious obligations; to ensure that adequate cash is generated for household demands and capital investment, and to have adequate leisure time. In managing the farm, the smallholder farmer wishes to obtain the best level of overall satisfaction (or utility) across (his or her) (household) multiple goals. Inevitably, some of the different goals will be in conflict (for example, cash income versus leisure) so the farmer will have to achieve a satisfactory balance between trading one goal off against another and to ensure the gain in satisfaction from the goal receiving increased emphasis is greater than the decrease in satisfaction incurred by decreasing the emphasis on the other goal or goals.

10.2.2 Resources availability

The relative factor proportions at the farmers' disposal in terms of land, labour, capital ratios are major determinants in the choice of crops, livestock and production techniques. Conditions in Tonga do vary from island to island and from decision unit to decision unit, but if there is a valid generalisation, it is that in Tongan smallholder agriculture land availability and length of tenure is a significant constraint to any one household so that decisions on the use of the household land resources are critical.

10.2.3 The Constraints

A key issue is the impact of constraints. Through their influence on resource availability, constraints have significant effect on farmer's land use decisions, and thus on the level and nature of production, and the acceptance of improved innovations. For convenience, constraints may be classified into (a) the physical and economic environment within which the farm operates, (b) the starting conditions facing the farmer in formulating his production strategy, (c) the nature of the farm household production unit, and in particular its competing demand for family labour both for domestic and other economic activity, and (d) the perceived attitudes to climatic and market risks.

10.2.4 The Production strategy

One of the most impressive and consistent features of Tongan agriculture noted in Chapter 6 is the modification of farming systems in response to economic opportunities and incentives. Modifications may be in the timing, intensity and nature of farm operations and in the cropping pattern.

The development of the cohesive conceptual framework in this chapter reflects the close linkages of the social, cultural and psychological processes in land use decisions. However, little is known about the competition for farm resources and the nature of smallholder farmers' objectives and constraints. Therefore the aim was to examine the nature and interactions of the variables involved, drawing on the insights provided from observations of adjustments to economic pressures and social and cultural obligations. Through careful observation, precise and detailed knowledge of the technological, economic and social relationships were accumulated, and thus provide data for the model development.

10.3 Model Development

10.3.1 Basic Model: Typical emergent farmer in Masilamea village

Farms of emergent smallholders in Tonga have at least some elements of commercialisation and generate some cash for the purchase of essential items. The best way of illustrating this semi-subsistence farm type is with the aid of a structural model, as shown in Figure 10.2.

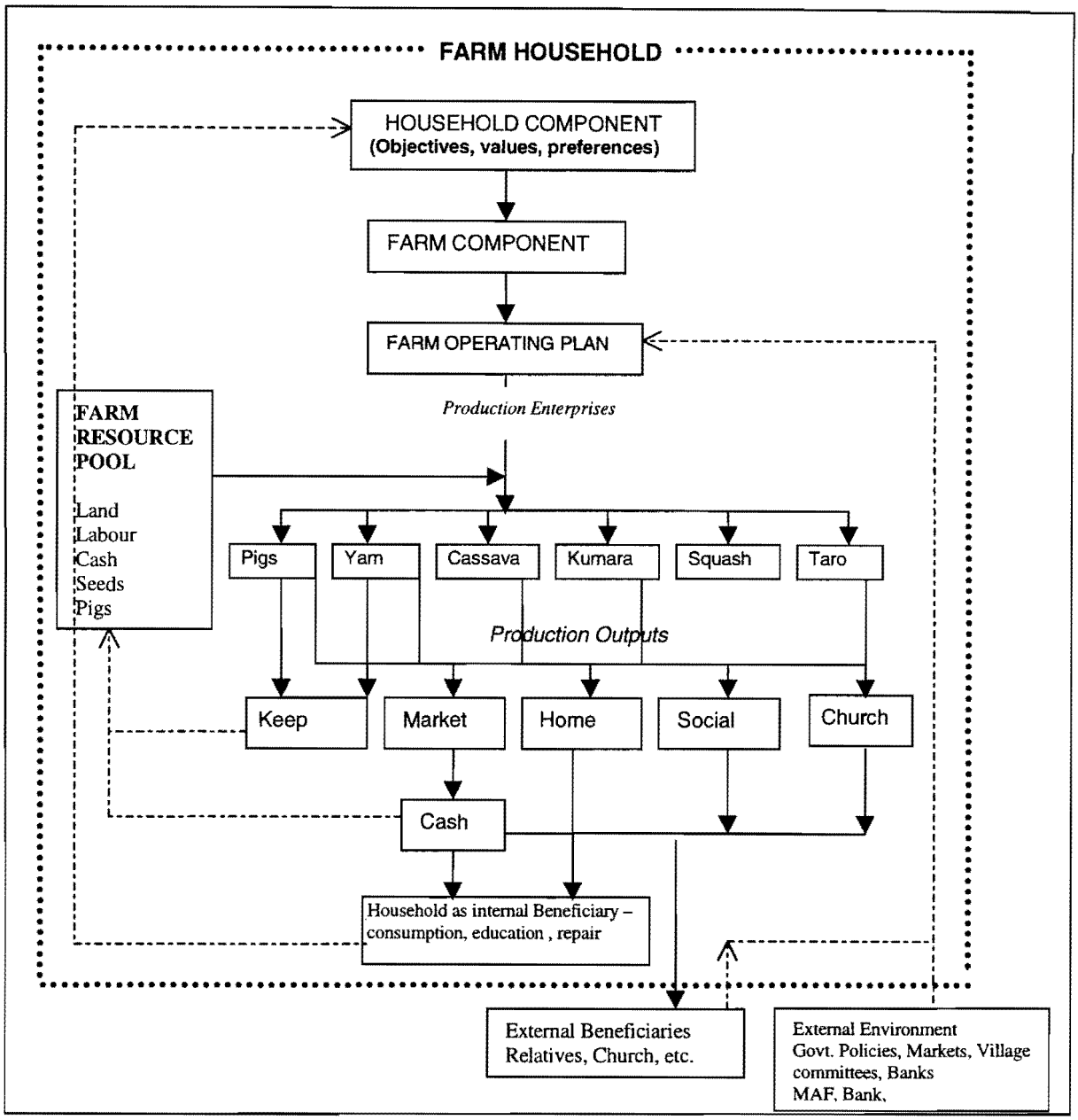
10.3.1.1 Household Component

The household is the decision-making unit which controls and establishes objectives (economic and social) and manages the farm household system. The objectives vary with the culture, tradition and the degree of commercialisation and the external influences to which the household is exposed. This study divided households into groups to allow some variations (discussed at greater depth later in this chapter). "Emergent" farm households operate within the limits set by the physical environment and available resources as do all sectors and groups. The household is also the primary internal beneficiary of the system in terms of consumption from farm produce as well as cash from selling surpluses. Households also distribute some of the system output to external beneficiaries (church, relatives, and community).

10.3.1.2 Farm Component: crops and livestock activities.

Farm operating plan: As discussed in Chapter 5.2, the head of the household and its members largely determine the farm-operating plan. It is also influenced by the requirements of external individuals and agencies such as farmers' groups, District Agricultural Committees, Ministry of Agriculture and Forestry extension, the church, and market agencies, as well as relatives.

Figure 10.2: Structural model of an emergent smallolder farming system in Masilamea village.



Source: Field survey, 1998

The ***Farm Resource pool*** consists of resources such as land, labour, cash, planting material and existing stock, which are initially present at the time of planning or commencing operation of the system. As shown in Figure 10.2, the farm resource pool supplies the requirements for the various activities of the different production enterprises.

The ***Production outputs*** of the farm (see Figure 10.2) are allocated to both the farm component itself and system beneficiaries who may well be internal or external to the system. The internal beneficiaries are the household itself, which requires staples and other products for normal living. External primary beneficiaries consist of needy relatives and friends, the immediate community and church organisations. To enable the continuation of the system in subsequent years, some

yam and pig output are cycled back to replenish seed or resource stock. Similarly, to replenish the cash resources, which were used during the year, some produce is sold.

10.3.2 Outline of the matrix

As noted in Chapter 3, the choice of appropriate mathematical programming methods was narrowed to a weighted goal programming version which is consistent with the major features of current farm practices and production environment in Tonga. The Goal programming model requires articulation of the decision-maker's preferences, that is, each goal under consideration (profit, safety, production level, etc.) is given a target or goal value to be achieved within the given set of constraints. The model minimises the deviations, or differences, among the desired goals and their aspiration levels. Weights are attached to the deviations according to the relative importance of each goal to the decision-maker. In a Tongan smallholder mixed cropping farm, goal programming can adequately incorporate the essential farm characteristics which influence the behaviour of the farm system to change. Such characteristics include the farmer's need to operate within limited resources to achieve and satisfy several goals. Goal Programming finds a satisfactory level of goal attainment that represents the best possible combination of goal achievement.

The second stage of model construction was designing the matrix form of the model. As well as accurately reflecting the system, the matrix was required to have logical divisions and be well documented. Matrix construction also involves quantifying the objectives, constraints and other matrix coefficients using data from the survey as well as secondary information.

The whole matrix consists of an objective function with 286 activities and 174 constraints. The seasonal or climatic assumptions are those for an average year although poor seasons can, and have, been considered in the model. Table 10.1 shows a very simplified representation of the overall model structure. Each row or column in Table 10.1 represents a number (indicated in brackets) of constraints or activities in the matrix. The table provides an overview of the model structure and the relationships between its various components. Greater detail is given in the following sections.

10.3.2.1 Goal Specifications

As noted in Chapter 6 the data collected in the present study allowed the objectives and priorities of the sample of village households based on the main decision maker, the head of the household (father), to be described and ranked. Six potential production objectives were identified for use in the study. The goal weighting for the three main farm types presented in Table 6.1 are used for the different models. Perhaps the most defining feature of Tongan smallholder households is the partial subsistence basis of their livelihood. Smallholder farmers are often referred to as semi-subsistence farmers in this context. In managing the farm, the smallholder farmer wishes to achieve that mix of goal attainment which gives the best level of overall satisfaction. The importance of each objective is reflected in the ranking and the weightings attached.

Table 10.1: Outline of matrix activities and constraints.

CONSTRAINTS	SUPPLY	ACTIVITIES							
		Crops(31)	Land (4)	Labour(24)	Leisure(36)	Pigs (17)	Subsistence food (39)	Subsistence cash(108)	Cash flow (24)
Land (15)		xxx	xxx						
Labour(35)		xxx		Xxx					
Leisure (12)					xxx				
Cash (12)		xxx						xxx	xxx
Credit (12)									
Living costs (12)								xxx	
Social costs (12)								xxx	
Church costs (12)								xxx	
Crop balances (9)		xxx					xx		
Subsistence requirements (13)							xxx		
Risk (5)		xxx					xxx		
Pigs (7)						xxx			
Marketing (17)									
Objective function (1)					xx		xxx	xxx	

Note: The figures in parentheses show the number of rows or columns of each category in the matrix.

xx = a block of coefficients

The data indicated the relative importance of ensuring that subsistence food and cash for household consumption, religious and social obligations are met.

Goal 1: Home consumption

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.

The farmers place restrictions on the staple food requirements of some crops included in the plan. This reflects a desire to abide with the District Agricultural Committee's recommendations to ensure home food consumption requirements are met as well as social and religious obligations, and to allow diversification against the possibility of fluctuating prices and, to a lesser extent, yield variation from season to season. The farm family's subsistence minimum consumption levels for major staple food crops are given in Table 10.3.

Table 10.2: 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 constraint is formulated as;

(i) Minimum home staple food requirement:

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

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

where: f_h = level of home food consumption

b_i = target level (b_1 = 1000kg, b_2 = 3000kg, b_3 = 3000kg, b_4 = 2200kg, b_5 = 3 head)

c_j = commodity type (c_1 = yam, c_2 = taro, c_3 = cassava, c_4 = kumara, $c5$ = porker)

and the variables with the subscripts h_n (negative deviation) and h_p (positive deviation) are referred to as deviational variables and represent the kilograms of crop, or number of pigs, of over, or under production relative to the minimum target level of production b_i. The objective is to minimise $f_{h_p}^{c_j}$.

(ii) Minimum living cost-monthly requirement:

$$250 = E_h^m - E_{h_n}^m + E_{h_p}^m$$

where: E_h = Living expenses in each month, m = month 1,2,3.....12. and the variables with the subscript h_n = negative deviation, and h_p = positive deviation

Home consumption also involves cash requirements for household demands. These include purchase of non-farm produced food essentials (flour, sugar, meat, etc), and other essentials such as clothing, education, and household utilities. Unlike the staple food requirement, the living costs are set up on a monthly basis of T$250 per month and derived from survey results in Chapter 8. This can be met not only from the cash generated from selling surplus produce but from off-farm income earnings and cash borrowed. Deviational variables with subscripts h_p and h_n represent the amount by which the minimum level is not met, or is exceeded respectively. The objective in the goal constraint is to minimise the under supply $E_{h_p}^m$.

Goal 2: Church obligation

The second goal is the desire to produce adequate staple food, livestock, and cash for church obligations.

(i) Minimum church staple food requirement:

$$b_i = f_c^{c_j} - f_{c_n}^{c_j} + f_{c_p}^{c_j}$$

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

where: f_c = level of church food consumption

b_i = target level (b_1 = 500kg, b_2 = 200kg, b_3 = 200kg, b_4 = 200kg, b_5 = 6 head)

c_j = commodity type (c_1 = yam, c_2 = taro, c_3 = cassava, c_4 = kumara, c_5 = porker)

and the variables with, the subscripts c_n (negative deviation) and c_p (positive deviation) are referred to as deviational variables, which represent the kilograms of crop, or number of pigs, of over, or under production relative to the minimum target level of production b_i. The objective is to minimise $f_{c_p}^{c_j}$.

(ii) Church monthly cash requirements:

$$b_m = E_c^m - E_{c_n}^m + E_{c_p}^m$$

where: E_c = Church expenses in each month, m = month 1,2,3.....12.

b_m = monthly cash requirement target level.

The variables with the subscripts c_n and c_p are the negative and positive deviations respectively.

The objective in the goal constraint is to minimise the under supply $E^m_{c_p}$.

Goal 3: Minimise risks

The third 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 in Goal 1, 2 and 4 are satisfied.

Farm decision-makers frequently associate risk with the failure to attain some given target return (Patrick *et al.*, 1985). Low (1974) developed one of the safety-first models that represent risk as the absolute value of negative deviations from some target level of achievement. These safety-first concepts are related to short-run survival, which appeared to be an important consideration among the Tongan farm households studied. The model used is designed to help farmers ensure that the solutions produce minimum food and income necessary to meet the minimum family food requirement and living costs each year. These are most appropriate requirements where the risk of calamity is large, either because of an inherently risky environment, or because the farmer is poor and has minimal reserves to fall back on in a bad year.

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 expect 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 third goal of minimising risk was incorporated as the following system constraints:

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

$$j = 1,2,....4$$

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.

Goal 4: Social obligation

The fourth goal of smallholder farmers is to produce adequate staple food, pigs, and cash for social obligations;

(i) Minimum social total food requirements:

$$b_i = f_s^{c_j} - f_{s_n}^{c_j} + f_{s_p}^{c_j}$$

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

where: f_s = social consumption

b_i = target level (b_1 = 500kg, b_2 = 600kg, b_3 = 200kg, b_4 = 1000kg, b_5 = 3 head)

c_j = commodity type (c_1 = yam, c_2 = taro, c_3 = cassava, c_4 = kumara, c_5 = porker)

s_n = negative deviation and s_p = positive deviation.

and the variables with, the subscripts s_n (negative deviation) and s_p (positive deviation) are referred to as deviational variables, which represent the kilograms of crop, or number of pigs, of over, or under production relative to the minimum target level of production b_i. The objective is to minimise $f_{s_p}^{c_j}$.

(ii) Minimum social monthly cash requirement:

$$b_m = E_s^m - E_{s_n}^m + E_{s_p}^m$$

where: E_s = Social expenses in each month m = month (1,2,3.....12).

b_m = monthly cash requirement level

and the variables with the subscripts s_n (negative deviation) and s_p (positive deviation) are referred to as deviational variables. The objective in the goal constraint for social requirements is to minimise the under supply $E_{s_p}^m$ of cash.

Goal 5: Surplus cash

The fifth goal reflects the smallholder farmers' desire to maximise profit from surpluses provided subsistence food and cash requirements are satisfied. The level of cash surplus at the end of the production period, in this case in April, is to be maximised.

$$SC_y = SC_t - SC_n + SC_p$$

where: SC_y = minimum annual surplus cash requirement level.

SC_t = surplus cash at end of year

and the variables with, the subscripts $_n$ (negative deviation) and $_p$ (positive deviation) are referred to as deviational variables. The objective is to maximise SC_t, or at least attain SC_y.

Goal 6: Leisure requirements

The final goal is to allow adequate time for leisure.

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

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^{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.

10.3.2.2 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:

$$MinZ = w_1 \sum_{j=1}^{5} f_{h_p}^{c_j} + w_2 \sum_{j=1}^{5} f_{c_p}^{c_j} + w_3 \sum_{j=1}^{5} f_{s_p}^{c_j} + w_4 \sum_{m=1}^{12} E_{h_p}^m + w_5 \sum_{m=1}^{12} E_{c_p}^m + w_6 \sum_{m=1}^{12} E_{s_p}^m$$

$$+ w_7 \sum_{m=1}^{12} l_{l_p}^m + w_8 SC_p$$

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.

10.4 Modelling Production Activities

The analysis of village smallholder farming systems (Chapter 6) revealed a mixed combination of food and cash crops and domestic livestock such as pigs and poultry was produced. The combination of livestock with crops results in a large number of activities, and an even larger number of different farm products. The production activities in the matrix include the major staple food crops (yam, taro, cassava, taro and sweet potatoes) and a specific cash crop – squash. Not all the crops and livestock that can be grown and raised are represented in the model, only the major food and cash crops identified in the survey were included. Some of the minor crops and livestock, including fruit trees, cattle and poultry, are in small quantities and the area planted and number kept does not justify explicit consideration. In addition, they do not have the financial or subsistence reasons for production expansion. Table 10.3 contains the input and output coefficients used in the crop components of the model. The expected yield values are fixed for all runs of the model undertaken for this study. Empirical values were obtained from an average of past gross margins analyses presented in Appendix 3. In the case of perennial crops like kava and vanilla with a growing period of 5 and 12 years respectively, all coefficients were divided by the number of years of growth.

Table 10.3: Summary of input and output requirements for each enterprise.

CROP	Labour	Capital	Yield	Price	GM/ha	Return to labour
	Hrs/ha	*T$/ha*	*kg/ha*	*(T$/kg)*	*T$/ha*	*T$/hr*
Yam (mixed)	1230	3089	12350	1.65	17,288	14.06
Giant taro	900	385	17000	0.4	6415	7.13
Colocasia taro	985	770	9880	0.60	5457	5.54
Xanthosoma taro	955	587	11100	0.50	6763	6.03
Sweet Potatoes	830	440	12000	0.25	2560	3.08
Cassava	840	620	18525	0.15	2159	2.57
Squash	600	1673	8000	0.50	2327	3.88
Watermelon	680	1040	18000	0.35	5260	7.74
Vanilla	720	175	698	10	6809	10.27
Kava	430	170	1000	12.00	11884	27.52

Source: Field survey, 1998; Gyles *et al.*, 1989

Tending pigs was the only livestock enterprise included in the model. Pig activities (*Activities 74–93*) incorporated include pig rearing, buying and selling. Farmer's obtain breeding sows and fatten their offspring for pork using some of the cassava production as feed to supplement coconuts. Breeding sows are incorporated in the model through a single activity. Each sow is expected to produce 10 healthy offspring per year and to require 0.20 replacements each year. That is, a breeding life of five

years is assumed, implying that on average 20 percent of the sows must be replaced each year. The replacement control equation implies that the number of young sows will be provided by rearing replacements on the farm or, alternatively, purchased.

Weaner activities include selling, purchasing, and keeping for porker production. Porkers can be sold, purchased or consumed (home, social, church). The minimum requirements for porkers are expressed in *constraints 155-157*. The litter balance row requires that the number of weaners, and replacements reared cannot exceed the number of piglets produced. Since the number of replacements required would be small relative to the total number of piglets produced, it is not necessary to include separate balance constraints for female and male piglets. As cassava can be fed to pigs, it is necessary to include options for feeding that links to the cassava balance row. This requires that the total amount of cassava used for subsistence consumption, pig feed, and sold, cannot exceed the amount produced.

10.5 Modelling Production Constraints

While an emergent smallholder farmer seeks to achieve the many objectives through production activities, the level of these activities is restricted by various technical and behavioural constraints. The constraints included in the model are; (1) monthly land constraints; (2) monthly labour constraints consisting of family labour supply and the availability of hired labour; (3) financial constraints which consist of money constraints, borrowing constraints and loan repayment constraints; (4) household subsistence consumption constraints; (5) flexibility constraints to account for risk and uncertainty related to farm prices, yield expectations, government programs, and restrictions on the aggregate supply of farm inputs. The details of resource constraints and restrictions are discussed below.

10.5.1 Modelling decision problems involving land

The supply of land resources in each period throughout the year must be known. The simplest form of land constraint arises where individual crops occupy land for a full year, in which case only one constraint may be required in intensive crop production, however, more than one crop can be produced from the same block of land within a single year. Thus, the year was divided into monthly periods and land constraints specified for each month within the year. This ensures that in no months of the year will the total land requirement for cropping exceed the supply of land.

The model includes a land area of 3.34 hectares, which is the average area of land held under secure tenure by each household. Provision is made for the short-term borrowing of land, which is common in Tonga (discussed in Chapter 6), as well as hiring land activities with restrictions on each:

(i) maximum of 2 hectares of borrowed land,

(ii) provision for the hire of up to 8 hectares at a cost of T$2000/ha per season.

Figure 10.3: Crop activities and land requirements.

						MONTH								
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Yam 1	I----	------	------	———	———	———	-----	-----	------	------	------	------	------	----I
Yam 2	I----	------	------	———	———	———	-----	-----	------	------	------	------	------	----I
Taro 1	I----	------	------	———	———	———	-----	-----	------	------	------	------	------	----I
Taro 2	I----	------	------	———	———	———	-----	-----	------	------	------	------	------	----I
Cassava 1	I----	------	------	———	———	———	-----	-----	------	------	------	------	------	----I
Cassava 2	I----	------	------	———	———	———	-----	-----	------	------	------	------	------	----I
Kumara 1		I-----	------	------	------	------	------	------	----I					
Kumara 2						I-----	------	------	------	------	------	------	----I	
Squash					I----	------	----I							

Source: Field survey, 1998

* '----' represents land occupation.

Each crop activity uses the land resource according to the period it occupies the ground (Figure 10.2). This bar chart depicts the land requirements of each potential activity. The majority of the root crops such as yam, taro and cassava occupy land for 9-12 months, sweet potatoes take six to seven months while squash only occupy land for 4 months (July-Oct).

As described in Chapter 6, Tongan farmers still operate to a broad framework of crop sequences. Such frameworks are often particular to individual farmers and relate to their production objectives and to the soil types and conditions found on the farm. Dent *et al.*, (1986) note that suitable rotations are the basis of farming systems. Rotational constraints include ensuring that the optimal cropping pattern does not violate the rotational sequences that are technically feasible. In particular, fallow land is constrained to allow planting next season's yam. The rotational requirements and preferences are incorporated into the model in the system constraints.

Different crops have different fertility requirements and ability to produce. Provided in the model are options for maintaining soil fertility either through fallowing or the use of fertilisers (organic and inorganic). The fallowing period varies from one year to as long as six years. The average time schedule consists of one to three years in fallow and 3 to 7 years in cropping. However, no farmer reported following a predetermined schedule, basing decisions upon crop yields.

The fertility constraint (Row 13) assigns coefficients to each crop activity to reflect the relative changes in soil nutrients and structure, which can be attributed to growing specific crops. Yam has the highest coefficient (0.5), which reflects the high fertility and good structure requirement. It can only be grown on the same land for two successive years before yield typically declines as a result of impoverishment of soil fertility. On other hand, taro, with a coefficient of 0.2, indicates that it can be

grown for 5 successive years. The fertility constraint defines these relative differences and ensures that the system chosen maintains or improves fertility.

10.5.2 Modelling decision problems involving labour

The demand for labour by Tongan farming systems often fluctuates throughout each month of the year. This suggests that labour is likely to be a limiting factor only at certain times of the year and labour constraints might be specified just for these periods. However, these periods are not known a priori. For this reason, to ensure that a farming system is developed which is feasible, it must be ensured that there is sufficient labour in each month. The labour requirement for each production enterprise activity is depicted in Table 10.4. Possibilities for augmenting the permanent labour supply from either family or hired casual labour are incorporated into the model.

The analysis in Chapter 7 showed that the main source of labour was the household. Farm work is normally done by more than one person, such that the head of the household is usually helped by one of his sons or relatives. Assuming 2 labour units each with a capacity of 30 man-hours per week plus help from the rest of the family members (2 hrs per week), there is a total family labour supply of 480 man-hours per month or 5760 man-hours per year. This supplies labour for farm activities and leisure. The leisure requirement activity is incorporated into the model as one of the goals. Labour requirements can be supplemented from hiring casual labour at a rate of T$3.00 per hour. Labour use cannot exceed the supply of family labour and hired labour. Selling of surplus family labour at a rate of $2.50 is included but constrained by the limited opportunities for off-farm employment and only occurred in marginal farm households. Thus sell labour is constrained to 10 hours/month.

Table 10.4: Monthly labour requirement per ha for major production activities.

MONTH	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
ACTIVITY						(hrs/month)						
Yam 1	250	100	50	50	100	50	50	100	200	100	100	80
Yam 2	200	100	100	80	250	100	50	50	100	50	50	100
Taro 1	50	100	50	50	50	50	50	50	50	50	50	50
Taro 2	100	50	50	50	50	50	70	50	50	80	50	50
Cassava 1	100	50	50	50	50	50	50	50	50	20	50	50
Cassava 2	50	50	20	50	50	100	50	50	50	50	50	50
Kumara 1		200	100	100	100	100	100	130				
Kumara 2						200	100	100	100	100	100	130
Squash				200	100	200	100					
Pigs												
Sow	2	2	2	2	2	2	2	2	2	2	2	2
Weaner	2	2										2
Rear sow	2	2	2	2	2	2	2	2	2	2	2	2
Porker			2	2	2	2	2	2	2	2	2	2

Source: Field survey, 1998

10.5.3 Modelling decision problems involving working capital

Access to working capital is important. If shortages of working capital arise and impose limitations on the farmer's production plans, then such limitations should be imposed on the goal-programming model. The farming system must be organised so that demand for working capital for specific periods, say monthly, can be satisfied from off-farm income, working capital on hand, or from borrowing.

The basic-on-farm supplies of short-term capital were obtained from the survey of household income and expenditure. The initial off-farm capital supply was calculated by determining borrowing for agricultural production and loans from various sources of credit. To construct the working capital constraints, the net requirements of activities for working capital each month were incorporated.
The financial segment of the matrix incorporates a monthly cash flow, for the payment of fixed cash costs and household living expenses and personal expenditure, social and church requirements, maximum borrowing constraint and repayment. A minimum cash requirement for home, church, and social consumption per month was incorporated in the model. These figures were determined from the analysis of the household expenditure pattern in Chapter 7 (Field Survey, 1998). The total demand for working capital and cash by each activity does not have to be met by funds on hand at the beginning of the year because funds will also be earnt throughout the year by various activities. Activities use or contribute to the cash stock in each month according to their cash flow characteristics. Any cash surplus generated in any month may either be saved to meet future deficits or transferred through the cash surplus activities to the objective functions. The monthly interest rate on savings is about 0.7 percent, which is the current market interest rate on savings in the Bank of Tonga and other commercial banks. Provision for credit comes from the Tonga Development Bank, which is the main source of credit for agricultural activities. The interest rate on agricultural loans under T$2000 is about 0.08 percent per month.

10.5.4 Selling and buying activities

Some of the resources available to farmers are not strictly fixed because they can be supplemented through hiring or renting additional units. If the fixed supply of labour is critical, for example, the farmer might hire additional workers. Similarly, the land area owned can be supplemented by renting additional land. These options were incorporated in the goal-programming model through buying activities. Such activities typically have a positive coefficient in the model's matrix representing the wage or rent paid. Selling activities for excess resources and farm outputs are also incorporated to reflect these options. Excess family labour can be hired out.

Buying and selling activities are also used in farm models to provide for the purchase of direct inputs and the revenue from sales. Provision is made for trading farm produce and livestock although limits

are placed on the extent of such transactions, partly as a behavioural constraint reflecting the subsistence nature of most Tongan smallholder households and the limited market opportunities. Provision is also made for households to purchase foodstuffs that are not produced.

10.6 Summary

The main focus of this chapter has been on the development of a model to represent smallholder farmers' production decision making in Tonga. The structure of the farm problem described was found to suit a programming approach. Previous studies (Hardaker, 1975; Delforce, 1990) have shown that comparable analytical requirements have been met with a mathematical programming approach. Choice within the mathematical programming models was narrowed to a weighted goal programming version which is consistent with the major features of current farm practices and the production environment in Tonga as reflected in the structural model in Figure 10.1. In a study specific to a Tongan smallholder mixed cropping farm, goal programming can adequately incorporate the essential farm characteristics, which influence the behaviour of the farm system. Such characteristics include the need for farmer's to operate within limited resources and a highly constrained environment to achieve and satisfy an economic and non-economic goal set.

The main farm activities in the model included the (1) production activities which consist of growing yam, taro, cassava, sweet potato, and squash, and tending pigs; (2) consumption activities which utilise production for home, social and church requirements; (3) selling activities which market the surplus of various farm commodities determined as a residual of production and consumption decisions; (4) labour use activities which consist of family labour supply and monthly labour hiring; (5) purchase activities which consist of agricultural inputs and non-farm durable and non-durable consumer goods and services; and (6) financial activities which consist of cash flow, short-term borrowing and loan repayment. The goal-programming model represents one annual production cycle starting from May. The matrix embodies activities and constraints reflecting the division of the year into two main cropping seasons (wet and dry) and into six-month periods within each season. The GP model assumes no technological change within the year of analysis. Each production activity in a representative farm can use one technology, expressed as a unique combination of input-output and yield coefficients. The results obtained from implementing this approach are presented and discussed in the next chapter.

CHAPTER 11

MODEL VALIDATION AND VERIFICATION

11.1 Introduction

The success and failure of a programming model must be measured by how well it predicts the particular phenomena in question (Anderson, 1974). Hence, having completed the design of a model, the modeller is faced with the task of determining if the model, when given proper inputs, produces results that are meaningful and are of use in relation to the analytical purpose for which the model was created. The first section of this chapter involves the testing and observation of the model output to assess the usefulness of the model for its intended purpose. An important part is model validation, which involves the testing of the verified model's ability to mimic the operation of the real world situation. The second part discusses the model solutions. The GP model provides three types of solutions: (1) the degree of goal attainment with the given resources; 2) identification of resource requirements to attain all the desired goals; and (3) the degree of goal attainment under various combinations of resources and goal priorities and weightings. This chapter presents the three separate solutions in order to demonstrate the capability of the models to analyse Tongan smallholder farm production.

11.2 Model Verification

Dent and Blackie (1979) considered a two step procedure for checking whether a model justifies persistent analytical attention; a) **verification** is the process of ensuring that the model behaves as the analyst intends it to it and hence involves the checking of the model for logical consistency; and b) **validation,** or deciding the adequacy of the model to mime the behaviour of the real system. In the model verification stage, some considerable care was devoted to the model construction to ensure there were no discrepancies between the matrix and its representation in the computer. The Lindo 1997 computer package includes a number of check procedures for data handling and processing which were used in conjunction with manual checking during the first stage of model verification. In the second stage of verification, preliminary results were obtained for the models and compared with existing situations. A few more errors were detected at this stage which led to some fundamental revisions and modifications.

Some of the errors included the implausible levels of sales both for livestock and crops thus generating an implausible level of surplus cash. In real situations, market opportunities are the major constraint in Tonga. Therefore restrictions were imposed on trading in crops and pigs. The market constraint varies between the three sub-regions as discussed in Chapter 5, with better market opportunities in Tongatapu not only for domestic consumption, but for export compared to Vava'u and Ha'apai. The levels of restrictions were estimated from the average sales per seller for each commodity in a season for each of the respective island groups.

The sale of agricultural labour was also reconsidered. The results from the fieldwork indicated that this activity only occurred with marginal farmers. Limited market opportunities exist for agricultural labour; therefore it was unrealistic to incorporate selling labour activities in the model as an income generating opportunity for emergent and progressive farm households. There was also variation among the island groups with more agricultural labour demand existing in Tongatapu and Vava'u where cash cropping is more intense compared to Ha'apai.

The initial formulation proved to be infeasible because pig production cost data was over specified and unrealistic. Once these errors had been remedied solutions were obtained and carefully reviewed to see that all the constraints and the activities were operating as intended. In this manner verification of the model proceeded to a stage where it was possible to be confident that all errors of importance had been corrected and the model was yielding solutions that closely resembled the existing situation in Tongan agriculture.

11.3 Model Validation

The second stage of checking the model involves deciding if the model is a sufficiently valid representation of the real world situation (Anderson, 1974). An analysis framework was constructed to represent decision-making processes on smallholder farm management and this was subjected to validation. In the use of models, the confidence that can be placed on generated output will depend upon the accuracy with which the model reflects the essential behaviour of the real system. Validation procedures are generally based on comparing the model predictions with what farmers are actually doing and so determine the degree to which the model can mimic a situation that occurred in the past. If the predictions differ from reality, we conclude the initial model assumptions were wrong and need modifying. On the other hand, if the predictions closely resemble reality then we conclude that assumptions were right and model is a true representation of existing situation. The model then needs to be tested over a range of circumstances.

The validation test used helps to 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:

$$MaxZ = -w_1 \sum_{j=1}^{5} f_{h_p}^{c_j} + w_2 \sum_{j=1}^{5} f_{h_n}^{c_j} - w_3 \sum_{j=1}^{5} f_{c_p}^{c_j} + w_4 \sum_{j=1}^{5} f_{c_n}^{c_j} - w_5 \sum_{j=1}^{5} f_{s_p}^{c_j} + w_6 \sum_{j=1}^{5} f_{s_n}^{c_j}$$

$$- w_7 \sum_{m=1}^{12} E_{h_p}^{m} + w_8 \sum_{m=1}^{12} E_{h_n}^{m} - w_9 \sum_{m=1}^{12} E_{c_p}^{m} + w_{10} \sum_{m=1}^{12} E_{c_n}^{m} - w_{11} \sum_{m=1}^{12} E_{s_p}^{m} + w_{12} \sum_{m=1}^{12} E_{s_n}^{m}$$

$$- w_{13} \sum_{m=1}^{12} l_{l_p}^{m} + w_{14} \sum_{m=1}^{12} l_{l_n}^{m} - w_{15} SC_p + w_{16} SC_n$$

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.

In order to assess the degree to which the model reflect farmer's choice, the optimal plan provided by each model solutions were validated against the survey data with the actual operating conditions of the representative farms in each zone. These actual conditions compared to model results are presented and discussed below.

11.4 Model Results and Analysis

As outlined in Section 10.3 above, farms were categorised in order to develop a model for each particular class. The prime objective of categorising farm types by geographical region and farmer types is to provide homogenous groups each one of which has a specific model. Farm size, marketing opportunity, degree of commercialisation, and differences in the geographical location for each island group classify the reference farm types. The survey work suggested there were three main farmers' group (marginal, emergent, and progressive). An important aspect of the modelling experiment is recognising the different characteristics featured in the three main farm types in terms of their preferences and goals, skill level, motivation and ability to utilise available resources. Further consideration is also given in this section to develop models that are representative not only for each particular farmer group but to reflect the behaviour of each reference farm type within the different geographical regions. The three main island groups are characterised with different market access and ability of different crops to perform. As a result, a total of eight reference farm types were chosen to represents the situation of the three major farm types (marginal, emergent, progressive) in the three sub-regions.

Farm 1 :	Progressive farm in Tongatapu
Farm 2:	Emergent farm in Tongatapu
Farm 3:	Marginal farm in Tongatapu
Farm 4:	Progressive farm in Vava'u
Farm 5:	Emergent farm in Vava'u
Farm 6:	Marginal farm in Vava'u
Farm 7:	Emergent farm in Ha'apai
Farm 8:	Marginal farm in Ha'apai

In the island of Ha'apai, the results from the survey indicated only two of main farm types exist (emergent and marginal). Data were collated for each representative farm in the 3 sub-regions, for the relative production activities, stocks of physical and of financial resources, constraints, and the different goals and their relative weightings and these were incorporated into each matrix. Results for the eight validated models are presented below to show the theoretical behaviour of each reference farm type.

The representative farm models were first run to determine the input requirements necessary to achieve all the goals, ranked on their relative importance, by each farm type. Information on achievement status for each goal, and changes in farmers' operating plans, can be analysed for the absolute changes in activity levels, or it can be used to study the distribution of the change itself.

11.4.1 Achievement of goals

The objectives of each farmer type are to ensure target levels for household food, cash and leisure requirements, social and church obligations are satisfied. Table 11.1 summarises the achievement status of the goals.

Goal 1: Home sustenance: According to the solution the most important goals, the household staple food requirements for yam, taro, cassava and kumara are met exactly. All variables with the subscript $_n$ (negative deviation) and $_p$ (positive deviation) are equal to zero. The living costs or monthly cash requirements were also fully met with the exception of porker consumption which was not met where $h_p = 3$.

Goal 2 refers to church obligations: The staple food and cash requirements for church obligations are fully met ($c_p = 0$).

Goal 3: Minimise risks: The achievement of the goal of minimising risk was reflected by the respective quantities of yam, taro, cassava and sweet potatoes sold in a poor year.

Goal 4: Social obligations: According to the goal programming basic solutions, staple food and cash requirements for social obligations are fully met ($s_p = 0$).

Goal 5: Profit maximisation: The solution showed the surplus cash that the farmer achieved at the end of the production year was adequate.

Goal 6: Leisure requirements: The goal programming basic solutions indicated that monthly leisure requirements are satisfied.

11.4.2 Farm Operating Plans

The GP model solutions identify and quantify the input (resource) requirements to attain all the desired goals. This is expressed in the farm plan specified by the optimum combination of activities in the solutions. Another useful byproduct is the quantification of surplus or unused resources available in each month (land, family labour and cash). In this section, the farm-operating plans are presented and the resource uses are analysed for each of the representative farm models.

11.4.2.1 Analysis of land use

As shown in Table 11.2, farm operating plans from the model solutions are comparable to the actual farm practices of the representative farms in the survey results. The validation results for the representative farms are close to those from the survey in terms of crop choice and the proportion allocated for each crop. The slight variations in total cropped area and percentage distribution may be attributed to some errors in the data used for actual production. As noted earlier, field results estimation were based solely on what the farmers could recall and the area was estimated to the nearest quarter acre or 0.1 hectare, and considering the low average cultivated area per farmer, such errors will be more significant in the results. However, the results indicate that the models are accurate and do reflect the decision-making process of the different farm types.

It is also important to note that these figures tend to be different to those reported in the 1993 Land Use crop survey and elsewhere. The main reason for variation is due to the effect of the time of the year the survey was carried out as most of the reported land use records referred to the land use at the time of the survey. During the year a farmer may have some garden under cultivation, may have abandoned others and clear some new ones and especially for root crops that are mostly planted all year round. In some cases he may harvest more than one crop from the same area. The measurement of the amount of land under cultivation at one time, therefore, will not necessarily provide information on the total amount used during the year. The figures used for the model design are production figures estimated from previous year total production.

In view of the different duration of various crops, land use is summarised in total hectares per year and showed the proportion of cropped area allocated to different crops by each farm type. One can notice that land use and cropping pattern during the first year varies within farm types and among the different geographical regions. All the four root crops were included in the plan for each farm type despite variations in their respective area cultivated. The significant feature of emergent and marginal households is almost all the cultivated land is under root crops. It shows the marginal farm households in the three regions rely mostly on the root crops for food and cash with the total area cultivated less than one hectare. Emergent farm households grew less than 1.5 hectares.

Squash as a cash crop was included in the farm plan of emergent and progressive farm households in Tongatapu while kava and vanilla featured in Vava'u's emergent and progressive farm households' operating plans. A major significant difference in the total area under crops in which progressive farm households in Tongatapu (Farm 1) farmed 2.5 hectares, or 74 percent of the standard tax allotment compare to 1.5 hectares for progressive farm in Vava'u (Farm 4). The discrepancy is attributed to squash requiring more land compared to kava and vanilla. As showed in Table 11.2, 1.1ha (42%) of total cropped area is occupied by squash while 17 percent by yam. However in Vava'u, 37 percent of total cropped land is under kava and vanilla and 73 percent is under root crops.

Table 11.1: Achievement status for the goals in each model solution.

		TONGATAPU			VAVA'U			HA'APAI	
Goal	**Annual requirements**	**Progressive**	**Emergent**	**Marginal**	**Marginal**	**Emergent**	**Progressive**	**Emergent**	**Marginal**
		Farm 1	***Farm 2***	***Farm 3***	***Farm 4***	***Farm 5***	***Farm 6***	***Farm 8***	***Farm 7***
1. Home sustenance	Living costs (T$)	3600	3000	2640	2640	2820	3600	2640	2160
	Yam consumption (kg)	950	720	300	300	720	950	650	300
	Taro consumption (kg)	1200	900	900	1200	900	1200	900	1200
	Cassava consumption (kg)	800	1200	1500	1500	1200	800	1350	1500
	Kumara consumption (kg)	850	1000	400	600	1000	850	850	600
	Porker consumption (head)	3	2	2	2	2	3	2	2
2. Religious obligations	Church costs (T$)	1440	905	580	580	830	1440	750	430
	Yam consumption (kg)	300	300	50	60	300	300	200	60
	Taro consumption (kg)	200	100	30	30	100	200	100	30
	Cassava consumption (kg)	200	100	30	30	100	200	100	30
	Kumara consumption (kg)	200	90	30	30	90	200	90	30
	Porker consumption (head)	8	6	4	4	6	8	5	4
3. Risk minimisation	Poor year consumption	Achieved	Achieved	Achieved	Achieved	Achieved	Achieved	Achieved	Achieved
4. Social obligations	Social costs (T$)	480	300	180	180	240	480	180	120
	Yam consumption (kg)	600	250	30	30	250	600	200	60
	Taro consumption (kg)	400	200	30	30	200	400	200	60
	Cassava consumption (kg)	400	300	30	30	300	400	300	30
	Kumara consumption (kg)	270	170	60	60	170	270	120	60
	Porker consumption (head)	4	3	3	3	3	4	3	3
5. Profit maximisation	Surplus cash in April (T$)	3610	717	119	178	724	3000	476	128
6. Leisure time	Leisure (hours/unit)	Achieved	Achieved	Achieved	Achieved	Achieved	Achieved	Achieved	Achieved

Table 11.2: Summary of optimal farm plans compared for different farm types in model solutions and actual survey results.

	TONGATAPU									VAVA'U									HA'APAI					
Production Activity	Progressive			Emergent			Marginal			Progressive			Emergent			Marginal			Emergent			Marginal		
	Model	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*
Yam 1 (ha)	0.27	0.30	13%	0.17	0.20	21%	0.05	0.06	32%	0.27	0.30	13%	0.13	0.12	-5%	0.05	0.06	32%	0.11	0.12	6%	0.04	0.06	48%
Yam 2 (ha)	0.14	0.12	-14%	0.15	0.17	16%	0.05	0.06	24%	0.11	0.12	14%	0.06	0.06	-4%	0.04	0.06	48%	0.10	0.09	-9%	0.04	0.06	63%
Taro 1 (ha)	0.35	0.30	-13%	0.14	0.12	-17%	0.09	0.09	-6%	0.26	0.30	16%	0.13	0.12	-4%	0.08	0.06	-25%	0.11	0.12	12%	0.08	0.09	17%
Taro 2 (ha)	0.08	0.06	-25%	0.14	0.12	-16%	0.09	0.09	-6%	0.08	0.09	9%	0.05	0.06	12%	0.08	0.06	-25%	0.11	0.12	12%	0.08	0.09	17%
Cassava 1 (ha)	0.29	0.30	5%	0.27	0.30	12%	0.26	0.27	4%	0.23	0.27	19%	0.28	0.30	8%	0.25	0.30	21%	0.29	0.30	3%	0.26	0.30	19%
Cassava 2 (ha)	0.11	0.12	12%	0.21	0.20	-5%	0.26	0.27	4%	0.11	0.12	11%	0.23	0.27	16%	0.25	0.27	8%	0.28	0.30	8%	0.26	0.30	19%
Kumara 1 (ha)	0.10	0.12	25%	0.09	0.08	-8%	0.05	0.06	35%	0.08	0.09	18%	0.07	0.09	32%	0.04	0.06	60%	0.07	0.09	36%	0.04	0.06	60%
Kumara 2 (ha)	0.10	0.12	25%	0.09	0.08	-8%	0.05	0.06	35%	0.08	0.09	18%	0.07	0.09	32%	0.04	0.06	64%	0.07	0.09	36%	0.04	0.06	64%
Squash (ha)	1.05	1.21	16%	0.19	0.40	107%	-	-	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kava (ha)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.25	0.30	22%	0.17	0.20	23%	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanilla (ha)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.15	0.12	-20%	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total crop (ha)	2.48	2.67	8%	1.46	1.68	16%	0.90	0.96	16%	1.61	1.82	13%	1.19	1.33	11%	0.83	0.94	14%	1.15	1.25	9%	0.83	1.04	26%
Fallow (ha)	0.48	0.40	-15%	0.32	0.23	-28%	0.16	0.24	3%	0.39	-	-88%	0.25	0.18	-28%	0.14	0.09	-33%	0.24	0.18	-24%	0.14	0.12	-12%
Fertilise area (ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surplus T$-Apr	3611	2500	-31%	717	400	-44%	119	89	-25%	3000	1700	-43%	724	300	-59%	178	60	-66%	476	175	-63%	128	40	-69%

"NA" indicates the model cannot choose the activity

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

Minus (-) figures indicate negative percentage deviation from the model solution

Cropped area values are rounded off to 2 decimal places.

Table 11.3 summarises the total land used (in hectares and percentage) during each month and their respective percentage. It is most notable that in progressive and emergent farm households in Tongatapu, who are involved in squash, that only during the squash season is more than 44 percent and 71 percent of the available land farmed respectively. It is only with progressive farms in Tongatapu that more than 50 percent of standard tax allotment is used while for farmers in Vava'u more than 40 percent of the available land is occupied. Emergent and marginal farm households use about 32 and 24 percent respectively.

The implication of this finding is that the existing standard allotment of 3.34 hectares is not fully utilised which indicates there is potential and room for crop intensification. The result is consistent with earlier findings (Delforce, 1990; MAF, 1994b) that despite an apparent shortage of land, existing production for those who own land and have access to other's land used less than 50 percent of the total arable land available.

11.4.2.2 Analysis of labour use

Table 11.4 represents the monthly distribution of labour expressed in man-hour units for model solutions compared to the actual results in each of the representative farms in a production year. In progressive farm households in Tongatapu, August to November represents the labour peak period with more than 50 percent of family labour being used during the squash season. The minimum leisure requirement per month for each farm type was easily met and over achieved. The last row in Table 11.4 shows the average number of hours of family labour each unit contributes to agricultural activities. In progressive and emergent farm households the two labour units each contribute 25 hours and 18 hours respectively. In marginal farm households characterised with an average of one labour unit providing the agricultural labour, an average of 12 hours a week of productive agricultural work is carried out. The discrepancy in model figures compared to the actual hours is attributed to the interpretation of productive hours and estimation errors by farmers. Model solutions represent productive farm work and do not include travelling time and resting hours during the day. The data also implies that surplus labour is available, which provides an opportunity for intensification if more markets were available, and other crop activities possible.

11.4.2.3 Analysis of cash flow

In reviewing farm performances it is important to distinguish between cash and non-cash items. For some purposes it may be important to know how much cash is generated by the farm and, relatedly, how much cash is available to the farm household to meet such needs as home food consumption, church and social expenditure. The amount of cash generated by the farm that can be devoted to household purposes can be calculated by making appropriate adjustments to the farm net cash flow. Cash surpluses at the end of each production year (April) include farm cash revenue, cash borrowed plus other household receipts such as wages for any off-farm employment and remittances.

The annual cash flow in each of the representative farm models is summarised in Table 11.5. The data shows the average total income each farm household type receives and from each source. It shows significant variation among the different farmers' groups but little variation between regions.

Progressive farmers in both island groups earned more than T$10,000 a year compared to about T$5500 to T$7500 for emergent households while marginal farmers earn less than T$5500. There is little significant difference between the different regions. As expected Table 11.5 shows that agricultural income contributes more than 75 percent of total income in progressive farm households, 65 percent in emergent and about 45 percent in marginal farm households. All farmer types in each region borrowed cash, which comprised less than 10 percent of total income. Off-farm income is a more prominent source in marginal farm households (45%).

The production expenditure for associated crops and household requirements is also depicted in Table 11.5. After variable production costs, living, social and church expenditure is deducted to give the surplus cash at end of the financial year (April). The farmers indicated that this money was used for other consumption requirements, home improvement and reinvested into the farm or placed into interest bearing investments.

Table 11.6 showed the composition of agricultural income among the eight representative farms from model solutions is comparable to actual results. In terms of the total value, the solutions showed that yam, squash, kava and vanilla are the major sources of agricultural income. Progressive farm households in Tongatapu derived the bulk of agricultural income from the sale of squash (41%) and yam (39%). Emergent farm household earned 21 percent from squash and the remaining from sales of root crops. Likewise for progressive and emergent farmers in Vava'u with yam, kava and vanilla contributing 85 percent of total agricultural income. Marginal farm households, as expected, showed total reliance on selling surplus root crops for cash. They do not grow specific cash crops as emergent and progressive farms do. However, selling of pigs is also a significant source of income.

11.5 Conclusion

Most models developed for farm management have focused on the analysis of input (resource) requirements and they have generally neglected, or often ignored, the unique values and goals of smallholder farmers and their decisions structures. However, these are important factors, which greatly influence the production decision process. After the examination of Tongan smallholder farming systems from a methodological point of view, it was apparent that Tongan smallholder farmers operate in a complex environment characterised with severe resource and other constraints with conflicting multiple goals.

In this study Goal Programming is utilised because it allows the optimisation of goal attainments while permitting an explicit consideration of the existing decision environment. Perhaps its greater value is that its application highlights the dynamic relationships that exist between productive activities, technologies, constraints and farmers' objectives. With the assumption that the socio-economic rationale of the Tongan farmer is well expressed in the set of the objectives incorporated, goal programming can be very useful, particularly in the design of development policies and programs. Goal programming models may be used to explore the probable consequences of a given action or

Table 11.3: Average monthly area of cultivated land per month by farm types in model solutions and actual survey results.

	TONGATAPU									VAVA'U									HA'APAI					
MONTH	Progressive			Emergent			Marginal			Progressive			Emergent			Marginal			Emergent			Marginal		
	Model	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*
May	1.24	1.20	-3%	1.09	1.11	2%	0.81	0.84	4%	1.37	1.49	8%	1.05	1.10	4%	0.75	0.81	8%	1.01	1.05	4%	0.75	0.90	20%
June	1.34	1.32	-1%	1.17	1.19	1%	0.85	0.90	6%	1.45	1.58	9%	1.12	1.19	6%	0.79	0.90	14%	1.08	1.14	6%	0.79	0.96	22%
July	1.34	1.32	-1%	1.17	1.19	1%	0.85	0.90	6%	1.45	1.58	9%	1.12	1.19	6%	0.79	0.90	14%	1.08	1.14	6%	0.79	0.96	22%
August	2.38	2.53	6%	1.37	1.59	16%	0.85	0.90	6%	1.45	1.58	9%	1.12	1.19	6%	0.79	0.90	14%	1.08	1.14	6%	0.79	0.96	22%
September	2.38	2.53	6%	1.37	1.59	16%	0.85	0.90	6%	1.54	1.71	11%	1.12	1.22	9%	0.79	0.90	14%	1.08	1.14	6%	0.79	0.96	22%
October	2.48	2.65	7%	1.46	1.67	15%	0.90	0.96	7%	1.62	1.80	11%	1.2	1.31	9%	0.83	0.99	19%	1.15	1.23	7%	0.83	1.02	23%
November	2.48	2.65	7%	1.46	1.67	15%	0.90	0.96	7%	1.62	1.80	11%	1.2	1.31	9%	0.83	0.99	19%	1.15	1.23	7%	0.83	1.02	23%
December	1.43	1.44	1%	1.26	1.27	1%	0.90	0.96	7%	1.53	1.67	9%	1.2	1.28	6%	0.83	0.99	19%	1.15	1.23	7%	0.83	1.02	23%
January	1.53	1.32	-14%	1.17	1.19	1%	0.85	0.90	0%	1.45	1.58	0%	1.12	1.19	6%	0.79	0.90	14%	1.08	1.14	0%	0.79	0.96	22%
February	1.53	1.32	-14%	1.17	1.19	1%	0.85	0.9	0%	1.45	1.58	9%	1.12	1.19	6%	0.79	0.9	14%	1.08	1.14	0%	0.79	0.96	22%
March	1.53	1.32	-14%	1.17	1.19	1%	0.85	0.9	0%	1.45	1.58	9%	1.12	1.19	0%	0.79	0.9	14%	1.08	1.14	0%	0.79	0.96	22%
April	1.53	1.32	-14%	1.17	1.19	1%	0.85	0.90	-17%	1.45	1.58	9%	1.12	1.19	6%	0.79	0.90	14%	1.08	1.14	6%	0.79	0.96	22%
Total crop area	2.48	2.65	7%	1.46	1.67	15%	0.90	0.96	7%	1.62	1.80	11%	1.2	1.31	9%	0.83	0.99	19%	1.15	1.23	7%	0.83	1.02	23%
% Area farmed	74	79		44	50		27	29		49	54		36	39		25	30		34	36		25	31	

"% diff" indicates the percent discrepancy between model solutions and the actual survey results.

Minus (-) figures indicate negative percentage deviation from the model solution.

Cropped area values are rounded off to 2 decimal places.

Table 11.4: Summary of family labour use for agricultural purposes (in hours and percent) in each month.

	TONGATAPU									VAVA'U									HA'APAI					
Monthly Labour(hrs)	Progressive			Emergent			Marginal			Progressive			Emergent			Marginal			Emergent			Marginal		
	Model	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*
May	188	240	28%	167	240	44%	126	144	14%	189	240	27%	141	240	70%	120	144	20%	161	240	49%	119	144	21%
June	167	240	44%	141	240	70%	104	144	38%	163	240	47%	120	240	100%	98	144	47%	132	240	82%	97	144	48%
July	134	240	79%	130	240	85%	107	144	35%	135	240	78%	119	240	102%	101	144	43%	125	240	92%	101	144	43%
August	332	288	-13%	161	240	49%	79	144	82%	124	240	94%	95	240	153%	75	144	92%	94	240	155%	75	144	92%
September	260	288	11%	168	240	43%	92	144	57%	153	240	57%	111	240	116%	86	144	67%	120	240	100%	85	144	69%
October	252	288	14%	156	240	54%	92	144	57%	144	240	67%	112	240	114%	85	144	69%	112	240	114%	85	144	69%
November	344	288	-16%	191	240	26%	108	144	33%	136	240	76%	122	240	97%	102	144	41%	127	240	89%	103	144	40%
December	144	180	25%	116	120	3%	86	100	16%	145	120	-17%	108	120	11%	81	100	23%	105	120	14%	80	100	25%
January	161	180	12%	131	120	-8%	89	100	12%	164	120	0%	115	120	3%	84	100	19%	116	120	0%	83	100	20%
February	152	240	58%	130	240	85%	106	144	36%	151	240	59%	125	240	92%	101	144	43%	125	240	0%	101	144	43%
March	114	240	111%	102	240	135%	75	144	92%	122	240	97%	90	240	0%	71	144	103%	91	240	0%	70	144	106%
April	157	240	53%	162	240	48%	144	144	0%	154	240	56%	128	240	88%	137	144	5%	165	240	45%	137	144	5%
Total family	***2405***	***2952***	***23%***	***1755***	***2640***	***50%***	***1208***	***1640***	***36%***	***1780***	***2640***	***48%***	***1386***	***2640***	***90%***	***1141***	***1640***	***44%***	***1473***	***2640***	***79%***	***1136***	***1640***	***44%***
Hired labour		240																						
hrs/week	***25***	***28***	***14%***	***18***	***25***	***41%***	***13***	***16***	***21%***	***19***	***25***	***34%***	***14***	***25***	***81%***	***12***	***16***	***31%***	***15***	***25***	***69%***	***12***	***16***	***31%***

"% diff" indicates the percent discrepancy between model solutions and the actual survey results.

Minus (-) figures indicate negative percentage deviation from the model solution.

Table 11.5: Summary of annual cash flow in the representative farms model solutions compared to the actual survey results.

REGION				TONGATAPU									VAVA'U						HA'APAI					
FARMER TYPE	Progressive			Emergent			Marginal			Progressive			Emergent			Marginal			Emergent			Marginal		
Model Farm	*Farm 1*			*Farm 2*			*Farm 3*			*Farm 4*			*Farm 5*			*Farm 6*			*Farm 7*			*Farm 8*		
	Model	*Actual*	*%dev*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*	*Model*	*Actual*	*% diff.*
Income (T$,000)	12.59	11.10	-12%	7.49	6.58	-12%	4.52	3.80	-16%	10.56	8.22	-22%	6.04	6.58	9%	4.42	3.77	-15%	7.49	6.58	-12%	4.53	3.50	-23%
Farm Income	10.09	8.40	-17%	5.37	4.25	-21%	1.88	1.55	-17%	8.54	6.50	-24%	3.92	3.54	-10%	1.85	1.50	-19%	5.37	4.45	-17%	1.87	1.65	-12%
Cash Borrowed	0.30	0.50	67%	0.40	0.00	-100%	0.40	0.00	-100%	0.30	0.00	-100%	0.40	0.30	-25%	0.30	0.00	-100%	0.40	0.30	-25%	0.55	0.00	-100%
Off-farm income	2.20	2.20	0%	1.72	1.72	0%	2.25	2.25	0%	1.72	1.72	0%	1.72	1.72	0%	2.27	2.27	0%	1.72	1.72	0%	2.11	1.85	-12%
Expenditure (T$)	9.80	8.82	-10%	6.70	5.85	-13%	4.46	3.66	-18%	7.96	7.08	-11%	5.82	5.61	-4%	4.41	3.69	-16%	6.70	6.15	-8%	4.43	2.81	-37%
Production cost	3.98	2.80	-30%	2.10	1.65	-21%	0.66	0.49	-26%	2.14	1.56	-27%	1.53	1.42	-7%	0.76	0.35	-54%	2.10	1.65	-21%	1.17	0.48	-59%
Living cost	3.60	3.60	0%	3.00	3.00	0%	2.64	2.64	0%	3.60	3.60	0%	2.82	2.82	0%	2.64	2.64	0%	3.00	3.00	0%	2.16	1.78	-18%
Social cost	0.48	0.48	0%	0.30	0.30	0%	0.18	0.14	0%	0.48	0.48	0%	0.24	0.24	0%	0.18	0.18	0%	0.30	0.30	0%	0.12	0.12	0%
Church cost	1.44	1.44	0%	0.90	0.90	0%	0.58	0.40	-31%	1.44	1.44	0%	0.83	0.83	0%	0.52	0.52	0%	0.90	0.90	0%	0.43	0.43	0%
Loan repayments	0.30	0.50	66%	0.40	0.00	-100%	0.40	0.00	-100%	0.30	0.00	-100%	0.40	0.30	-25%	0.30	0.00	-100%	0.40	0.30	-25%	0.56	0.00	-100%
Surplus T$-Apr	3.61	2.70	-25%	0.72	0.33	-55%	0.12	0.05	-62%	3.00	2.35	-22%	0.72	0.33	-55%	0.12	0.05	-62%	0.48	0.15	-70%	0.13	0.05	-65%

"% diff" indicates the percent discrepancy between model solutions and the actual survey results.

Minus (-) figures indicate negative percentage deviation from the model solution.

Cropped area values are rounded off to 2 decimal places.

Table 11.6: Percentage composition of agricultural income composition for each representative farm in the model solutions compared to actual results.

	Tongatapu						Vava'u						Ha'apai			
Production	Progressive		Emergent		Marginal		Progressive		Emergent		Marginal		Emergent		Marginal	
Enterprise	Model	Actual	Model	Actual	Model	Actual	Model	Actual	Model	Actual	Model	Actual	Model	Actual	Model	Actual
Farm Income (T$)	10093	8400	5370	4250	1875	1550	8536	6500	3920	3540	1850	1500	5370	4450	1874	1650
Yam sales (%)	39	36	46	36	52	55	38	31	34	29	54	47	63	56	48	42
Taro sales (%)	12	8	14	18	18	16	9	8	8	9	10	7	14	11	11	6
Cassava sales (%)	4	4	3	7	15	7	3	5	3	3	4	7	4	7	4	0
Kumara sales (%)	3	6	5	11	5	6	2	5	5	9	3	7	5	9	3	3
Squash sales (%)	41	46	21	28	0	0	-		-		-		0		0	0
Kava sales (%)	-		-		-		35	37	51	37	0	0			-	
Vanilla sales (%)	-		-		-		12	15	0	0	0	0	-		-	
Porker sales (%)	0		10	0	27	16	0		10	14	29	33	14	17	34	49

"% diff" indicates the percent discrepancy between model solutions and the actual survey results.

Minus (-) figures indicate negative percentage deviation from the model solution.

Cropped area values are rounded off to 2 decimal places.

innovation for the farm as a whole. In turn, this exploration can lead to a new conclusion concerning the functioning of the farming systems and its dynamics.

The results of the model verification and validation exercise would suggest that the models generally perform satisfactorily and they have sufficient validity to warrant their use as a policy analysis tool. It is appropriate, however, to consider those aspects of the models where the model solutions deviated from the actual practices. The causes and implications of such deviations should be noted in the interests of ensuring careful use of the models. Deviant projections can probably be attributed to one of two possible causes; either the model structure is different from the real world system, or the data available to estimate model relationships, and to run the models, are imperfect. Since the essence of modelling is to provide a simplified representation of a real world system, some structural imperfection is inevitable and acceptable if the model as a whole performs satisfactorily.

With respect to imperfect data for estimating structural relationships and running the model, these may be lead to deviant projections but not necessarily invalidate the underlying structural assumptions. As mentioned earlier in this study, in relation to various aspects of system analysis, some deficiencies seem likely to be present in the data used in model construction and operation. In particular, expenditure, consumption, and production relationships are likely to be affected to some extent. The apparent validity of the model in the light of the structural simplifications and data deficiencies mentioned above, would suggest that the model structure is basically sound and that the modelled system is relatively insensitive to the various effects of imperfect data.

The GP approach is appropriate for budgeting and planning in smallholder farming situations. However, the GP model requires the farmers to be capable of defining, quantifying and ordering objectives and provides the best solution under the given constraints and priority structure. The purpose of this study is to use GP to model the complex decision problems in Tongan smallholder farmers' land use decisions. The eight representative farm models presented are a good illustration. However, each goal may benefit from further in-depth analysis as would the interactions between the major components of farming systems, social cultural, economic and institutional environments, farmers goals and priorities. The results of this research will provide a more realistic picture which can be built on in the future.

In the next chapter, the model for each representative farm type is put to its intended purpose with a series of experiments to examine and to explore the effects of various policy instruments. The results should assist the Government in designing policies that are effective in the achievement of farmers' goals and objectives, and on the output changes relative to Tonga's balance of payments objectives.

CHAPTER 12

MODEL IMPLEMENTATION AND APPLICATION

12.1 Introduction

Improving the material well-being of Tongans requires practical and achievable economic development. The model was developed and designed to allow the assessment of possible policy changes designed to achieve this objective. In this section representative farm models were used to analyse some of the different policy issues (economic and institutional) facing the different smallholder farm types discussed in earlier chapters. The models were used to predict the likely consequences of changes in cropping systems in terms of production, input demand, credit needs and employment. The impact of different policy instruments on farm household production is evaluated against the results of a base-run of each farm type model, in which the current production activities and consumption behaviour of the corresponding household types are reflected.

12.2 Modelling Different Policies

The system analysis in Part 2 revealed the need for the Government to give more priority to agriculture and better agricultural development planning by setting appropriate policies for improved agricultural resource use. There is a need to identify effective policy instruments that have significant influence on smallholder farmers' land use decisions.

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 reform 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 would 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. As discussed in Chapters 6 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.

Policy experiments and analysis were focussed on major areas which the government policies may have a major influence. In particular, major policy instruments include land; market, technology, labour and credit systems and these are explored in this study. The major policy options were explored using the basic model. The results and policy implications are presented and discussed in this section.

12.2.1 Modelling land reform policies

In agriculture the control of land resources is the most important determinant of employment, investment and the distribution of income within the traditional agriculture. Obviously the control of land is important because it determines how much of the land is brought into production. The problems with the existing land tenure system and the increasing number of people without land in Tonga and the case for a broader reform of institutional structures of land distribution has been discussed in Chapter 7. It is widely acknowledged that the indigenous Tongan land tenure system is a constraint on land productivity. The findings from this study indicate not only an increasing number of people without land, but also that many smallholder farmers have the resource capacity, time and commercial initiative to utilise more land than they command. Understandably most farmers are reluctant to develop their lands to any substantial extent unless they are certain that the improved lands 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.

Land reform involves change in the rights to agricultural property and the income derived by virtue of ownership of that property. The full case for broader land reform, therefore, rests upon the need to encourage on-farm investments and production for export, to increase productive employment in agriculture, and to prevent an even greater migration of families from rural to urban areas. However, because land rights are considered to be a cornerstone of Tongan society, any major land reform is essentially a political and social phenomenon and will take time to implement.

There are a wide variety of possible reforms of land systems. Delforce (1990) noted different strategies for land reform have been suggested to mitigate the problems of landlessness and improve access to land (Delforce, 1990; Sevele, 1973; Hardaker, 1975; Fukofuka, 1994). Some reforms may modify claims to income from land without effecting any change in the existing distribution of land or pattern of land holdings. For example, Maude (1965) and Hardaker (1975) proposed imposing a progressive land tax on idle land to discourage non-users from retaining their land. However, for political reasons this reform was not implemented since it would have the greatest impact on the major estate holders, the Nobles, Crown and the Government. Moreover, the definition of idle land might be problematic, given the traditional practice of fallowing. In 1999, a proposed land reform was put forward to Parliament which argues strongly for the abolishment of absentee land ownership by people who are residing overseas permanently. However, the proposed reform met with government resistance, mainly because the government feared that goods and money remits by these same absentee landowners might cease if their land rights were removed.

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. A reform of this kind, with an upper limit determined by some criteria of sufficiency, would appear to have the following merits: it would prevent the market from becoming the determinant of ownership of land; it would not necessarily interfere with the pricing mechanisms as a means of allocating resources other than land; it would encourage the adoption of land augmenting technological changes on individual farms and long term investments (eg. perennial crops), and it would also contribute to more equity development. The implementation of such land reform would not be easy to administer; however, it would be a "once for all affairs" and would be less demanding of administrative expertise than continuing direct taxation and administrative redistributions of income. The objectives of pre-emptive structural reforms would seem to require at least the greater security of tenure to encourage on-farm investments. However in the Tongan situation, where traditional agriculture is widespread, a ceiling on the size of holdings would seem to be a most appropriate form of pre-emptive structural change.

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 12.1 and 12.2 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 12.1). The social requirement for porkers was partially achieved. In addition, significant changes in the farm operating plan occurred (Table 12.2) 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 12.1: 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 12.2: Summary of Tongatapu emergent farmers' farm plan under different allotment sizes.

Production activity	3.34 ha	1.67ha	Change	1.11ha	Change	0.835ha	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%

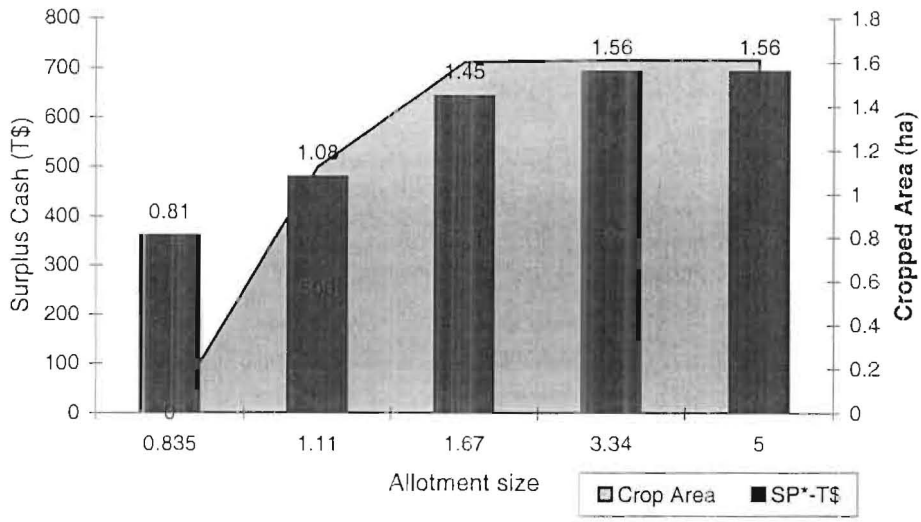
"Change" indicates the percentage deviations in values compare to the initial model (3.34 ha).

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

Cropped area values are rounded off to 2 decimal places.

Figure 12.1 summarises the effects of parametric variations of allotment size on respective cropped areas and surplus cash derived at the end of the production year in an emergent farm household in Tongatapu.

Figure 12.1: Summary of total cropped area and surplus cash under different allotment sizes.



SP*-T$ = surplus cash at end of the year

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. Table 12.3 summarises the effects of subdivision of existing allotments to 1.67 and the 1.11 hectares on progressive farm households in Tongatapu and Vava'u. Land Reform 2 shows the greatest impact on Progressive farmers in Tongatapu (Farm 1), with total cropped area reduced by 56 percent. 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. There were no significant effects on the Vava'u progressive household situation (Farm 4) at 1.67 hectares; however at the 1.11 allotment size (Land Reform 2) the surplus cash and the total cropped area were reduced by 27 and 31 percent respectively, and with kava being entirely excluded from the plan.

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 12.2, 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.

Table 12.3: Effects of reducing allotment size on progressive farm households' land use plans.

Production activity	FARM 1 : Tongatapu					FARM 4 : Vava'u				
	3.34	*1.67*	*Change*	*1.11*	*Change*	*3.34*	*1.67*	*Change*	*1.11*	*Change*
Yam 1 (ha)	0.27	0.27	0%	0.27	0%	0.27	0.27	0%	0.28	4%
Yam 2 (ha)	0.14	0.26	82%	0.17	21%	0.11	0.11	0%	0.11	5%
Taro 1 (ha)	0.35	0.35	0%	0.23	-34%	0.26	0.26	0%	0.13	-50%
Taro 2 (ha)	0.08	0.08	0%	0.08	0%	0.08	0.08	0%	0.08	-1%
Cassava 1 (ha)	0.29	0.29	0%	0.11	-63%	0.23	0.23	0%	0.11	-53%
Cassava 2 (ha)	0.11	0.11	0%	0.11	0%	0.11	0.11	0%	0.11	0%
Kumara 1 (ha)	0.10	0.10	0%	0.06	-43%	0.08	0.08	0%	0.06	-25%
Kumara 2 (ha)	0.10	0.10	0%	0.06	-43%	0.08	0.08	0%	0.08	0%
Squash (ha)	1.05	0.12	-89%	0.00	-100%	NA	NA	NA	NA	NA
Kava (ha)	NA	NA	NA	NA	NA	0.25	0.25	0%	0.00	-100%
Vanilla (ha)	NA	NA	NA	NA	NA	0.15	0.15	0%	0.15	0%
Total crop (ha)	2.48	1.67	-33%	1.08	-56%	1.70	1.70	0%	1.11	-31%
Fallow (ha)	0.48	-	-100%	-	-100%	0.39	0.12	-69%	-	-100%
Fertilise area (ha)	0.00	0.44	100%	0.33	100%	-	0.27	100%	0.30	100%
Surplus T$-Apr	3611	3547	-2%	2640	-27%	3000	3000	0%	2187	-27%

"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.

Farm 1= Tongatapu progressive farm, Farm 4= Vava'u progressive farm

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 that any government policy decisions regarding further subdivisions of existing tax allotments, into two (1.67 ha) allotment sizes appear to adequately provide the food and cash needs for the average family. Therefore, division of existing 3.34 hectares holdings into 1.67 hectares units seems advisable and thus supports recommendations by Maude (1965) and Hardaker (1975). 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 investment in longer term for 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.

Clearly, the non-use of agricultural land is at variance with the current development needs of Tonga and some means must be developed to bring as much of this land as possible into production. It is suggested that regulations should be promulgated to restrict the maximum area of land held by any individual, including nobles, and to ensure that as much of the remaining undistributed land is reallocated as tax allotments to landless households. 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.

12.2.2 Impact of market policies

One way in which the behaviour of Tongan farmers can be modified to achieve national development objectives is by providing them with appropriate economic incentives. Many of the innovations that could be included in an agricultural development strategy have their impact on farmers only indirectly through input delivery or output markets. Farmers might be encouraged to intensify production or diversify production by making available cheap inputs, by offering high returns on their outputs, or by reducing the market risks they face. In addition a new technology might be profitably adopted by some farmers only if there are some complementary changes made in the markets. In this sub-section the opportunities for encouraging agricultural development in these ways are explored. Activities in a programming model will not only be confined to production; marketing activities carried out by the farm households will also often be present, and market reforms may have their impact directly on these activities.

12.2.2.1 Output prices

Market innovations may be embodied in institutional or infrastructural developments, 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. Such developments may save some of the time that farm-household members must devote to selling farm produce and to buying farm and household requisites. Because improvements in input and output marketing most directly affect prices and net revenue, it is appropriate to evaluate them in the model. To examine the operation of the different models under different price conditions, 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 12.4 to 12.6. 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 12.4, 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 squash area. The increased 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 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 12.4: Effects of squash price variations on progressive and emergent farms in Tongatapu.

Production activity		Emergent				Progressive				
	Basic	*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 12.5 and 12.6, 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.

12.2.2.2 Market Avenues

As discussed in Chapter 5, marketing has always dominated the list of constraints facing agricultural development in Tonga. The key issue always raised by farmers is "*Are there markets for the increased agricultural output*?" The emphasis on agricultural marketing is now firmly with the private sector. Government continues to intervene in some marketing areas chiefly by licensing exporters, market research and development, as well as quality control. Recently, the government has been seeking agreements on market access for farm produce in other countries, such as Fiji and the Samoas. Negotiations have entailed the establishment of quarantine protocols. Market innovation also includes market research and development. It is important for policy makers to predict the likely farmer responses to new market opportunities for existing and new crops. New marketing avenues, which mean that more constraints on what that can be sold may be relaxed, or including new cash commodities, can be incorporated into the model as new activities.

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 12.7 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 12.5: 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 12.6: 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 12.7: 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 avenues 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 showed in Table 12.7, 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. Improvement is required in market arrangements to give producers better and more secure rewards for their efforts in producing crop and animal products for sale. The most promising developments in this area have been through the expansion of vanilla, squash and kava sales in recent years. Improvement is also required in exports of traditional root crops. As noted in Chapter 5, export of root crops is mainly targeted at the Pacific Island communities overseas. Fleming and Hardaker (1995) claimed that Tonga's performance in exporting root crops to New Zealand and Australia has been poor compared to Western Samoa. Apparently the Samoans have established a formal wholesale and retail network, whereas much of the Tongan produce is distributed through informal family and church networks. As a result both stock management and payments are unreliable as some sellers prefer to travel to the destination market to do their own marketing and to collect the money. In 1994, MAF proposed the Government should purchase land for setting up a marketing centre and facility in Auckland. However, decisions on the proposed export market reform would require an appropriate feasibility assessment; in addition, such a venture would be costly.

In the area of local market reform, probably the least activity has taken place. The fieldwork revealed that poor market infrastructures in the outer islands is a constraining factor for domestic sales of agricultural produce. There is a need for improvements in market facilities, such as the establishment

of an appropriate market centre in Ha'apai Islands, and in main roads and transportation for Vava'u. These infrastructure facilities are important to boost agricultural production, however, the government does need to carry out a feasibility study to assess the benefits and cost.

12.2.3 Effects of Improved Technology

Agricultural research and extension have become a significant component of agricultural development. Technological change can be an appropriate part of agricultural development. Appropriate crop production technologies not only increase the efficient use of land, labour, and capital, but also hasten the farmer's adoption of viable and economic production technologies. Improved technology can reduce the marginal cost of production by offsetting the scarcity of one or another conventional agricultural resource; for example, the introduction of new varieties of seeds and inorganic fertilisers is substantially offsetting the scarcity of land in several countries. For successful crop husbandry, the main activities of agricultural research include: soil fertility evaluation trials, crop management trials, screening of cultivars under different environments, development of new cropping patterns, improved tillage practices, crop protection methods, water management, and post-harvest studies. These activities must, however, be carried out both in the ideal conditions of research stations, and on practising farm situations.

The quality of research in terms of achievements depends upon two things: the capability of the researcher and the availability of adequate research facilities. The single most crucial factor in agricultural research is the availability of well-qualified and adequately trained technical manpower capable of solving complex farm problems. Therefore, a good research system derives from multidisciplinary research establishments, highly qualified manpower, adequate fund allocations, and proper research management and co-ordination. As discussed in Chapter 5, the present main research establishment in the country is centralised in Tongatapu. The lack of proper research facilities, infrastructure and manpower resources are the main constraints to broadening the scope of research activities and undertaking worthwhile research to other sub-regions of different agro-ecological zones (Vava'u and Ha'apai).

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 Tongan 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 that improve yield and productivity. In this model experiment, productivity improvement measures are assumed to increase root crop yields by at least 20 percent of current base yields.

The effect of introducing improved production technologies under prevailing conditions is reflected in the technological change simulation. Table 12.8 summarises the effects of improved management technologies that increase the yield for root crops. It shows that with improved 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 12.8: 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.

As would be expected making available improved technologies allows subsistence requirements to be satisfied from a smaller land area, with resultant increases in market surplus both of the staple crops and of cash crops. Continuing effort is therefore needed to strengthen the basic support services for Tonga's agriculture; particularly crucial is technical and advisory assistance, through an effective extension service, agricultural research, and improved marketing facilities. The problem of limited land resources can be reduced by focusing on crop productivity improvement techniques either through the use of field tested improved cultivars, improved management, or improved plant nutrition through judicious use of organic and inorganic fertilisers.

The survey results also revealed a discrepancy in yields from on-station research trials compared to the average yield farmers get for some of the major crops (Fakava and Pole, 1994). In addition, productivity varies between households and different farmer categories indicating there is already

scope for more widespread dissemination of improved technologies. There are opportunities to strengthen indigenous organic farming methods and techniques, and to explore progressive entry into the expanding niche market for organically grown products which command premium prices (eg. vanilla, banana, squash and vegetables). It has been suggested that there is a lack of interaction between farm, extension and research systems in Tonga. Fieldwork revealed that farmers are not adopting the best available technologies. This may be because the technologies being extended are not well matched to the needs and circumstances, or it may be that improvements are needed in the way extension is conducted.

The farming systems research and extension approach may offer a means of improving the collaboration between users, producers and disseminators of improved technologies. This problem has been a key consideration in the recent restructuring of the MAF Research and Extension division to allow more qualified staff to be in the field and in regular contact with farmers. However agricultural research and extension is hampered by financial and manpower resources which tend to restrict research activities to on-station based research, with little on-farm trials to develop better understanding of farm-level realities of smallholders. This makes it particularly important to give priority to a more effective programs of agricultural research to develop improved production and marketing technologies which are suitable for existing conditions and can be widely adopted by smallholders. As noted in Chapter 7 the practice of indigenous technology by farmers is still common thus indicates the need for MAF researchers to consider for further validation.

One of the technical problems facing Tongan agriculture, especially with the decreasing land resources as discussed in Chapter 7, concerns crop rotations and soil fertility. The general findings from the survey is that a shift from subsistence to semi-subsistence farming, and a move toward commercial farming, has been the major development in agriculture during the last 20 years. Farmers still practice a system of mixed cropping, but due to the shortage of land the length of fallow has been reduced, and the system of farming is exposed to higher inputs such as machine cultivation, use of chemicals and fertilisers and more intensive farming. With limited land resources and declining soil fertility problems, perhaps the most useful type of technological innovation should involve improvement in fallowing practices or application of fertiliser and other soil fertility management techniques which allow greater cropping intensity to be sustained. It raises the issue of the urgent need for research and development work to develop crop rotations and farm production methods which are not only attractive and viable to farmers, but also sustainable in maintaining the soil's productive capacity. Recommendations for further research should include:

(i) Use of legumes (eg. *Dolichos lablab* – Tongan bean) as a short-term fallow.

(ii) Use of a more balanced crop rotation pattern with a legume crop as part of the rotation eg peanuts.

(iii) Use of intercropping, especially using long-term crops such as kava and vanilla to help retain the soil structure.

(iv) Improved cultural practices (eg. Mulches, organic fertilisers).

(v) More livestock-crop interaction, especially proper use of manure for soil fertility management.

(v) Improving the level of education of the rural work force through agricultural education in schools, farmer training, and the distribution of essential information to farmers.

The fieldwork also revealed that one impediment to the expansion of production was the shortage of planting material, especially kava, vanilla, colocasia taro and vegetables. Establishment of a tissue culture laboratory and nursery plots in main regional centres would provide the Ministry of Agriculture and Forestry with a ready means of disseminating improved crop varieties as well as overcoming the problem of planting material shortages.

Another area where the farmers need help is the maintenance of crop quality. As discussed in Chapter 5 and revealed during the fieldwork, the current capacity to produce quality crops is less than desirable and lower quality is a major factor contributing to the loss of markets, such as the demise of the banana industry. MAF (1994c) noted the high rejection rate for current export crops such as squash and vanilla had been a major problem in 1993 and 1994. In response, the Ministry set up a Quality Management and Control system in the Quarantine division. Farmers need regular access to advice on improved cultural practices and control of pests and diseases. The MAF Research and Extension service of the ministry, therefore, has a major role to play in the dissemination of relevant knowledge to improve management skills on pest and disease control as well as quality improvement.

12.2.4 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 as discussed in Chapter 9. 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).

Labour 3: Family monthly labour supply of 480 hours (basic- 2 adult).

The achievement status of goals and the corresponding farm plans generated for the basic model with parametric variation in family labour availability are summarised in Tables 12.9 and 12.10 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.

The pattern of land use resulting from 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 results also showed that labour requirements in some months are supplemented by hired labour (a total of 50 hours of hired laboured 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 12.9: Achievement status for goals for variation in family labour supply.

Goal	Annual requirements	Farm 2	Labour1	Labour 2
		480 hrs	*240 hrs*	*180 hrs*
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
	Hired Labour (hrs)	0	50	255

A = Achieved, PA = Partially achieved

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

Farm 2 = Tongatapu emergent farm

Table 12.10: Summary of emergent farm plan under different family labour supply levels.

Production activity	Basic	Labour 1	Change	Labour 2	Change
	480 hrs	*240hrs*		*180 hrs*	
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 issues discussed in Chapter 9 of young people from more remote islands like Ha'ano to Tongatapu for further education and employment opportunities, which reduces family labour available. This implies that when labour resource is a limiting resource, farmers will give more priority to home food requirements. The results also indicate the effects when farmers give more value to leisure or off-farm employment relative to time given to agricultural activities.

12.2.5 Effects of Off-farm Earnings

Farm household labour supply is important both as a farm production input and in other ways. 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. As noted in Chapter 11, 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 12.11. 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 (as shown in Table 11.5). Farms 2 and 3 showed that the goals were not achieved at both zero and T$50 off-farm income levels. As Table 12.11 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.

Changes also occurred in the associated farm plans and the amount of surplus cash generated. The effects of off-farm income levels on production farm plans are summarised in Table 12.2 and Figure 12.2. Progressive and emergent farm households, despite variation in their respective cash surplus and total areas cropped, showed similar responses to changes in off-farm income level. In both cases, with off-farm income below T$120, more crops were grown but there was a lower cash surplus. However, with off-farm income of more than T$120, both the total cropped area and the cash surplus increased. A different outcome was observed in marginal farms (Farm 3), where there was a significant decrease in the total cropped area as off-farm income decreased.

Table 12.11: 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), such as for the purchase of non-staple food, household consumption needs, church obligations and some social needs. 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

Table 12.12: Effect of varying off-farm income levels on the achievement of goals for the three main farm types in Tongtapu.

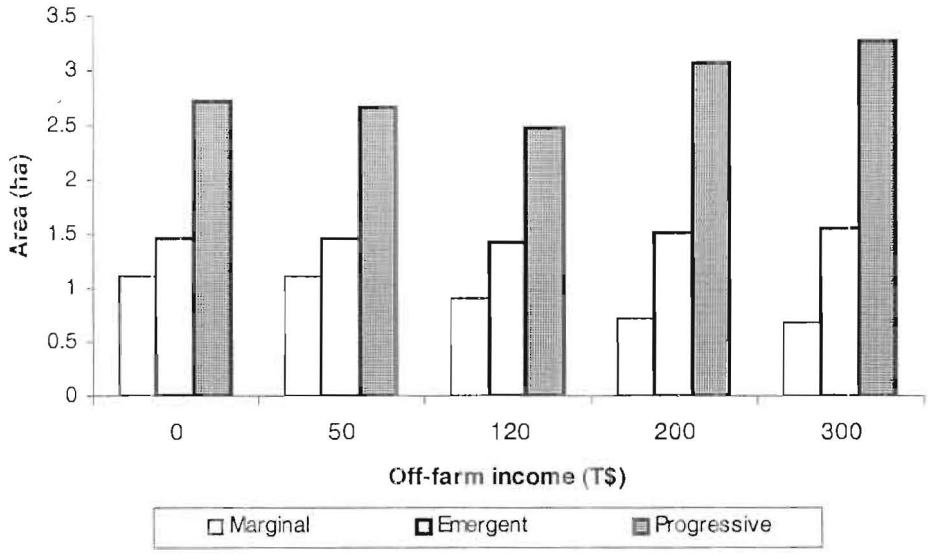
Goal	Annual requirements	Marginal FARM 1				Emergent FARM 2				Progressive FARM 3			
	Off-farm income (T$)	***0***	***50***	***200***	***300***	***0***	***50***	***200***	***300***	***0***	***50***	***200***	***300***
1. Home sustenance	Living costs (T$)	3600	3600	3600	3600	3000	3000	3000	3000	2346 (-294)	2346 (-294)	2640	2640
	Yam consumption (kg)	950	950	950	950	720	720	720	720	300	300	300	300
	Taro consumption (kg)	1200	1200	1200	1200	900	900	900	900	900	900	900	900
	Cassava consumption (kg)	800	800	800	800	1200	1200	1200	1200	1500	1500	1500	1500
	Kumara consumption (kg)	850	850	850	850	1000	1000	1000	1000	400	400	400	400
	Porker consumption (head)	3	3	3	3	2	2	2	2	2	2	2	2
2. Church obligations	Church costs (T$)	1440	1440	1440	1440	905	905	905	905	80 (-500)	80 (-500)	580	580
	Yam consumption (kg)	300	300	300	300	300	300	300	300	50	50	50	50
	Taro consumption (kg)	200	200	200	200	100	100	100	100	30	30	30	30
	Cassava consumption (kg)	200	200	200	200	100	100	100	100	30	30	30	30
	Kumara consumption (kg)	200	200	200	200	90	90	90	90	30	30	30	30
	Porker consumption (head)	8	8	8	8	0 (-6)	0 (-6)	6	6	2 (-4)	2 (-4)	4	4
3. Risk minimisation	Poor year consumption	A	A	A	A	A	A	A	A	A	A	A	A
4. Social obligations	Social costs (T$)	480	480	480	480	253 (-47)	300	300	300	30 (-180)	30 (-180)	180	180
	Yam consumption (kg)	600	600	600	600	250	250	250	250	30	30	30	30
	Taro consumption (kg)	400	400	400	400	200	200	200	200	30	30	30	30
	Cassava consumption (kg)	400	400	400	400	300	300	300	300	30	30	30	30
	Kumara consumption (kg)	270	270	270	270	170	170	170	170	60	60	60	60
	Porker consumption (head)	4	4	4	4	2(-1)	2(-1)	3	3	3	3	3	3
5. Profit maximisation	Surplus cash in April (T$)	3079	3297	3611	3951	4354	492	1088	1517	0	0	475	899
6. Leisure time	Leisure (hours/unit)	A	A	A	A	A	A	A	A	PA	PA	A	A

A = Achieved, PA = Partially achieved

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

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.

Figure 12.2: Summary of total cropped area under scenarios of different levels of off-farm income for representative farm types in Tongatapu.



12.2.6 Effects of Credit policies

Another production incentive often used in agricultural policy is the provision of credit. The credit facilities available to farmers have been discussed in greater depth in Chapter 5. With respect to credit, the level of short or long-term borrowing is determined by the farmer's capacity to repay a loan and his willingness to borrow. The current interest rate and term for possible loans was specified in the credit component of the model. As shown earlier in Chapter 11, credit accounts for less than 10 percent of total income and varies among the three main farm types.

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 12.13. 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 12.13: 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	3000	0.89	474	0.83	129
5	1.61	3000	0.89	474	0.83	128
8	1.61	3000	0.89	475	0.83	128
12	1.61	3000	0.89	475	0.83	50
15	1.61	3000	0.89	475	0.83	50

* IR = Interest Rate

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

12.2.7 Modelling risk

As noted earlier, due to risk aversion behaviour, smallholder farmers undertake certain enterprises strictly to meet household's subsistence food requirements. Drought and climatic hazards present major risks in semi-subsistence farming. The three representative farm models on Tongatapu are used to explore situations when production and yield face varying levels of risk. The risk yield estimates were based on information from MAF agronomists. Two main scenarios were used:

Risk 1 : There is a medium yield reduction in poor years as follows: yam(16%), taro(23%), cassava (48%), kumara (28%) and squash (13%).

Risk 2 : There is a drastic yield reduction in poor years as follows: yam(32%), taro(41%), cassava (61%), kumara (44%) and squash (50%).

Table 12.13 summarises the modelled effects of these yields reductions. Risk 1 showed no significant effect on total cash surplus for all farm types. However there was significant variation in the total cropped area with increases of 20 percent for progressive, and 3 percent for emergent, and no effect for marginal farms. In the Risk 2 situation, there was a 42 percent increase in the total cropped area for both emergent and progressive farms, and a corresponding 10 and 30 percent reduction in surplus

cash, respectively. For marginal farm households, the total crop area increased by 33 percent and surplus cash reduced by at least 33 percent.

The results indicate the significance of production risk management behaviour among Tongan smallholders. Fieldwork results showed that with farmers' experience of traditional root crops, they have a fair idea of yield discrepancy between poor and good years for specific crops. Consequently they always produce in excess for food security reasons. This raises an important issue for MAF Research and Extension in terms of the development of improved technologies and information for assisting farmers to reduce yield risk eg. drought and disease resistant cultivars, and better management techniques and practices such as irrigation, and the use of fertilisers. Market price risk was not explored using the model but it was raised in the fieldwork. This included a suggestion for a price support scheme whereby farmers would receive a guaranteed price for their output, regardless of the prevailing market price. This could apply to squash and vanilla where the fluctuation in price is seen as a risk, and discourages some farmers. Some respondents also raised the lack of a crop insurance facility and support to help farmers in sharing the burden of losses occurring in agriculture as a result of disasters, whether natural (drought, hurricane, hail, etc.) or man made fires beyond farmers' control. Thus the suggestion for government to establish a reserve fund to serve as a cushion for such crop losses.

Table 12.14: Effects of yield risk on different farm types in Tongatapu.

Production activity	Progressive					Emergent					Marginal				
	Basic	*Risk1*	*% Change*	*Risk2*	*% Change*	*Basic*	*Risk1*	*% Change*	*Risk2*	*% Change*	*Basic*	*Risk5*	*% Change*	*Risk*	*% Change*
Yam 1 (ha)	0.27	0.27	0%	0.27	0%	0.17	0.17	-1%	0.18	8%	0.05	0.05	0%	0.06	26%
Yam 2 (ha)	0.14	0.21	46%	0.68	384%	0.15	0.15	-1%	0.45	201%	0.05	0.05	0%	0.13	169%
Taro 1 (ha)	0.35	0.35	0%	0.35	0%	0.14	0.14	3%	0.14	3%	0.09	0.10	6%	0.18	91%
Taro 2 (ha)	0.08	0.08	0%	0.37	355%	0.14	0.14	3%	0.34	140%	0.09	0.09	0%	0.09	0%
Cassava 1 (ha)	0.29	0.29	0%	0.29	0%	0.27	0.27	1%	0.27	1%	0.26	0.26	0%	0.26	-2%
Cassava 2 (ha)	0.11	0.11	0%	0.11	0%	0.21	0.21	1%	0.21	1%	0.26	0.26	0%	0.26	-2%
Kumara 1 (ha)	0.10	0.10	0%	0.29	200%	0.09	0.12	35%	0.25	176%	0.05	0.09	93%	0.15	224%
Kumara 2 (ha)	0.10	0.10	0%	0.29	200%	0.09	0.09	-2%	0.09	-2%	0.05	0.05	0%	0.07	47%
Squash (ha)	1.05	1.48	41%	0.88	-16%	0.19	0.19	-1%	0.13	-33%	0.00	0.00	0%	0.00	0%
Total crop (ha)	2.48	2.98	20%	3.53	42%	1.45	1.49	3%	2.06	42%	0.90	0.94	5%	1.19	33%
Surplus T$-Apr	3611	3576	-1%	3264	-10%	717	715	0%	500	-30%	119	119	0%	80	-33%

"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.

12.3 Modelling farmer's goals and priorities

Given that the representative models developed in this study are useful for analysis of individual policy instruments, further consideration is given in this section to using the models for assessing the value and importance of the goals and priorities of different farm types. A series of experiments using the eight representative farm models was conducted. These explored the significance of non-economic and social goals that characterise Tongan smallholder farmers most importantly, church and social obligation and leisure goals.

12.3.1 Modelling the significance of church and social obligations

Chapter 9 identified the strong influence, if not dominance, of religious and socio-cultural considerations on Tongan household farming decisions and activities. This takes the form of strict observance of social norms and customs, including religious beliefs and practices. 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 surplus cash April (0.0001)
Church 2: Less weight on church obligation (0.0001) in favour of surplus cash April (0.1)
Social 1: More weight on social obligation (0.1) and less on surplus cash April (0.0001)
Social 2: Less weight on social obligation (0.0001) in favour of surplus cash April (0.1)
Leisure 1: More weight on leisure (0.1) and less on surplus cash April (0.0001)
Leisure 2: Less weight on leisure (0.0001) in favour of surplus cash April (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 12.15 and 12.16. 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), 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 which Church 1 the emergent farmer had a 48 percent reduction in surplus cash, and a 31 percent increase in cropped area.

Table 12.15: 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 12.16: 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).

Table 12.17: 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).

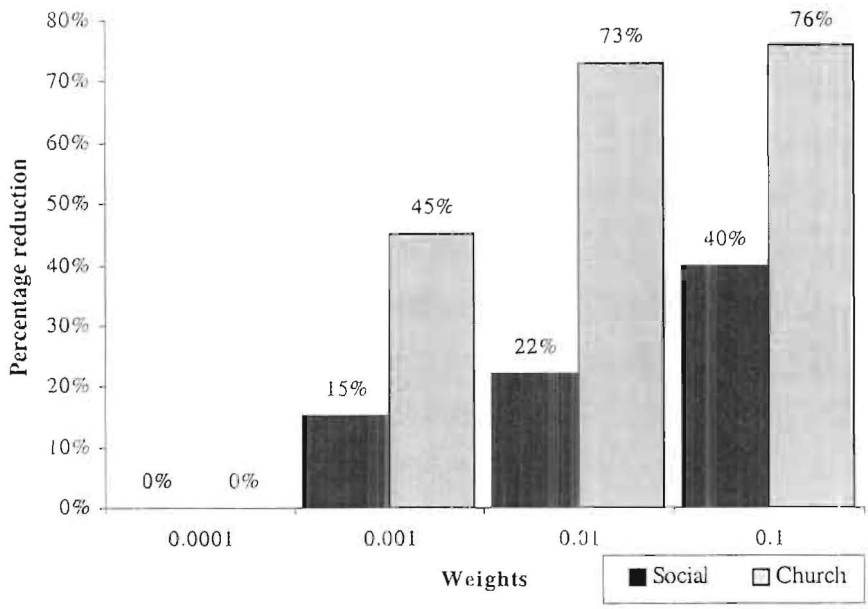
Cropped area values are rounded off to 2 decimal places.

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 173 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 12.3 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.

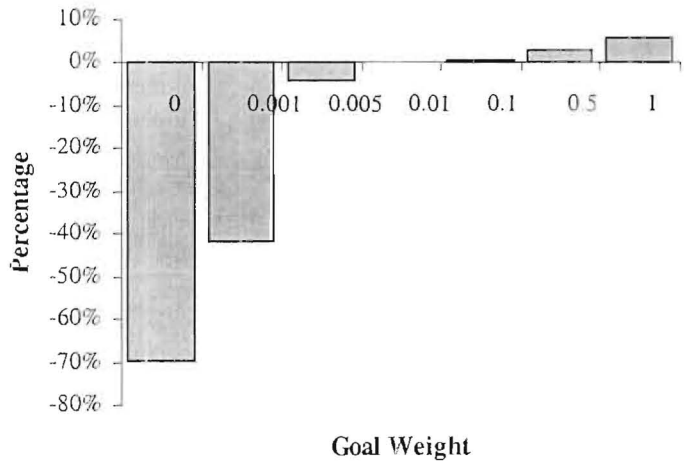
Figure 12.3: Percentage reduction in surplus cash when varying goal weights for social and church obligations in an emergent farm household in Tongatapu.



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 12.4 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. The significance of social and church obligations also raises an important issue for MAF Research and Extension in terms of a closer collaboration with church leaders and to encourage church and community based farm groups (*toutu'u*). Group members will be more involved in development programmes if intervention is channelled through church and community leaders.

Figure 12.4: 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 12.17. 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 maximisation scenario. It thus 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 12.18 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 declines in favour of growing more squash, and then 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.

Table 12.18 : 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.

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.

These results show that any changes to the goals and priorities or preferences of smallholder farmers, as specified in the objective function, would have a significant impact on productivity and overall farm production. The reality is that farming communities are comprised of different farm groups with different goals, preferences, attitudes, aspirations and financial conditions that restrict them in drawing benefits from farm resources. Of the three main farm types, progressive farms were found to have the best access to resources and market, but most importantly, they have the attitude and motivation to excel in the efficient mobilisation of their resources. This highlights the importance for Government officials to understand the farmers' priorities and relative goals in the design and prescription of effective development policies and programmes.

At the farm level, successful crop husbandry needs good skills, expertise and management to utilise available resources. The successful development of a public and private infrastructure, and institutional services for agriculture, first depend on the managerial skills and capabilities of farmers to boost farm productivity. Farmer characteristics such as educational attainment, farming experience, financial condition, all directly influence their perceptions of, and attitudes toward, technological innovations. It may be possible for government, through educational and training programs and the rural development schemes, to improve farmers' perceptions and to help develop positive attitudes towards commercialisation and the adoption of innovations. Government can indirectly influence farmers' goals through education and training programmes, and the provision of incentives for farmers to put a higher priority obtaining a cash surplus rather than non-economic social goals. This would enhance commercial production and there would be more outputs to be sold, and there would be more cash available for on farm investment. Some of the livestock development projects (discussed earlier in Chapter 5) failed to improve breeds or stocks of pigs and cattle because they are mostly raised for social and cultural obligations rather than for cash.

Some marginal households work just hard enough to maintain themselves and no more, even when there is considerable potential for further production. This is due to their goals and preferences which are expressed in a lack of the commercialisation mentality and motivation that is the driving force of progressive farmers. Without doubt, most villagers desire money and material possessions and they are definitely interested in obtaining them. However, if their achievement involves sustained and strenuous effort, the cost is commonly considered too high. The things that money buys are attractive, but rarely attractive enough to compensate for a loss of leisure time. As Hau'ofa and Ward (1980) argued, if smallholder farmers are content in their low input type of agriculture, why change it? This debate must be considered by the people of Tonga and decision made on whether greater commercialisation is appropriate. For the development of educational and health facilities development will be essential.

12.4 Aggregation for macro-policy consideration

Micro-level studies of the Tongan smallholder farming system can contribute to a critical assessment of macro-economic policies as agricultural development is affected by decisions made at the farm level, by the groups and by the villages. This study has focussed on understanding decision-making behaviour at smallholder farm level in Tonga. In the first part of this chapter a number of farm models that are representative of the major groups and regions were developed and solved by variations in some key parameters of policy interest, such as output prices, resource levels, technology goals and priorities. Different farm types with different behavioural assumptions were found to produce different farm plans and achieve different levels of output. It would, therefore, be interesting to analyse the actual behaviour of Tongan smallholder farmers using the results of these analyses to infer the response of all farms of the same category as an input to the macro-level model. For agricultural policy macro-level decisions these farm-planning studies of representative farm situations can be integrated into an aggregate model. Aggregate models are those in which the micro-level resource allocation problems are solved first, then the macro-level implications are derived. Even though the sample used cannot be justified statistically for a generalisation of the Tongan situation (and an aggregate model is beyond the scope of this study), it is possible to identify through the aggregation of the different representative farm models, the implications of goal orientation for agricultural development programming by Government.

12.4.1 Indicative investment in the interventions

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 12.19.*

Table 12.19: 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
	Total Investment Required	***T$270,000***

* Estimates based on planning department experience

12.4.2 Indicative project benefits

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 12.21 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 12.20 below.

Table 12.20 shows that if the project is 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 12.20: Summary of proposed project benefits (T$).

Farm Type	Region	% Farm type	No. of growers	Incremental T$	Incremental at 100 % T$M	Incremental at 40 % T$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
		Total Incremental Benefit			*3.30*	*1.32*

Table 12.21: Summary of the projected changes in representative farm land use patterns.

	TONGATAPU									VAVA'U									HA'APAI					
Production activity	Progressive			Emergent			Marginal			Progressive			Emergent			Marginal			Emergent			Marginal		
	Farm 1			*Farm 2*			*Farm 3*			*Farm 4*			*Farm 5*			*Farm 6*			*Farm 7*			*Farm 8*		
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.

12.5 Summary

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. The results of this study show that the objectives of the individual smallholder farmer are unlikely to be those of maximum output and productivity. They are more likely to want to satisfy multiple objectives, such as producing enough for subsistence; catering for religious and social obligations, having adequate time for leisure; earning some cash through sales; and being able to play their appropriate roles in their society and culture. These objectives were quantified and introduced into the models which offered more realistic solutions to the smallholder farmers in their practical settings. Dynamic properties were included in the models through the requirements and preferences for non-economic motives (church and social obligations), savings, and investment by different types of households.

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 results of this research show that the economic behaviour and production plans of the different categories of farmers are determined not only by the resources available, technology and the institutional constraints, but the also by preferences and importance attached to each objective or goal. Although the preferred plan still does not guarantee the best results, the resource-use inefficiency could be considerably lowered while still meeting the farmer's other production goals.

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.

The discussion in earlier chapters has shown that the potential of the agriculture sector to contribute to economic development of Tonga is substantial. It is, therefore, very important that efforts are made to make agriculture competitive, profitable and attractive for income generation. This will require

appropriate development strategies, and policies to implement the strategies. Eight representative models which were developed to represent the different farm categories in three main regions were used for critical assessments of macro-economic policies. Policy experiments and analysis focussed on major areas in which the government policies may have a major influence, including the land, market, technology, labour and credit systems. It also included areas where Government has an indirect influence, in particular the preferences, priorities and goals associated with different types of farms.

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.

As noted in Chapter 9, 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 out-migration puts more localised pressure on the land available for cultivation, which results in more intensive use of land, reduced fallow and increasing 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^2).

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. As noted in Chapter 8, 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 (particularly for increased number of staff, vehicles, and other facilities and equipment). 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 from the export of agricultural products. 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.

CHAPTER 13

CONCLUSIONS AND SCOPE FOR FURTHER RESEARCH

The final chapter is comprised of three sections. The first section treats the overall approach and empirical results of the study. In the second section, study conclusions are made as to the overall value of the study. Consideration is also given to the implementation of the goal programming approach to develop models representing the different farm types within village situations for the assessment of different policies under a range of farming conditions. The final section is devoted to providing suggestions for further research along the lines followed in this study.

13.1 Summary

At the very beginning (Chapter 1), this study set out a theme of trying to gain some insight into the farm-level production decision making of Tongan smallholder farmers. While the prime objective of this study was to develop a farm-level production model to assist policy analysis, a secondary, but parallel objective, was to analyse and describe aspects of smallholder farmer decision making behaviour in Tonga. In particular, the goals and priorities they have, the production and consumption behaviour, and the significance of social and cultural values on smallholder farm production decisions.

The major problem facing policy analysts and development planners is a lack of a reliable model and framework that adequately portrays the productive behaviour of the Tongan farmers which can be used for effects and impact assessment interventions. This has been identified by previous researchers (Hardaker, 1975; Brook, 1980; Delforce, 1990) due to a variety of factors influencing the economic decisions of smallholder farmers. The approach adopted was to understand the broad, strategic aspects of decision-making and the behaviour of farmers rather than to focus on specific farming decision scenarios. Accordingly, the present study was designed to provide an integrated approach to studying smallholder farmer behaviour. The smallholder farmers' behaviour must be examined in relation to the set of circumstances within which they operate. In this respect the analyses described in Part 2 provide some useful insights into aspects of farmer behaviour and the Tongan agricultural system. Such insights include the identification of goals and priorities, resources available and use, institutional and economic factors, and social cultural factors that impinge on production decisions and operating plans of different smallholder farm types.

The system analysis revealed that Tongan smallholder farmers operate in a complex environment characterised with severe resource and other constraints to achieve conflicting multiple goals. Agricultural production does not follow a regular pattern in Tonga; most farmers do not specialise, in the sense of devoting all their time to either cash cropping or subsistence farming; most do a little of both. Subsistence crops are intercropped with cash crops, and both can enter the market according to the seasonality of the money needs of the households. The motivation to plant is determined by the need to provide the family with adequate food, but is also strongly influenced by the necessity to meet church, social and communal responsibilities and obligations. In other words, the motivation behind economic decisions is not purely economic; many short and long-term, everyday decisions are made by reference to their effects on the network of social relationships regulating village life.

With respect to the modelling objective, it would appear that much of the potential value attributed to farm-level production models as described in Chapter 2 has been realised. The mathematical representation of the decision-making processes was based on the conceptual framework of the factors and the complex relationships thought to influence a Tongan smallholder's allocation of resources in agricultural production. Goal Programming (GP) offered a number of appealing features to handle complexities of the system and appears to be well suited to the problem. The model is consistent not only with the physical view of the farm but also with the way it behaves, or reacts to stimuli and changes over time with respect to agricultural development policies. The model has incorporated some of the complex features of smallholder farming system such as the existing mix of enterprises (and alternatives to them) and the way these enterprises compete for the use of the limited resources available. Goal programming was chosen as the analytical tool since there is no attempt to optimise the system's behaviour to schedule events in the most economically efficient way; contrast the assumption is that the farmers attempt to satisfy a multiplicity of goals and other requirements, a more realistic assumption of the circumstances.

What the model is designed to do is, in effect, to ask the same questions of a farm plan as the farmer is considering. From the answers, the model deduces whether the farm plan would be workable to the farmer, that is, whether he would be able to generate sufficient resources to satisfy the goals given the constraints under which he farms and the level of technology available to him. The farm plan is taken to cover a year – from May to April – to coincide with the major planting season beginning in April.

Conceptually the model has three main parts (i) Production objectives which reflect the relationships that determine the farmer's requirements from his farming operation; (ii) those relationships that define his assessment of the constraints which he needs to consider in deciding upon a farm plan; (iii) those relationships which make up his and the household personality. The personal characteristics influencing a farmer's choice of plan are difficult to include in a mathematical model. Household preferences of different staple foods are reflected in the amount of each required. Emergent rural

farmers' willingness to be self sufficient in staple food requirement and livestock needs was reflected in the omission of purchasing staple food and the limit on buying porkers and weaners.

The models developed are detailed and flexible enough to simulate a wide range of policy scenarios within a framework which adequately represents complex aspects of the farming systems. Also, the flexibility and detail of the models provide the basis for representing a range of farm conditions and for describing policy responses in terms of a number of farm performance parameters. As such the models should provide policy makers and analysts with a useful analytical tool.

13.2 Conclusions

The results of the estimations in this research may not be of direct use by farmers, but they certainly should provide the basis not only for guidance in general policy formulation, but more specifically for indicating the direction and magnitude by which relevant instrumental variables need to be manipulated or introduced to achieve some desired objectives. In addition, the model should also furnish reasonable information on how smallholder farmers might respond to agricultural development programs such as improved technologies and new crops. Without a better understanding of farmer structures, goals and objectives that determine economic behaviour and motivation, the planners and policymakers cannot fully appraise the potential of agricultural development programs on production, farm income, and farmer welfare.

The semi-subsistence, or semi-commercialised, nature of Tongan smallholders is characterised by being motivated primarily by many objectives that contribute to maximising family satisfaction. Satisfaction is not only increased by the benefits of farm output, but also decreased by the cost of sacrificing food, leisure, and money, or taking risks. Realising a profit on the sale portion of the crop is important, but maximising profit is not always the over riding consideration in allocating land and other resources. Increased profits increase family satisfaction to a certain extent. At some levels, profit maximisation might be secondary to family satisfaction and enterprises and productive processes that allow the family greater security and satisfaction might take precedence over those that are more profitable.

A major feature of all the smallholder farmers studied, regardless of farm size, and location, was their practice of using crop mixtures in which a number of crops were intermingled in the same field. This practice was, therefore, examined in some detail for consistency with the major goals identified. Exclusive subsistence production is rarely found; generally the survey results show that a certain amount of produce (*crops, livestock, handicrafts*) is sold, either those surplus to family needs, or specialised cash crops such as vanilla, squash and coffee.

The strong farm-household relation may not indicate that farmers lack economic motivation. In fact the results of this study shows that some farmers are responsive to prices. Similarly, the farmer's choice to produce traditional or subsistence crops that are less profitable than cash crops does not necessarily reflect indifference to economic returns. Farming is inherently risky because the individual farmer has no control over his physical and economic environment. The farmer tries to reduce his risks by judicious selection of enterprises, by crop diversification, and by spreading production over the growing season.

A majority of farmers in Tonga are risk avoiders, which means that they will choose less risky activities even though they may not be the most profitable on average over a period of years. Growing traditional crops for home consumption as well as cash crops may provide protection against various risks. Many farmers could maximise their average profits by growing only cash crops, but they maximise their satisfaction by avoiding risks.

The question arises as to the potential for adapting the GP model to the three different farm types and different geographical regions. The study revealed little variation amongst the 3 main categories in terms of farm structure, crop composition, which was dominated by root crops, in all regions. The main variation was in the cash crops types. For example, vanilla and kava are dominant cash crops in the Vava'u models but not in Ha'apai and Tongatapu models. Therefore, the model was designed as a blueprint model so that considerable flexibility is possible through variation in input data of crop composition and respective areas without a need for structural changes.

This study assessed some agricultural policy options as Tonga requires estimates of the likely responses by different types of smallholder farmers, and an appraisal of the impact on the farm household of the proposed measures. These judgements require a goal understanding of the nature of agricultural farming systems, including the characteristics and behaviour of different types of agricultural production units. These are typically smallholdings supporting complex systems of mixed crop and livestock production. These farming systems are managed by farm households who must cope with a range of uncertain factors, including market prices, weather, pest and diseases, and government policies. This improved understanding can improve the diagnosis of agricultural development programs and, *ex ante,* assessments of the likely responses to, and impacts of, alternative agricultural policies and programs. Through experimentation with the Tongan household agricultural system, it should be possible to design packages of policies and practices tailored to the economic behaviour of Tongan smallholder farmers.

13.3 Implications for Further Research

The final section is devoted to the discussion of the limitations of this research and suggestions for number of lines which the present modelling approach in this study could be refined, and extended further in future research.

In the process of the study major areas of data deficiency became apparent. The empirical results of this study should be interpreted with some caution considering the following limitations. One is the meagreness and the quality of the production data. A major problem identified during the survey is that every farmer surveyed did not keep farm records, therefore data for expenditure, income and output were based on what they could recall and estimate during the time of survey. An important implication for MAF extension and research activities is to encourage farmers to keep farm records so that accurate and reliable data will become available for further research.

The second is the simplification and implicit restrictions entailed in the models. For example, in activity budget estimations, we have to assume that the prices are exogenous and somehow can be observed from input markets with everybody paying the same price. But in the real world, at least in the study area, the markets are not well established and the costs are not easy to evaluate. For example, for labour, some farmers might obtain labour from specific customary arrangements so that it is not clear what the real cost is. Another example is the marketing cost of produce has been set at an estimated figure as much of the packaging is currently made in the household – what is its true opportunity cost?. This needs researching.

It is important, also, not to overlook the limitations associated with this type of model. In addition, there is the aggregation problem which must be considered when using the representative models for a general specification of Tongan smallholder farming systems. Another restrictive assumption made was to assume that the level of technology for each enterprise was constant among the three main island groups and in the three main farm types. In reality, there are variations in terms of soil types and the technology used. If the model is to draw conclusions about the behaviour of a group of farms, then analysts should be aware of the potential for aggregation bias. Further research is required to elucidate these factors and so obtain better forecasts for the whole of Tonga.

As discussed in Chapter 7, livestock is a major component of the farming system and has a significant impact on the economy. The unique examination of village cattle, chicken, and pig production in Tonga should seek to determine the potential for increased livestock production in view of the increasing demand for meat in Tonga. However, reliable farm data and gross margin analysis information was not available, therefore other livestock were not fully explored. The scope could be broadened to focus on crop-livestock interrelationships in the smallholder production system. This

would be rewarding in view of the high importation of meat products, and the apparent potential to substitute imports.

Cattle provide draft power and manure as well as meat while controlling weeds on fallow land by feeding on grass and other edible plants. Pigs and chickens in contrast are found to be competitive in resource use with human food crops. Further study to analyse these relationships should provide unique insights into specific constraints controlling livestock reproduction and growth under traditional farming systems.

The model should explore more with livestock subsystems, based on a small scale tethered cattle module, which may make better use of surplus family labour and the fallow land. The outputs will not only be milk, sold for cash, but also include manure to improve soil fertility. Similarly, the model can also be extended further to include more interaction from the pigs in which the system allows a manure contribution to soil fertility for crop production. However, this can only be achieved through providing sufficient economic and technical information on small scale livestock production from further MAF research. Effective policy simulations at the farm level do need appropriate and reliable farming systems database.

Another limitation of this study was the time horizon of the models, which was reflected in a one-year time span and encompassed a balanced production plan, whereas the comparison data was for a specific year which may not have reflected a balanced average year system. The model should be extended to a multi-period model, which looks at the generation of a long run production, and the yearly trend could there be more useful. A recursive programming model (Hazel and Norton, 1986) where several decision-making periods are executed one after another with the results of the previous decisions affecting the current resource endowments is a conceptually appealing approach. With the time and data constraints the approach of conceptually incorporating the recursive aspects and what data to use to develop empirical model was beyond the scope of this research. However, it is an important area for future research provide appropriate time series of data could be established.

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LIST OF APPENDICES

Appendix 1 : The Ministry of Agriculture and Forestry

The Ministry of Agriculture and Forestry (MAF) is a long established agency. MAF plays a key role in relation to the formulation and implementation of agriculture policy (Lincoln International, 1993). In 1998, major changes were made in the MAF organisational structure in response to the need to improve the performance of the Ministry. A number of studies, including a sectoral study (World Bank, 1990), an operation review (ADB, 1995) and a strategic plan (MAF, 1995), have pointed to the need to improve the quality of MAF services and to be more efficient in assisting farmers to improve productivity. These studies emphasise the need for an organisational reform to be able to achieve those goals. In 1997 the Government of Tonga requested the Asian Development Bank (ADB) to provide technical assistance to establish MAF as an efficient and effective organisation responsive to the technical and market information needs of farmers.

The ADB report recommended an organisational restructure of MAF. According to Ruhen (1998), the main features of the restructuring included; (a) a farmer centred approach; (b) improved skills and service delivery from extension officers; (c) more highly qualified extension officers, and (d) reorganisation of MAF with a reduction in the number of divisions from 8 to 5 (see Figure 1a). The new organisational structure consisted initially of five main divisions; Corporate, Research-Extension, Regulatory, Forestry, and Services. Briefly, the functions of the various divisions are described in the following sections.

A1.1 Research- Extension division

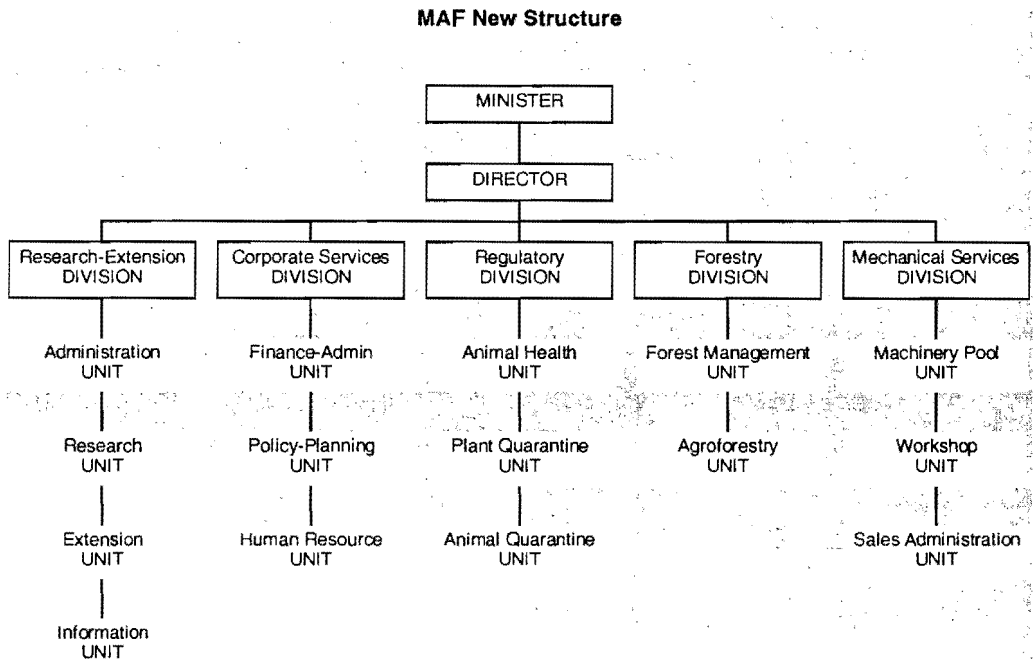
The Research–Extension division is responsible for agricultural research and technology development. It consists of 4 integrated units. The Administration unit provides internal administration services, manages Vaini farm services and coordinates special projects. The Research unit conducts applied on-station research into most aspects of agricultural production including the agronomy of present and potential cash crops, pastures, soil science, entomology, and plant pathology and animal nutrition (Ruhen, 1998). The Research unit activities are principally carried out at the Government Experimental Farm at Vaini on Tongatapu. The Extension unit is responsible for extension and advisory services in all aspects of agriculture. It generates sound farm management practices in Tongan farming systems through applied research and the demonstration of proven technologies; it provides farmers with technical and market advice through a participatory approach from the subject matter specialists and district extension teams. The Information Unit is designed to produce and disseminate technical, farm management, and market information to farmers using radio and other media. This includes regular radio broadcasts and the publication of agricultural information. It also has the responsibility for the coordination and publication of the MAF Annual Report.

A1.2 The Service (Commercial) division

The Services Division provides tractor hire and cultivation services with machinery pools stationed in most parts of the country. It also provides advice on cultivation practices and technology adaptation, and manages the Talamahu national market (MAF, 1997). The Service division plans to fully privatise the workshop and machinery operation in the next three years.

Figure.A1: Ministry of Agriculture and Forestry organisation structure.

Source: Ruhen, 1998



A1.3 The Regulatory division

The main functions of the regulatory division include border protection for control of pests and diseases invasion; quality control of exports, post harvest treatment of export crops, and the development of export quality regulations, and the certification of import and export goods (MAF, 1997).

A1.4 The Forestry division

The Forestry division's main function is to promote and implement forestry development programs in the Kingdom, with particular emphasis on the Forestry farm in 'Eua. Agroforestry development programs are also administered not only in Tongatapu but also in the outer islands (Ruhen, 1998). The Forestry division will be split into two units as part of the commercialisation of its plantation and nursery activities and the future integration of its agroforestry activities into the new Research and Extension division.

A1.5 The Corporate division

The Corporate Services division consists of three functional units. The Policy and Planning unit's key roles are to develop and recommend policies that are consistent with national strategic objectives and provide MAF program and divisional managers with effective planning and updated project monitoring and evaluation services. This unit is also responsible for the compilation of agricultural statistics and market information and co-ordination of donor assistance programs (Ruhen, 1998). The Human Resource unit helps managers establish a productive and efficient working environment through effective performance assessment practices, focused training programs that are consistent with the priority development needs, and public service reform strategies recommended by the Government. The Administration unit is also directly responsible to the staff administration and financial management control (MAF, 1998).

Appendix 2: Farming System Household Questionnaire

Village: _____ ***Head of Household:*** _____
Date of Visit _____ ***Respondent(s):*** _____

i. General Information

1. Describe household composition.

2. State the level of Household Income derived from the following in the last 12 months.
   a) Employment $_____ b) Remittances from Overseas $_____
   c) Business $_____ d) Sales of Agricultural Produces[1] $_____
   e) Exchange of products $_____ (approx. value)

3. What were the major expenditures by the household during the last 12 months on the following.
   a) Food Consumption $_____ b) Repair and Maintenance of Home $_____
   c) Education $_____ d) Church Donations $_____ e)Family and Social Obligation$_____

   f) Others (list) eg. Tobacco $_____Kava $_____Electricity $ _____Water $_____

4. What are food consumption habits?
   Bought: _____ *Own grown:* _____

ii. Farm Household Decision-making

5. Describe how farm decisions are made within the household. Who makes decision on farm production? and why?

iii. Farm Household Goals, Priorities and Preferences

6. What are the most important objectives of your farming? [*Rank from most to least*]

4 How successful are you in achieving your objectives? [*Explain your answer*]

8. What is the major benefits from your farming activities?

What are the major problems and constraints to achieving your objectives?
[*Rank from most to least*]

10. What would you suggest to solve or reduce the problems & constraints?

iv. Land access and utilization

11. Describe the main cropping pattern, crops grown, purpose and their respective area.

Crop Type	*Purpose*	*Mixed/Monocrop*	*Area*

12. Provide details of the number of Tax Allotments under your management, how much of each are under cropping and fallowed and land holding status.

13. How do you plan your crop rotations?

14. How often do you fallow your land?

15. Which crop would you like to produce more of? And why?

16. What were the major changes implemented in your farm operations up to now? Why changes?

17. What kind of changes to your farm structure to improve your production - in terms of enterprises, technology, capital, will you undertake in the near future?

[1] Includes crops, livestock, firewood

18. What stops you from increasing the size of your farm? What is the limiting factors?

19. What problems do you find in terms of access to land? Why and what are the solutions?

20. What proportion of your farm production are for:
    a. *Home consumption*
    b. *Family and Social Obligation*
    c. *Church Obligation*
    d. *Sales*

21. Provide the number of livestock that you keep and disposed during the last 12 months.

Type	Number Kept	Number disposed	Value	Reasons for disposal

22. How do you manage your livestock?

23. What are the major problems in regard to livestock? Is it possible to expand stock? What are the possible solutions?

v. Farmers' Technical & Managerial Skills

24. When did you start farming on a regular basis?

25. What are your main sources of advice on land use and land management practices?

What do you think of the Extension Services/MAF Activities operating in this area?

27. What kind of service improvement do you want from MAF Extension services?

28. How do you clear and prepare your land for cultivation?

29. What issues & constraints do you face in land preparation for farming?

30. What new-technological packages are you aware of but not using?

31. What potential benefits are offered by the new packages?

32. Explain a new-tech package you are aware of and understand[2]?

33. What risks are involved in adopting these new packages?

34. Why have you not adopted these new-technology packages?

vi. Access to Labour and labour use

35. Describe access and use of family labour.

	Family Labour
Who	
Gender	
Hours of work	
Problems	

36. Describe access and use of hired labour

	Hired Labour
Who[3]	

[2] New varieties, fertilizers, plant protection packages for vegetables, squash, watermelon etc.
[3] either individuals or kautaha

Gender

Hours of work

Type of Work

Rates of Pay

Problems

vii. Market Access

37. How much of each commodity that you produce are marketed locally and overseas?

Name of commodity	*Where*	*Selling Price/unit*

For each commodity marketed, who set the price and what are the lowest prices acceptable to you?

39. For which commodities do you anticipate expansion in market opportunities? Give reasons for your answer.

40. What are likely constraints to development of those market opportunities and how can the opportunities is enhanced?

viii. Infrastructure

41. What are your views on the conditions of the following infrastructure facilities and how it affects your farming decisions?
    i) Roads?
    ii) Wharves?
    iii) Packing & Storage Sheds?
    iv) Markets?

42. If you are empowered to decide on infrastructure development, what are three priority infrastructures improvements would you authorize now? [Give reasons]

ix. Institutional and Support Services

43. How effective are the government policies and incentive schemes that Government provides? Please explain.

44. In your opinion, what sort of policies and incentives should be provided to motivate you and fellow workers to increase agricultural productivity?

45. Where do you seek credit for finance farm activities?

46. How effective are bank credit policies to your endeavour. Suggest improvements.

ix. Group Farming and Growers Association

47. With what types of village and farm group do you involve in.? Why or why not?

48. What are the objective(s) of the group?

49. What activities do these groups carry out?

50. How do you benefit from working as a group?

51. What problems do these farm groups face? What opportunities do you see for addressing these problems?

Appendix 3: Villages Information

Total population by sex and number of households, actual farmers and land utilisation for sub-regions, districts and villages.

	Population[4]				Farmers and Farming area[5]			
Village	Total	Males	Females	No. of HH	No. of Actual Farmers	Crop Area (Acres)	Land Area (Acres)	Av. Farm Size to No. of Farmers
TONGATAPU SUB-REGION								
Kolofo'ou District	***15,903***	***7,894***	***8,009***	***2,339***	***224***	***1314.0***	***2266.9***	***5.7***
Kolofo'ou	10,044	4,988	5,056	1,494	166	993.0	1711.6	5.8
Ma'ufanga	4,924	2,404	2,520	699	58	321.0	555.3	5.5
Kolomotu'a District	***13,115***	***6,469***	***6,646***	***2,037***	***302***	***1542.0***	***2668.7***	***5.1***
Kolomotu'a	6,415	3,143	3,272	1,040	207	1227.4	1863.1	6.6
Haveluloto	3,070	1,528	1,542	469	18	65.1	144.3	3.8
Tofoa/Koloua	2,298	1,093	1,205	289	22	113.2	206.3	5.1
Hofoa	609	317	292	94	18	82.9	168	4.6
Puke	403	204	199	63	18	53	132	3.0
Sia'atoutai	320	184	136	82	1	97.7	182.3	5.1
Vaini District	***11,104***	***5,618***	***5,486***	***1,676***	***667***	***3465.1***	***6277.2***	***5.3***
Vaini	2,697	1,387	1,310	421	162	862.4	1494.3	5.5
Malapo	582	284	298	82	33	184.7	359.5	5.7
Longoteme	730	388	342	108	56	273.5	855.0	4.9
Folaha	706	336	370	115	59	281.2	486.8	4.9
Nukuhetulu	329	157	172	55	26	105.7	208	4.1
Veitongo	1,080	541	539	146	64	347.6	552.0	5.5
Ha'ateiho	1,825	918	907	267	120	703.3	1046.8	6.0
Pea	2,152	1,091	1,061	327	99	455.6	802.8	4.6
Tokomololo	1,003	516	487	155	46	244.9	464.0	5.3

[4] 1986 Population Census

[5] 1993 Land Use and Crop Survey

Village	Population[6] Total	Males	Females	No. of HH	Farmers and Farming area[7] No. of Actual Farmers	Crop Area (Acres)	Land Area (Acres)	Av. Farm Size to No. of Farmers
TONGATAPU SUB-REGION								
Tatakamotonga Dist.	***6,773***	***3,445***	***3,328***	***1,092***	***597***			
Tatakamotonga	1,789	889	900	274	146	761	1509.0	5.2
Holonga	538	256	252	85	17	64	137.5	4.2
Pelehake	648	301	347	109	71	437.5	629.3	6.7
Fua'amotu	1,683	948	735	284	130	684.9	1250.3	5.4
Nakolo	408	218	190	58	32	102.8	276.5	5.7
Ha'asini/Hamula	859	407	452	139	41	133.0	335.0	3.4
Lavengatonga	308	146	162	54	35	173.7	337.5	5.1
Haveluliku	166	84	82	25	87	328.5	972.0	4.1
Fatumu	404	196	196	64	38	144.0	363.3	4.0
Lapaha District	***7,005***	***3,462***	***3,543***	***1,056***	***610***	***2368.1***	***5541.6***	***4.0***
Lapaha	1,969	934	1035	280	183	661.2	1716.8	3.8
Hoi	479	236	243	73	23	86.5	198.3	4.2
Nukuleka	253	137	116	41	6	20.0	49.5	3.3
Makaunga	340	169	171	54	7	26.0	65.3	3.7
Talafo'ou	432	222	210	68	51	195.0	447.0	3.9
Manuka	221	106	115	29	10	35.5	81.5	3.7
Navutoka	726	360	366	115	62	189.5	508.8	3.2
Kolonga	1,393	721	672	206	141	631.1	1340.3	4.5
Afa	353	177	176	49	28	122.8	258.5	4.4
Niutoua	662	309	353	104	84	373.3	755.8	4.5
'Eueiki Is.	85	47	38	19	15	27.2	120.0	1.8

[6] 1986 Population Census

[7] 1993 Land Use and Crop Survey

Village	Population[8] Total	Males	Females	No. of HH	Farmers and Farming area[9] No. of Actual Farmers	Crop Area (Acres)	Land Area (Acres)	Av. Farm Size to No. of Farmers
TONGATAPU SUB-REGION								
Nukunuku District	***5,863***	***2,912***	***2,951***	***809***				
Nukunuku	1,292	641	651	202	33	147.5	205.8	4.5
Matahau	490	256	234	70	50	251.0	355.0	5.0
Matafonua	259	137	122	41	10	58.3	74.5	5.8
Fatai	282	142	140	41	19	107.4	178.3	5.7
Lakepa	368	191	177	54	31	147.2	252.0	4.7
Vaotu'u	464	205	259	69	52	346.7	523.5	6.7
'Utulau	501	229	272	80	65	416.6	587.0	6.4
Ha'alalo	383	173	210	61	28	167.8	280.3	6.0
Ha'akame	396	217	179	61	36	200.0	355.5	5.6
Houma	1,428	721	707	210	125	819.0	1291.8	6.6
Kolovai District	***5,863***	***2,912***	***2,951***	***809***	***341***	***1682.3***	***2656.6***	***5.0***
Kolovai	821	385	436	139	58	249.0	522.3	4.3
Te'ekiu	468	254	214	72	37	228.0	328.5	6.2
Masilamea	277	133	142	37	20	122.0	181.3	6.1
Fahefa	387	189	198	59	36	225.3	316.3	6.3
Ha'utu	175	81	94	28	26	151.4	210.0	5.8
Kala'au	144	72	72	25	9	35.2	57.8	4.0
Fo'ui	452	235	217	66	40	173.4	267.5	4.5
Ha'avakatolo	236	121	115	39	26	137.6	208.3	5.3
'Ahau	282	146	136	43	31	118.2	184.0	3.8
Kanokupolu	392	191	201	65	36	122.6	211.8	3.4
Ha'atafu	210	87	123	32	18	97.1	136.8	5.7
'Atataa Is.	187	97	90	29				

[8] 1986 Population Census

[9] 1993 Land Use and Crop Survey

Village	Population[10] Total	Males	Females	No. of HH	Farmers and Farming area[11] No. of Actual Farmers	Crop Area (Acres)	Land Area (Acres)	Av. Farm Size to No. of Farmers
VAVA'U SUB-REGION								
Neiafu District	***5,268***	***2,689***	***2,579***	***882***				
Neiafu	3,879	1,991	1,888	657	247	839.2	1729.0	3.4
Makave	371	196	175	59	31	82.4	178.3	2.7
Toula	243	114	129	38	51	56.4	132.0	1.1
'Utui	231	118	113	41	23	44.8	117.3	1.9
Ofu Is.	218	98	120	36	19	27.7	99.8	1.5
Okoa Is.	232	122	110	34	19	38.6	64.3	2.0
'Olo'ua Is.	94	50	44	17	13	18.4	54.8	1.4
Pangaimotu District	***1,247***	***650***	***597***	***205***				
Pangaimotu	659	343	316	101	45	138.2	335.0	3.1
'Utulei	159	88	71	29	10	45.7	88.0	4.6
Nga'unoho	176	81	95	28	11	26.8	73.3	2.4
'Utungake	253	138	115	47	22	69.2	159.5	3.1
Hahake District	***2,299***	***1,145***	***1,154***	***353***				
Ha'alaufuli	467	219	248	78	57	114.5	393.0	2.0
Ha'akio	227	108	119	33	20	45.5	106.3	2.3
Houma	169	83	86	28	15	31.0	89.3	2.1
Mangia	110	52	58	20	6	16.0	49.0	2.7
Ta'anea	648	330	318	90	40	108.0	260.3	2.7
Tu'anekivale	358	179	179	60	20	66.3	147.0	3.3
Koloa	193	114	79	28	29	64.9	118.5	2.2
Holeva	127	60	67	16	18	24.2	46.3	1.3

[10] 1986 Population Census

[11] 1993 Land Use and Crop Survey

Village	Population[12] Total	Males	Females	No. of HH	Farmers and Farming area[13] No. of Actual Farmers	Crop Area (Acres)	Land Area (Acres)	Av. Farm Size to No. of Farmers
Leimatu'a District	***2,884***	***1,461***	***1,423***	***471***				
Leimatu'a	1,329	687	642	231	157	966.2	1394.0	6.2
Holonga	515	263	252	81	50	178.2	357.8	3.6
Feletoa	485	229	256	72	68	171.5	223.5	2.5
Mataika	555	282	273	87	73	236.1	491.8	3.2
Hihifo District ***2,093***	***1,060***	***1,033***	***353***					
Longomapu	715	355	360	110	80	590.5	782.5	7.4
Taoa	445	230	215	82	58	373.4	504.0	6.4
Tefisi	505	263	242	85	83	456	635.8	5.5
Vaimalo	95	43	52	18	26	105.5	136.5	4.1
Tu'anuku	333	169	164	58	33	233.0	346.0	7.1
Motu District	***1,384***	***706***	***678***	***283***				
Kapa	90	50	40	25	23	37.3	114.0	1.6
Falevai	179	87	92	38	28	41.9	89.3	1.5
'Otea	162	85	77	27	24	27	72.0	1.1
Lape Is.	26	18	8	7				
Matamaka	187	95	92	35	22	41.6	92.5	1.9
Nuapapu	177	90	87	37	38	107.3	225.5	2.8
'Ovaka Is.	113	59	54	24	22	18.3	121.0	0.8
Taunga Is.	107	47	60	21	10	8.7	21.8	0.9
Hunga Is.	343	175	168	69	90	107.6	352.0	1.2

[12] 1986 Population Census

[13] 1993 Land Use and Crop Survey

Village	Population[14] Total	Males	Females	No. of HH	Farmers and Farming area[15] No. of Actual Farmers	Crop Area (Acres)	Land Area (Acres)	Av. Farm Size to No. of Farmers
HA'APAI SUB-REGION								
Pangai District	***2,850***	***1,447***	***1,403***	***504***				
Pangai	1,487	772	715	262	71	153.4	398.7	2.3
Hihifo	901	448	453	164	88	201.5	448.8	2.4
Holopeka	187	93	94	33	26	55.1	162.3	2.2
Koulo	275	134	141	45	29	61.0	166.2	2.1
Foa District	***1,410***	***699***	***711***	***247***				
Fangale'ounga	287	138	149	38	25	41.3	105.2	1.7
Fotua	243	123	120	41	35	61.2	166.2	1.0
Lotofoa	399	200	199	73	50	120.4	265.3	2.8
Faleloa	413	204	209	81	62	116.5	355.8	2.0
Ha'afakahenga	68	34	34	14				
Lulunga District 1,584	***790***	***794***	***275***					
Ha'afeva Is.	450	237	213	72	58	76.8	214.8	1.3
Tungua Is.	301	154	147	52	71	99.0	201.8	1.4
Fotuha'a Is.	190	97	95	33				
'O'ua Is.	266	118	148	47	37	46.8	153.0	1.3
Matuku Is.	142	77	65	22	19	16.3	49.8	0.9
Kotu Is.	233	107	126	49	26	10.2	21.0	0.4

[14] 1986 Population Census

[15] 1993 Land Use and Crop Survey

Village	Population[16] Total	Males	Females	No. of HH	Farmers and Farming area[17] No. of Actual Farmers	Crop Area (Acres)	Land Area (Acres)	Av. Farm Size to No. of Farmers
Mu'omu'a District	***885***	***452***	***433***	***173***				
Nomuka Is.	686	338	348	132	50	162.3	315.0	3.2
Mango Is.	83	49	34	18	10	9.0	67.8	0.9
Fonoifua Is.	111	60	51	22	16	17.4	48.0	1.1
Nomukeiki Is.	5	5	-	1				
Ha'ano District	***891***	***457***	***434***	***173***				
Fakakai	237	125	112	40	56	76.9	233.5	1.4
Pukotala	173	84	89	30	25	41.2	97.0	1.7
Ha'ano	214	108	106	46	42	74.1	157.5	1.8
Muitoa	103	58	45	19	19	55.0	107.6	2.9
Mo'unga'one	164	82	82	38				
'Uiha District	***1,299***	***650***	***678***	***243***				
'Uiha	632	312	320	113	64	93.7	252.7	1.5
Felemea	248	115	133	58	50	64.0	168.7	1.3
Lofanga Is.	330	156	174	50				
Tofua Is.	89	67	22	22				

[16] 1986 Population Census

[17] 1993 Land Use and Crop Survey

Appendix 4 : Important Staple and Commercial Crops

1. **Yam**: There are two major types of yams grown in Tonga: Early yam (*'ufi tokamu'a)* and late yam (*'ufi tokamui)*. The early yams have long, thick tubers and late yams have smaller, spherical tubers. The early yam is the most prestigious of Tonga preferred crops and is undertaken by most households. Yams are an essential feast food and are traditionally given as gifts as well as a valuable cash crop for the domestic and export markets. The 1993 Land Use Crop Survey showed that yam was grown by 83 per cent of households surveyed with 3454 hectares acres being planted.

Table A1: Economics of Yam Production.

Early Yam - Gross Margin per hectare (monocrop)				
1.1 Gross Income				
Activity/Item	Yield - kgs	25kg bsk	Price - $/kg	Gross Income
Local sales	12350	494	1.65	$20,377.50
1.2 Variable Costs (T$)				
Activity/Item	Quantity		Price	Direct cost
Planting material (kg)	1655		1.50	$2,482.50
Mechanical cultivation (hours)	10		30.00	$300.00
Chemicals (litres)	0		0.00	$0.00
Packaging (baskets)	494		0.50	$247.00
Transport to market (trips)	6		10.00	$60.00
Total Variable Costs				***$3,089.50***
1.3 Gross Margin				***$17,288.00***
Return to variable costs				***$5.60***
1.4 GM Returns to Labour				
Land preparation/planting (hours)	360			
Maintenance (hours)	450			
Harvesting (hours)	420		Return per labour hour	
Total labour requirement (hours)	1230		$14.06	
Total labour cost ($3.0/hr)	***$3,690.00***			
1.5 Gross Margin Sensitivity Analysis			***Yield: kg/ha***	
	Price: $/kg	10000	12000	14000
	1.55	12410.5	15510.5	18610.5
	1.75	14410.5	17910.5	21410.5
	1.95	16410.5	20310.5	24210.5
1.6 Additional Data				
Time to harvest (months)	9-12mths	Plant spacing (m)		2 x 2
Planting time	May to Aug	Plant density (pl/ha)		2500

Source: Field survey, 1998; Gyles *et al.*, 1989

Yams are generally the first crops to be planted after a fallow period and commonly grown as an intercrop with giant taro, plantain or American taro, kava and vanilla. Early yams are planted from May and July and harvested in March and April. Late yams are planted from August to October and harvested around May to July. Average planting densities for early yam and late yam is 2500 and 3200 plants/ha respectively. Early yams usually grow for 9 to 12 months and late yams normally grow for 8 to 12 months. Yams can store well for 3 to 6 months if kept in a

well-ventilated cool store. Careful harvest and post-harvest handling will ensure longer storage life.

2. **Giant taro:** scientific name - *Alocasia macrorrhiza*, Tongan name - *Kape*. The giant taro is another prestigious traditional crop found on a majority of bush allotments. Giant taro is an important subsistence crop and and also produced for the domestic and export markets. The two common varieties are *kape hina* (white) and *kape fohenga* (dark). Giant taro is commonly planted as an intercrop with yams. Planting is often coincides with yam planting, generally from March through to September. Giant taro takes about 12 to 14 months to mature and is harvested from August through November. Giant taro planting density is on average 1650 plants per hectare for intercropping and 3200 plants/ha for monocropping. The average weight per stem is 12 kilograms.

Table A2: Economics of Giant Taro Production.

Giant Taro - Gross Margin per Hectare (as Intercrops)				
1.1 Gross Income				
Activity/Item	Yield – kgs	Stems	Price - $/kg	Gross Income
Local sales	17000	1650	0.4	**$6,800.00**
1.2 Variable Costs				
Activity/Item	Quantity		Price	Direct cost
Planting material (stems)	1700		0.05	$85.00
Mechanical cultivation (hours)	8		30.00	$240.00
Transport to market (trips)	6		10.00	$60.00
Total Variable Costs				***$385.00***
1.3 Gross Margin		From Local Sale		**$6,415.00**
Return to variable costs				***$16.66***
1.4 GM Returns to Labour				
Land preparation/planting (hours)	300			
Maintenance (hours)	350			
Harvesting (hours)	250		Return per labour hour	
Total labour (hours)	900		$7.13	
Total labour cost (T$3/hr)	$2,700.00			
1.5 Gross Margin Sensitivity Analysis				
			Yield: kg/ha	
	Price: $/kg	15000	17000	19000
	0.3	$4,115.00	$4,715.00	$5,315.00
	0.45	$6,365.00	$7,265.00	$8,165.00
	0.65	$9,365.00	$10,665.00	$11,965.00
1.6 Additional Data				
Time to harvest (months)	12 to 15		Plant spacing (m) 3 x 3	
Planting time	All year		Plant density (pl/ha) 1750	

Source: Field survey, 1998; Gyles *et al.*, 1989

3. **American taro**: scientific name - *Xanthosoma spp.*, Tongan name - *Talo Futuna*;

This aroid of tropical American origin was probably introduced into Tonga during the nineteenth century (Thaman, 1976). *Xanthosoma* taro has become one of Tonga's most important staple crops and most frequent grown crop, and is of primary importance in the household food consumption basket. Farmers like American taro because it can be planted all the year round

provided the rainfall does not drop below 1000 mm, although most planting occurs between June and September. The tubers take about one year to mature, and because they store well in the ground they can be left unharvested for up to two years without the cormels rotting. Consequently, it is occasionally an important species in fallow vegetation associations. Planting materials consists of tubers. After harvest, all taros can be stored up to three months. The corms of common and giant taro are eaten while normally only the cormels of American taro are used as food since the main corms are often very acrid. The young green leaves, *lu*, of the American and common taro plants can be eaten as a green vegetable after cooking.

Table A3: Economics of Xanthosoma Taro Production.

Xanthosoma Taro - Gross Margin per Hectare				
1.1 Gross Income				
Activity/Item	Yield - kgs	25kg bsk	Price - $/kg	Gross Income
Taro corm	11100	444	$0.50	$5,550.00
Taro leaves	800	bundles	$1.00	$800.00
Total sales				***$6,350.00***
1.2 Variable Costs				
Activity/Item	Quantity		Price	Direct cost
Planting material (stems)	1250		0.10	$125.00
Mechanical cultivation (hours)	6		30.00	$180.00
Packaging (baskets)	444		0.50	$222.00
Transport to market (trips)	6		10.00	$60.00
Total Variable Costs				***$587.00***
1.3 Gross Margin		***From Local Sale***		***$5,763.00***
Return to Variable Costs				***$9.82***
1.4 GM Returns to Labour				
Land preparation/planting (hours)	275			
Maintenance (hours)	350			
Harvesting (hours)	280		Return per labour hour	
Marketing (hours)	50			
Total labour (hours)	955		$6.03	
Total labour cost (T$3/hr)	***$2,865.00***			
1.5 Gross Margin Sensitivity Analysis			Yield: kg/ha	
	Price: $/kg	8500	10000	12000
	0.45	$3,238.00	$3,913.00	$4,813.00
	0.6	$4,513.00	$5,413.00	$6,613.00
	0.75	$5,788.00	$6,913.00	$8,413.00
1.6 Additional Data		Plant spacing (m)		1.3 x 1.3
Time to harvest (months)	8 to 24	Plant density (pl/ha)		10000
Planting time	All year			

Source: Field survey, 1998; Gyles *et al.*, 1989

4. Colocasia taro: scientific name - *Colocasia esculenta*, Tongan name - *Talo Tonga;*

Colocasia taro is an ancient introduction to Tonga and is cultivated as one of the staple foods throughout the country. The popularity of the crop has increased in the last 10 years due to the increasing demand for fresh corms migrant communities overseas. A cyclone in Western Samoa in 1991 followed by the Taro blight disease in 1993 virtually destroyed Samoan production, the

major supplier of colocasia taro provided the opportunity for Tonga to pick up the temporary reduction in supply.

Table A4: Economics of Colocasia Taro Production.

Colcasia Taro - Gross Margin per Hectare				
1.1 Gross Income				
Activity/Item	Yield – kgs	25kg bsk	Price - $/kg	Gross Income
Taro corm	9880	395	$0.60	$5,928.00
Taro leaves	300	bundles	$1.00	$300.00
Total sales				***$6,228.00***
1.2 Variable Costs				
Activity/Item	Quantity		Price	Direct cost
Planting material (stems)	6675		0.05	$333.75
Mechanical cultivation (hours)	6		30.00	$180.00
Packaging (baskets)	395		0.50	$197.50
Transport to market (trips)	6		10.00	$60.00
Total Variable Costs				***$771.25***
1.3 Gross Margin		***From Local Sale***		***$5,456.75***
Return to Variable Costs				***$7.08***
1.4 GM Returns to Labour				
Land preparation/planting (hours)	275			
Maintenance (hours)	380			
Harvesting (hours)	280		Return per labour hour	
Marketing (hours)	50			
Total labour (hours)	985		$5.54	
Total labour cost (T$3/hr)	***$2,955.00***			
1.5 Gross Margin Sensitivity Analysis			Yield: kg/ha	
	Price: $/kg	8500	10000	12000
	0.45	$3,053.75	$3,728.75	$4,628.75
	0.6	$4,328.75	$5,228.75	$6,428.75
	0.75	$5,603.75	$6,728.75	$8,228.75
1.6 Additional Data		Plant spacing (m)		1.0 x 1.5
Time to harvest (months)	8 to 12	Plant density (pl/ha)		6670
Planting time	All year			

Source: Field survey, 1998; Gyles *et al.*, 1989

Colocasia taro is best planted on March to April to synchronise harvest periods with the export demand to New Zealand, which is greatest in December to January. The other planting period is between August and October during the wet season and optimum yields obtained. Colocasia can be grown both as a monocrop at plant density of 5000 plant per hectare or intercrop of 3800 plants per hectare. Colocasia taro does not store well after harvest (2 weeks).

5. **Cassava:** scientific name - *Manihot esculenta*, Tongan name – *Manioke* is an important staple food in Tonga, grown widely as a subsistence crop. It ranks low in consumer preferences, reflected in low prices for cassava in the domestic market relative to other staples. In the 1985 Agricultural Census, it was found that 80 percent of households grew cassava on an average area of 1.3 acres per household. The leaves and roots of cassava are an important source of

animal feed. Cassava is generally the last crop in the cropping cycle, following the yam crop and subsequent taro and sweet potato crops. It is frequently planted twice in succession in the same plot, after which the land is left fallow.

Table A5: Economics of Cassava Production.

Cassava - Gross Margin per Hectare				
1.1 Gross Income				
Activity/Item	Yield - kgs	25kg bsk	Price - $/kg	Gross Income
Local sales	18525	741	0.15	$2,778.75
1.2 Variable Costs				
Activity/Item	Quantity		Price	Direct cost
Planting material (stems)	6000		$0.00	$0.00
Mechanical cultivation (hours)	6		$30.00	$180.00
Packaging (baskets)	740		$0.50	$370.00
Transport to market (trips)	7		$10.00	$70.00
Total Variable Costs				***$620.00***
1.3 Gross Margin		***From Local Sale***		***$2,158.75***
Return to variable costs				***$3.48***
1.4 GM Returns to Labour				
Land preparation/planting (hours)	300			
Maintenance (hours)	350			
Harvesting (hours)	150		Return per labour hour	
Marketing (hours)	40		$2.57	
Total labour (hours)	840			
Total labour cost (T$3/hr)	***2520***			
1.5 Gross Margin Sensitivity Analysis			Yield: kg/ha	
	Price: $/kg	10000	12000	14000
	0.1	-$1,159	-$959	-$759
	0.25	$341	$841	$1,341
	0.35	$1,341	$2,041	$2,741
1.6 Additional Data		Plant density (pl/ha)		10000
Crop Form	Monocrop	Time to harvest (mths)		Sep-24
Planting time	All year	Plant spacing (m)		1.0 x 1.0

Source: Field survey, 1998; Gyles *et al.*, 1989

Cassava can be planted all year round. Cassava is commonly grown as a monocrop, planted immediately after the previous crop has been harvested, although it may be planted while the previous crops remain in the ground. It is sometimes grown as an intercrop with crops such as pineapples, vanilla, kava and corn. Cassava can be harvested after 8-15 months, or left unharvested for up to 2 years. Once harvested, the cassava roots begin to deteriorate in only a few hours. They can be stored in the ground for two years or more.

6. Sweet Potato: scientific name - *Ipomea batatas,* Tongan name - *Kumala.*

Sweet potato is the third most important staple food crop. As a cash crop sweet potatoes is attractive since it has a much shorter production period than other root crops, with some varieties being ready to harvest four months after planting. In the 1985 Agricultural Census, it was found that

662 households on an average area of 0.9 of an acre grew sweet potato. In the traditional cropping cycle, sweet potato is planted second to either yam or taro. Sweet potato is used as a feast food. The leaves are frequently used as pig feed.

Table A6: Economics of Sweet Potato Production.

Sweet Potatoes – Gross Margin per Hectare				
1.1 Gross Income				
Activity/Item	Yield - kgs	25kg bsk	Price - $/kg	Gross Income
Local sales	12000	480	0.25	**$3,000.00**
1.2 Variable Costs				
Activity/Item	Quantity		Price	Direct cost
Planting material (stems)	25000		$0.00	$0.00
Mechanical cultivation (hours)	5		$30.00	$150.00
Chemicals (litres)	0		$0.00	$0.00
Packaging (baskets)	480		$0.50	$240.00
Transport to market (trips)	5		$10.00	$50.00
Total Direct Costs				**$440.00**
1.3 Gross Margin				**$2,560.00**
Return to variable costs				***$5.82***
1.4 GM Returns to Labour				
Land preparation/planting (hours)	300			
Maintenance, mounding (hours)	350			
Harvesting (hours)	180		Return per labour hour	
Total labour (hours)	830		$3.08	
Total labour cost (T$3/hr)	***$2,490.00***			
1.5 Gross Margin Sensitivity Analysis				
			Yield: kg/ha	
	Price: $/kg	8500	11000	13000
	0.10	$410.00	$660.00	$860.00
	0.20	$1,260.00	$1,760.00	$2,160.00
	0.30	$2,110.00	$2,860.00	$3,460.00
	0.40	$2,960.00	$3,960.00	$4,760.00
1.6 Additional Data				
Time to harvest (months)	4 to 5	Plant spacing (m)		1.2 x 0.9
Planting time	March - July	Plant density (pl/ha)		9140

Source: Field survey, 1998; Gyles *et al.*, 1989

The best yields are obtained when sweet potato is planted between March and July. Spacing ranges from 1.0 m x 1.0 m to 1.0 m x 1.5 m; an average of 1.2 m x 0.9 m is equivalent to 3700 plants/ac. Sweet potato is harvested mostly after 4-5 months, but can be harvested from 3-8 months.

7. **Squash:** scientific name – *Cucurbita maxima (var. Delica)*, Tonga name - *Hina.*

Buttercup squash (*Cucurbita maxima D.*) is a hybrid member of the pumpkin family. It has become an attractive vegetable in Japan and a standard staple. Squash is the most important export commercial crop from Tonga. Production of squash for export to Japanese market

started in 1987 and during the last ten years squash export industry has developed to become the mainstay of the Tongan economy.

Table A7: Economics of Squash Production.

Squash - Gross Margin per Hectare				
1.1 Gross Income				
Activity/Item	Yield - kgs	25kg bsk	Price - $/kg	Gross Income
Local sales	8000		$0.50	$4,000.00
1.2 Variable Costs (T$)				
Activity/Item	**Quantity**		**Price**	**Variable Cost**
Planting material (kg seed)	2.5		$300.00	$750.00
Fertilizer - NPK (40kg bags)	10		$27.00	$270.00
- Urea (40kg bag)	5		$22.00	$110.00
Mechanical cultivation (hours)	5		$35.00	$175.00
Chemicals -			$0.00	$200.00
Packaging (bins)	18		$6.00	$108.00
Transport to market (trips)	3		$20.00	$60.00
Total Variable Costs				***$1,673.00***
1.3 Gross Margin				**$2,327.00**
Return to variable costs				***$1.39***
1.4 GM Returns to Labour	***Hours***			
Land preparation/planting (hours)	50			
Maintenance (hours)	300			
Harvesting (hours)	150		Return per labour hour	
Grading (hours)	100		$3.88	
Total labour (hours)	600			
Total labour cost (3.0/hr)	***$1,800.00***			
1.5 Gross Margin Sensitivity Analysis			Yield: kg/ha	
	Price: $/kg	7000	8500	10000
	0.35	$777.00	$1,302.00	$1,827.00
	0.55	$2,177.00	$3,002.00	$3,827.00
	0.75	$3,577.00	$4,702.00	$5,827.00
	0.95	$4,977.00	$6,402.00	$7,827.00
1.6 Additional Data				
Time to harvest	3 months	Plant spacing (m)		1.5 x 1.5
Planting time	July to August	Plant density (pl/ha)		4500

Source: Field survey, 1998; Gyles *et al.*, 1989

The main export variety grown is Delica. The best planting time is around July to August during the drier part of the year. Planting materials consists of imported seeds purchased through squash exporting companies or seed stores. Favourable results have been found using chicken manure (0.60 kg per planting point at planting), and NPK. Sowing rate of about 1800 planting points per acre (spacing of 1.5m x 1.5m). Seeds are planted 3 to each planting point at a depth of 3 cm. Squash takes about three months to mature with harvests occurring in November.

8. Kava: scientific name - (*Piper methysticum*), Tongan name - *Kava Tonga.*

Kava is the source of an important ceremonial and social drink in Tonga. The roots and rhizomes of the kava plant are cut, sun-dried and crushed into a powder. The powder is mixed

with water to produce a mildly narcotic drink predominantly consumed by men. Kava grows best after a long period of fallow. Approximate spacing of 1.5m by 1.5m can be used (i.e., 4500 plants/ha).

Table A8: Economics of Kava Production.

	Kava - Gross Margin per Hectare					
1.1 Gross Income		Year				Total
	1	2	3	4	5	
Yield (kg dried)	0	0	0	0	5,000	
Price ($/kg)					$12.00	
Gross Income	0	0	0	0	$60,000.00	$60,000.00
1.2 Variable Costs						
Activity/Item						
Planting material (1500stems)	450	0	0	0	0	$450.00
Mechanical cultivation (5 hours)	150	0	0	0	0	$150.00
Harvest cost					130	$130.00
Transport to market (trips)					100	$100.00
Total Variable Costs	***$600***	***$0.00***	***$0.00***	***$0.00***	***$230.00***	***$830.00***
1.3 Gross Margin	-$600	$0	$0	$0	$59,770	$59,170.00
Return to variable costs						$71.28
1.4 GM Returns to Labour						
Land preparation/planting (hours)	200					200
Maintenance (hours)	300	300	300	250	200	1,350
Harvesting (hours)					200	200
Processing (hours)					320	320
Selling (hours)					80	80
Total labour requirement (hours)	500	300	300	250	800	2,150
Total labour cost ($) @3.0	$1,500	$900	$900	$750	$2,400	$6,450
Margin after labour costs	-$2,100	-$900	-$900	-$750	$57,370	$52,720.00
1.5 Gross Margin Sensitivity Analysis				Yield: kg/ha		
	Price: $/kg	3000	4500	5500	6500	
	7.00	$21,000	$31,500	$38,500	$45,500	
	9.00	$27,000	$40,500	$49,500	$58,500	
	11.00	$33,000	$49,500	$60,500	$71,500	
	13.00	$39,000	$58,500	$71,500	$84,500	
1.6 Additional Data						
Time to harvest (years)	5					
Planting time	Jan to Apr		Return per labour hour			
Plant spacing (m)	1.5 x 1.5			$27.52		
Plant density (pl/ha)	4500					

Source: Field survey, 1998; Gyles *et al.*, 1989

January to April is the preferred time of planting since high humidity is required shortly after the germination phase. Intercrops can be planted once the kava is 3 months old; common intercrops are yam, taro and bananas. Intercrops will provide food and/or cash in the period while the kava is not productive. Kava used to be harvested after 5 to 10 or more years of growth. It is now harvested as early as 3 to 4 years after planting. Kava processing includes

cleaning of stems and roots with water, cutting up the product for quicker drying, and drying in the sun. On average 1kg of green kava yields 0.6kg of dry (powdered) kava.

9. **Vanilla:** scientific name - *Vanilla planifolia*, Tongan name - *Vanilla.*

Vanilla is an important cash crop in Tonga. In Tonga, vanilla production is concentrated in Vava'u, where soil and climate are particularly suited to the crop. Vanilla is normally planted at a spacing of about 2.5m between rows and 1.5m along rows can be used or 1000 plants/ac. Well-managed vanilla plantations should produce for 12 to 15 years. The first vanilla fruiting is in the third year of growth, to be harvested in the fourth year. For this reason it is common to grow intercrops in the first 2 years of production to supply food and cash to offset accumulating development expenditures. Crops such as pineapples, vegetables, yams and taro can be grown. Intercrops will not only provide food and cash for the farm family, but also will shade the young vanilla plants and reduce the need for extra mulch and weeding.

The price of vanilla beans is dependent upon the world market for vanilla. The study showed that current farmgate price of $10 kg green beans.

Table A9: Economics of Vanilla Production.

1.1 Gross Income						Year								Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Yield (kg\ha)		0	0	0	50	185	865	1250	2250	1430	850	800	700	8380
Price ($/kg) – Green		10	10	10	10	10	10	10	10	10	10	10	10	
Gross Income		0	0	0	500	1850	8650	12500	22500	14300	8500	8000	7000	**$83,800.00**
1.2 Direct Costs														
Establishment Costs		Cost/unit												
Planting material (3500stems)	0.5	1,750	0	0	0	0	0	0	0	0	0	0	0	$1,750.00
Mechanical cultivation (5 hrs)	30	150	0	0	0	0	0	0	0	0	0	0	0	$150.00
Support trees (1750)	0.1	175	0	0	0	0	0	0	0	0	0	0	0	$175.00
Transport (2 trips)	10	20	0	0	0	0	0	0	0	0	0	0	0	$20.00
Total Direct Costs		$2,095.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$2,095.00**
1.3 Gross Margin		-$2,095.00	$0.00	$0.00	$500.0	$1,850.0	$8,650.0	$12,500.0	$22,500.0	$14,300.00	$8,500.00	$8,000.00	$7,000.00	**$81,705.00**
1.4 GM Returns to Labour														
Land preparation/planting (hours)		400												400
Support tree establishment (hours)		140												140
Vanilla establishment (hours)			165											165
Weeding (hours)		200	200	200	200	200	200	200	200	200	150	100	100	2,150
Mulching (hours)		120	30	30	30	30	30	30	30	30	30	30	30	450
Replanting vanilla (hours)				30										30
Looping (hours)			30	50	50	50	50	50	50	50	50	50	50	530
Pruning support trees (hours)			30	40	50	50	50	50	50	50	50	50	50	520
Flower induction (hours)				10	15	20	25	30	30	30	25	20	20	225
Pollination (hours)				50	125	175	200	250	300	300	250	250	200	2,100
Harvesting (hours)					20	60	150	250	250	300	300	250	200	1,780
Processing (hours)													320	320
Total labour requirement (hours)		860	455	410	490	585	705	860	910	960	855	750	970	8,810
Total labour cost ($) @3		$2,580	$1,365	$1,230	$1,470	$1,755	$2,115	$2,580	$2,730	$2,880	$2,565	$2,250	$2,910	$26,430
Margin after labour costs		-$4,675	-$1,365	-$1,230	-$970	$95	$6,535	$9,920	$19,770	$11,420	$5,935	$5,750	$4,090	$55,275.00

1.5 Gross Margin Sensitivity Analysis		Yield: kg/ha			
	Price: $/kg	3000	4500	5500	6500
	8.00	$24,000	$36,000	$44,000	$52,000
	10.00	$30,000	$45,000	$55,000	$65,000
	12.00	$36,000	$54,000	$66,000	$78,000

1.6 Additional Data	
Time to harvest (years)	5
Planting times	Jan to Apr
Plant spacing (m)	1.5 x 1.5
Plant density (pl/ha)	4500

Return per labour hour
$9.27

Source: Field survey, 1998; Gyles *et al.*, 1989