

ECONOMICS SERIES

SWP 2010/06

Setting Agricultural Research Priorities in
Fiji

Ron Duncan



Setting Agricultural Research Priorities in Fiji

Emeritus Professor Ron Duncan
Crawford School of Economics and Government
The Australian National University
Canberra ACT

July 2010

Setting Agricultural Research Priorities in Fiji

Emeritus Professor Ron Duncan
Crawford School of Economics and Government
The Australian National University
Canberra ACT

Introduction

Agriculture should play a key part in the Fijian economy in terms of providing subsistence in the rural areas and helping to ensure food security for the society as a whole; as well as contributing to export earnings and foreign exchange. The agricultural sector is seen in many quarters as a key driver of the increases in export earnings and import substitution needed to reverse the continuing increase in the trade deficit. However, the agricultural sector has been performing very poorly over a long period. Further, the potential of the agricultural sector to increase output and export earnings is not as great as many appear to believe.

Increased productivity is essential to the agricultural sector contributing to the economy in the ways envisaged; and research is critical to attaining the increased productivity. But in order for agricultural research to fulfill this role, there has to be better understanding of why the agricultural sector is performing so much below expectations. Therefore, as well as outlining a framework within which to undertake an assessment of agricultural research priorities, this paper discusses the characteristics of the agricultural sector in Fiji that have to be taken into account in deciding on what kinds of research to undertake.

The structure of the paper is as follows. In the first section, an analytical framework for assessing research priorities is outlined. The focus is primarily on productivity-increasing research but attention is also paid to research that improves a country's prospects in export markets, such as through overcoming quarantine barriers. Attention is also given to the evaluation of research that improves agriculture's contribution in the subsistence sector, which is a very important part of the Fijian economy and society.

In the second section, recent trends in the agricultural sector are discussed in order to provide background to the discussion of research priorities. Discussion

of what is called the 'commercial' sector is separated from discussion of the 'village' or subsistence sector because the people and farming systems involved are so different. In section 3, background material is presented that focuses on behavioural characteristics of Fijian society that affect agricultural performance and will also affect the ultimate success of research projects.

Section 4 discusses the recent history of agricultural research in Fiji, as its status has a large bearing on what it will be capable of achieving. The section also discusses the relationship between basic and applied research in Fiji and past efforts at setting agricultural research priorities. Finally, in section 5 potential areas for agricultural research in Fiji are presented. There is some preliminary discussion of the parameters that will influence the payoff to research in these various areas, such as the 'size' of the activity/industry.

I. An Analytical Model for *Ex-ante* Evaluation of the Benefits of Research

Innovations derived from agricultural research basically fall into two categories: process innovations and product innovations. At times the distinction may be difficult to make as there may be some change in product associated with a new cost-reducing process, while development of a new product may also require the development of new technology. Agricultural research has been overwhelmingly oriented toward process innovations. A process innovation can be defined as an improvement in the technology of production such as new or improved breeds or varieties of crops and animals, improved controls over pests and diseases, or new or improved systems of farming. A process innovation means that the costs of production are reduced. When new or improved products are developed it means that consumers are offered greater choice in terms of a better quality product or a new product with different characteristics than existing products.

Ex ante and *ex post* assessments of agricultural research have focused on evaluations of the returns to research expenditure within a market context, that is within the context that the value of a product is the price set in a market equilibrating between the supply of the product and demand for the product. However, similar to other Pacific island countries, Fiji is a dual economy with a market-based, largely urban, component and a component in which a large proportion of the indigenous population carry on a largely 'subsistence' livelihood. Production activities are primarily for the individual household's consumption. Some household outputs may be exchanged (bartered) for products from other households; and surplus output may be sold in the local market for cash to provide for school fees, medical expenses, entertainment, etc.

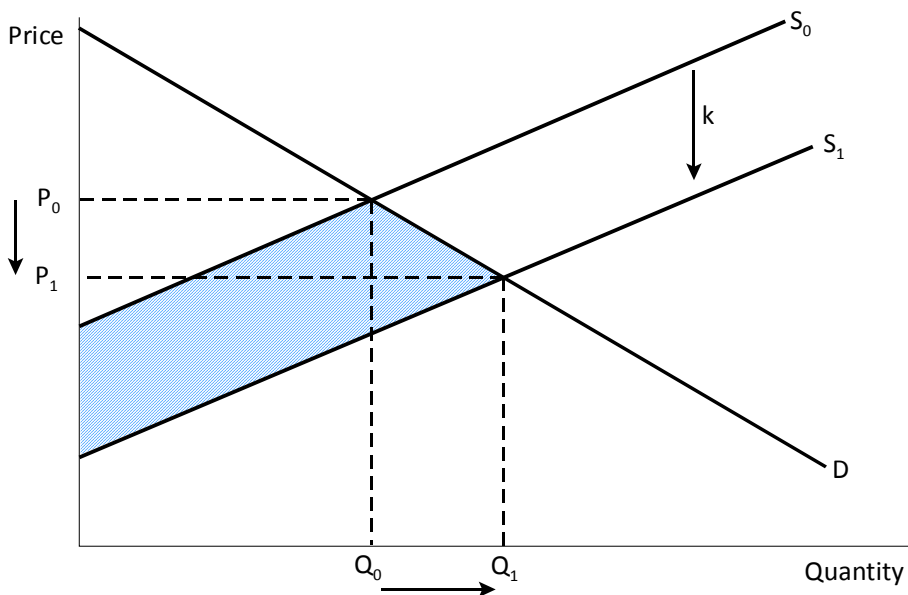
In examining the priorities for agricultural research, therefore, the role of research in improving the welfare of the indigenous population living largely subsistence livelihoods cannot be ignored. However, because subsistence output is not valued in the market, the question arises as to how to assess the returns to agricultural research in this sector and to prioritise such research along with research that affects the commercial sector. Moreover, in some cases agricultural research will affect both the commercial sector and the subsistence sector.

Below we outline frameworks within which benefit-cost analysis of the different forms of research may be undertaken for the purpose of setting agricultural research priorities. We also give some consideration to evaluation and prioritisation of research, which has impacts on the subsistence sector.

Productivity increasing research

Productivity-increasing research outcomes may take the form of improved varieties of plants or animals that give higher yields to farm inputs such as fertilizer applications or varieties that provide better drought resistance or improved resistance to pests and diseases. Productivity-increasing research may take the form of better farming systems or improved farm machinery that also lead to higher yields. These outcomes from research basically mean that the same level of output may be achieved with fewer inputs or using the same level of inputs can achieve a higher level of output.

Figure 1: Productivity Increasing Research



The benefits of such increases in productivity can be thought of in terms of a shift rightwards of the supply curve for the product, as represented in Figure 1. With the same output now produced by fewer inputs, the supply curve, S_0 , shifts to the right (downwards) to S_1 , giving rise to a lower price for consumers

and an increase in 'producers' surplus', or 'rent', for the producers. The improvement in welfare for society as a whole is measured as the shaded area in Figure 1.

In undertaking a benefit-cost analysis of the expected net returns from a proposed research project using this framework, assumptions about the following benefits and costs have to be made:

- The size of the shift, k , of the supply curve resulting from the research. The analyst undertaking the evaluation should gather ideas from scientists familiar with the particular field as to their best guess of the outcome from the research. It is desirable to collect independent opinions, in addition to the views of those putting forward the research proposal. It is important to keep in mind that, from experience, on-farm yields will be lower than yields from research trials. Unfortunately, the quantity and quality of agricultural research in Fiji has declined substantially since the 1987 coups. Therefore, there is little good local scientific knowledge available about the likely responses to research on particular problems.
- The size of the activity/industry that will be impacted by the research outcome. The 'size' of the activity/industry basically depends upon the price of the output that will be affected and the size of the output, that is. the total revenue of the activity/industry.
- The cost of the research project (including the period over which the research will have to be conducted and the probability of success of the research). This information should be collected along with the views about the likely success of the research project.
- The rate of adoption of the research outcome (that is, how quickly will farmers adopt the research results). The rate of adoption of new technology differs greatly from one technology to another and can be influenced by many factors such as the expected level of profitability, the cost of the new technology, its labour and capital intensity, the extent of the difference from existing practices, and cultural practices (see later).
- The change in costs for farmers adopting the new technology.
- The discount rate used to convert the flow of future net benefits to a present value for the purpose of comparing the rate of return to other research projects or to other forms of investment. For example, the

standard discount rate used in ACIAR impact assessments is 5 per cent (Davis *et al* 2008).

It is now well known from earlier studies that the estimates of the present value of the net benefits of a research project are quite sensitive to changes in the assumptions. In particular, the estimates are sensitive to the rate and level of adoption of the new technology, the size of the productivity improvement expected (or loss prevented), and the value (quantity of output x price) of the output. For this reason it is wise to base present value estimates on conservative values of these assumptions.

In Figure 1 a parallel shift of the supply curve is assumed, that is. the industry's cost of production is reduced by equal amounts for both infra-marginal and marginal units of output. This is the assumption usually made when evaluating the producer surplus from shifts of the supply curve. However, as Duncan and Tisdell (1971) showed, assuming that parallel shifts of the supply curve will always prevail is unwarranted. Moreover, if the shift in the supply is not parallel and depending on the elasticity of the demand curve, the size of the producers' surplus may increase, remain unchanged, or even decline.

These points are illustrated in the matrix below.

Impacts of supply shifts and demand elasticity on producer surplus

Reduction of Costs at Margin Compared with Reductions in Infra-Marginal Costs	Perfectly Elastic Demand	Intermediate Elastic Demand	Perfectly Inelastic Demand
Less	+	+	+
Equal (parallel supply shift)	+	+	0
Greater	+	?	-

If infra-marginal costs fall by more than costs at the margin, the industry's surplus increases under all demand elasticities (first row). If infra-marginal costs and marginal costs decline equally (parallel shift), producer surplus increases if the demand curve is less than perfectly inelastic (second row). If, as in the third row, the decline in marginal costs is greater than the decline in infra-marginal costs, the change in producer surplus is positive when demand is perfectly

elastic (as usually assumed for sales into export markets), negative when it is perfectly inelastic, and positive if demand is perfectly elastic or is sufficiently elastic, or is negative if demand is perfectly inelastic or sufficiently inelastic (as may be the case for a globally-large producer).

Thus it is vital to try to gain the best estimates of the shift of the supply curve and what is likely to happen to costs of production at the margin and infra-marginally, and to understand the nature of the demand curve facing the activity/industry. Duncan and Tisdell (1971) pointed out that research that reduces costs more in marginal areas of an industry than in infra-marginal areas may well reduce and industry's surplus. Further, if export demand is less than perfectly elastic, as may well be the case with large producers such as the Australian wool industry or the Brazilian coffee industry, where consumers in export markets will benefit from cost-reducing research through lower prices, the returns to the country carrying out the research may decline.

Research that protects existing levels of output

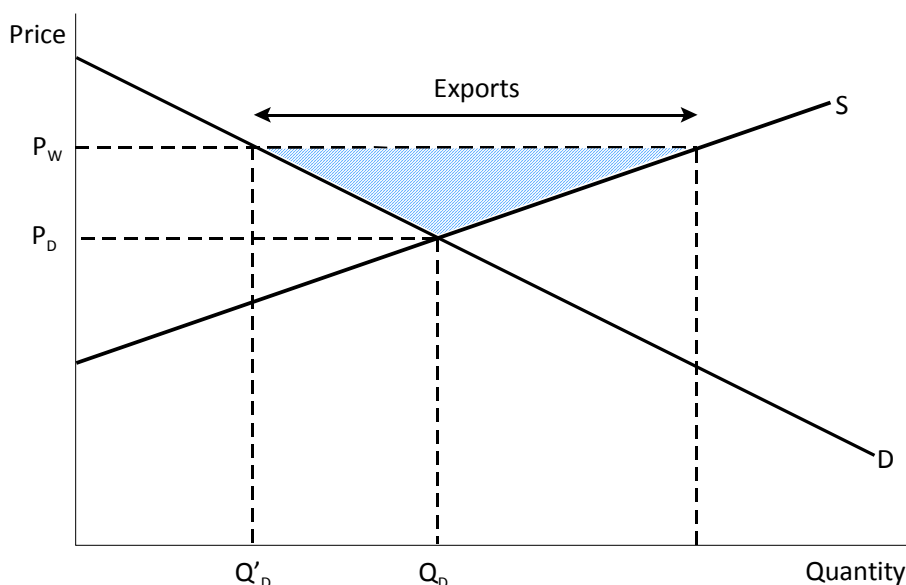
Research to control or protect against pests and diseases is essentially research that protects existing levels of output. The net benefits of such research may be evaluated in the same way as productivity-increasing research above. In this case, Figure 1 can be interpreted to illustrate the benefit of saving losses in output through research (that is, preventing a backward, or leftward, movement of the supply curve). In this case, the evaluation would be considering the same parameters, except that the parameter k would refer to the expected loss from the pest/disease if the research were *not* undertaken and the size of the industry would depend on the expected incidence of the pest/disease.

Research that overcomes quarantine barriers

Agricultural research may be undertaken to overcome quarantine barriers and thereby increase the international trade of a country—or protect against the threatened loss of export markets because of the threat of some pest or disease. The evaluation of the net benefits of such research is illustrated in Figure 2.

In this case it is assumed that initially there is no trade in the product. The supply curve and the domestic demand curve intersect at P_D which would be the domestic market price. If the quarantine barrier is overcome, the industry is able to export at the world market price, P_W , which is higher than the domestic price. Domestic supply is able to expand to Q_W to cater for the increase in sales due to the opening of the export market.

Figure 2: Trade Increasing Research



The net benefit to the country undertaking the research is the shaded area in Figure 2, which is the net outcome of an increase in producers' surplus and a loss to domestic consumers because of the higher price in the domestic market that shifts output from local consumers to consumers in export markets.

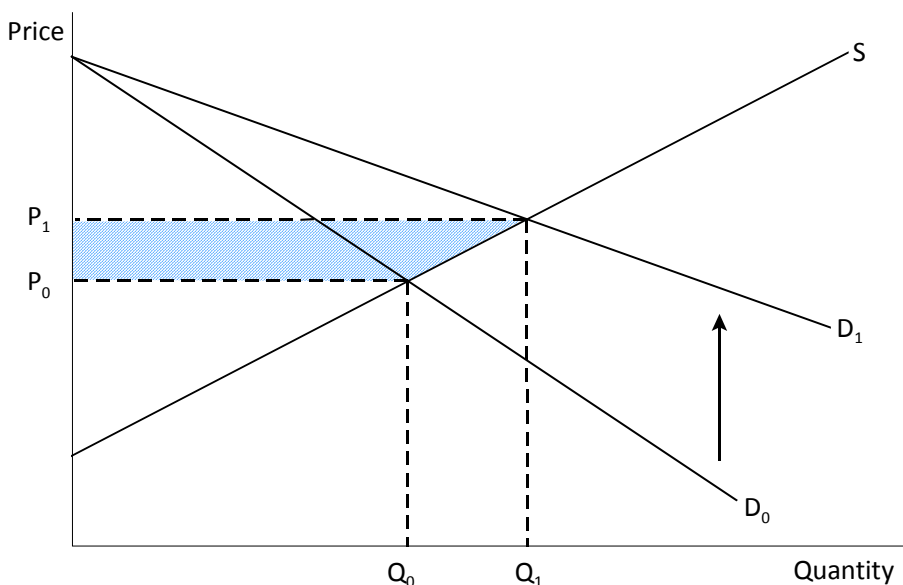
Estimates of many of the same parameters as detailed above would have to be made, such as the expected costs and probability of success of the research, the costs to farmers of adopting the research results, and the rate and level of adoption of the successful research. Additional estimates that would have to be made include the decline in domestic consumption due to the rise in price (which would mean estimating the price elasticity of domestic demand) and the increase in exports due to access to overseas markets. For the purposes of Figure 2 it is assumed that perfectly elastic international demand faces prospective exports. This assumption is realistic for small producers. However,

if international demand is not perfectly elastic, the size of the prospective international market would be less than in the perfectly elastic case. Where the quarantine barrier has been overcome in only one or only a few markets, it is more likely that export demand is less than perfectly elastic.

Research that improves the quality of products or leads to new products

Economic theory is not very helpful in dealing with the evaluation of research that leads to new or improved products. Where a new product is concerned, there is no *a priori* information about the size of the market or the price or income elasticities of the product. Therefore, guesses have to be made about these parameters. With respect to improvements in the quality of a product, there is some basis for making estimates of the size of the market and its characteristics.

Figure 3: Demand Increasing Research



As illustrated in Figure 3, an improvement in product quality (an upward shift of the demand curve from D_0 to D_1) that leads consumers to buy more of the product at a higher price will increase producer surplus unequivocally (shown by the shaded area). However, consumers do not necessarily gain as the change in consumers' surplus will depend upon the nature of the shift in the demand curve—the more inelastic the demand curve becomes, the more likely

it is that consumer surplus will increase; the less elastic the demand curve becomes, the less likely that consumer surplus will increase.

With process innovations that at the same time improve the quality of the output (shift the demand curve upwards) there is less need to be concerned about reductions in producers' surplus associated with the elasticity of the demand curve.

Research that affects the subsistence sector

Where agricultural research relates to products that are consumed in the subsistence economy but are also traded in the market economy, it seems reasonable to use the market price as the benchmark price for evaluating the returns to research in the subsistence sector. Products such as dalo, mandarins, oranges, and avocados, where the surplus output is sold to have cash income available, could fall into this category. However, there would be need for additional information such as the 'size' of the market for the particular product in the subsistence sector and the 'price elasticity' of demand for the product. Such information would have to be garnered from household surveys in the traditional villages.

However, there are forms of agricultural research where the primary application will be in the subsistence sector. These include farming systems, such as forms of 'slash and burn' agriculture that are employed in this sector and are not employed in the market sector. Some indigenous foods are primarily consumed in the subsistence sector and are not sold in the local markets. Also, certain agricultural pests and diseases may affect farming in villages and have little relevance elsewhere. In these cases there is no 'market' price for the commodity.

Possible ways in which the impacts of potential agricultural research could be assessed are the following:

- The maintenance of nutritional status. It may be appropriate to establish nutritional benchmarks for subsistence communities (say from FAO nutritional standards) and to assess the prospective productivity-enhancing benefits of research against these benchmarks.

- Productivity-increasing research could also be assessed on the basis of the savings in village labour input to achieve certain 'desired' or 'past' output levels.
- 'Willingness-to-pay' surveys may be carried out to establish the 'non-market price' and the 'size' of the market, similar to the surveys undertaken to establish 'prices' and 'markets' for non-market services such as environmental benefits.

It will be of great interest to see how effective these suggested forms of research assessment may be in practice.

II. Agriculture in the Fiji economy

According to the figures in Table 1 below, the share of agriculture in Fiji's GDP over the 1995–2007 period has declined from 15.3 per cent to 11.3 per cent. This decline is wholly due to the decline in the value of sugar output, as the other components of agricultural GDP have either shown increasing trends (livestock and subsistence) or at least not declined (non-sugar crops).

On closer examination of the data it can be seen that the increase in livestock products has taken place only in very recent times. From discussions with the meat industry it appears that this recent increase in livestock products is due to increased pig and poultry meat production. The pig and poultry sectors are dominated by the larger commercial producers. However, while poultry meat and egg output are increasing due to increased output by the commercial sector, the increases in pig meat output are due to increased smallholder output; output from the larger producers has been declining.

Beef and goat meat output are falling; although beef production in the informal sector may be increasing. There are no data for the informal sector on which to base a firm opinion; but anecdotal evidence suggests that cattle slaughtering for cultural and social occasions within the indigenous Fijian community has been increasing. Cattle slaughtering through the registered abattoirs continues to decline, and the increased killing of female cattle is a bad sign for the future of this industry.¹ The large beef schemes that were the basis for the beef cattle industry have not been sustained. While goat meat is still in high demand, it is suggested that the decline in output is due in large part to lighter carcass weights because of a decline in breeding lines.

The dairying industry has had difficulty in maintaining production, with the expiry of land leases being the major constraint to increasing milk output from the large bulk suppliers. Because of uncertainty about the renewal of their land leases, these farmers have been reluctant to make further investments. The poor nutritional value of pasture, the lack of improvement in feeding practices, and little improvement in the quality of the national herd have resulted in milk yields remaining at very low levels over the past 30 years.

¹ The 2007 Annual Report of the Ministry of Primary Industries noted that 90 per cent of the cattle slaughtered at the registered abattoirs were female, with some in calf at the time of slaughter.

The data indicate that the non-sugar crops and livestock sectors contributed an average 13.7 per cent of total agricultural exports over the 2004 to 2007 period. Dalo, kava, ginger, and cassava have been the main crops exported; although horticultural products (particularly pawpaws and vegetables, including chilies) are the fastest growing component of the agricultural exports. While dalo production and exports appear to be increasing, production and exports of kava and ginger have declined. In the case of kava, the decline is due to bans on imports of kava by the major developed country markets. In the case of ginger, production is declining because the main producers (Chinese farmers) are leaving the industry and attempts to have other farmers take on ginger production have had little success. The 2007 Annual Report of the Ministry of Primary Industries (MPI) noted that the area planted to ginger in 2007 had fallen by about one-third. This decline was attributed to the withdrawal of assistance in the form of seed material and other inputs to subsistence farmers. Cassava and dalo are the main traditional staple crops. Their availability in local markets depends upon the fluctuations in prices.

Besides dalo and cassava, rice consumption is the main source of calories in Fiji. Most rice demand is met through imports and there have been persistent calls for domestic rice production to replace imports. But despite millions of dollars spent by governments on developing infrastructure for irrigated rice and promoting rice farming schemes—as well as a period of tariff protection—rice production has not done well. All government-initiated, irrigated rice schemes have failed because these activities are economically inefficient in Fiji. Indeed, rain-fed rice growing for personal consumption has performed much better than the irrigated farming schemes. With the recent high global prices for rice, there have been increased dryland rice plantings and the Department is providing some support to this supply response through assistance to rice growers in the form of machinery and farm inputs.

Pawpaw area and output have increased recently, mainly as a result of establishing export markets in Australia and New Zealand through overcoming quarantine concerns in these importing countries. The production of other fruits such as mangos, pineapples, bananas, and watermelons has received considerable government assistance over the years in the form of farming schemes and provision of inputs such as planting materials and fertilizers. But it has been difficult to maintain consistent supplies of good quality fruit, in part because of poor farming practices and lack of attention to improvement in the

varieties cultivated. Honey production is an activity that has been doing well in recent years, with increases in the number of hives and in output per hive. However, because of quarantine concerns, honey cannot be exported in unprocessed form. The Department is looking at ways to export it through its use in processed fruits.

Table 1: Agriculture's Share of Real GDP (\$F million, 1995 constant prices)

Year	Sugar	Other Crops	Livestock Products	Subsistence	Total Agriculture	National GDP
1995	179 (49.2)	55	17	113 (31.0)	364 (15.3)	2,373
1996	179 (47.1)	69	18	114 (30.0)	380 (15.3)	2,487
1997	136 (40.8)	66	15	116 (34.8)	333 (13.7)	2,433
1998	101 (34.0)	63	16	117 (39.4)	297 (12.0)	2,464
1999	143 (41.7)	65	16	119 (34.7)	343 (12.8)	2,681
2000	132 (39.4)	68	16	119 (35.6)	335 (12.7)	2,637
2001	122 (37.8)	65	16	120 (37.2)	323 (12.0)	2,689
2002	125 (37.1)	73	18	121 (35.9)	337 (12.1)	2,774
2003	121 (36.7)	67	19	123 (37.3)	330 (11.8)	2,800
2004	122 (36.2)	71	21	123 (36.5)	337 (11.4)	2,953
2005	115 (34.0)	78	21	124 (36.7)	338 (11.4)	2,972
2006	121 (35.6)	69	24	126 (37.1)	340 (11.1)	3,073
2007	94 (28.9)	84	24	123 (37.8)	325 (11.3)	2,871

Note: The figures in brackets are Sugar as a percentage of Agricultural GDP (col. 2); Subsistence as a share of Agricultural GDP (col. 5); and Agriculture as a share of total GDP (col. 6). Total Agriculture excludes public sector agricultural activities.

Source: Reserve Bank of Fiji, *Quarterly Review*, December 2009.

The production of copra, the traditional cash crop of the outer islands, has experienced continuing decline over recent decades. Several attempts have been made to improve productivity and to diversify the industry, with little success. Copra production varies with price, but the trend in both has been downwards until recently. With the recent sharp increases in international grain and oil prices in 2007 and 2008, copra and coconut oil prices rose. The copra price reached a record high of \$F900 per ton in mid-2008. As a result of the increased price, weekly copra output almost doubled—albeit from a very low base.

Much of the estimated 60,000 hectares of coconuts are senile. Cyclones have had a devastating impact on plantations. While efforts have been made to replant with a hybrid variety, there are problems with the quality of the nuts produced. However, inter-cropping of the coconut trees with other crops such as dalo and yaqona has been successful in some areas.

Governments have provided income support to rural communities through the Coconut Industry Development Authority (previously the Coconut Board) and Copra Millers of Fiji Ltd. There is no evidence that these activities have improved the prospects for the development of coconut-based activities in Fiji.

Another indication of the poor performance of the agricultural sector is the decline in bank lending for agricultural investment. According to the Reserve Bank of Fiji, in 1994 commercial bank lending for sugarcane growing was \$F82.5 million. In 2006 it was only \$F2.8 million and has now virtually ceased. Commercial bank lending for 'Other' agriculture was \$F37.9 million in 1994 (3.5 per cent of total commercial bank lending); by 2006 it had declined to only \$F19.8 million (0.8 per cent of total commercial bank lending). Fiji Development Bank lending to the agricultural sector (including sugar) has also declined substantially. In 1992 it was \$F67.9 million (of a total of \$F246 million). In 2006 it was \$F37.6 million (of a total of \$F424 million) and in 2009 had recovered to \$F49.2 million following government pressure to lend more to agriculture.

Foreign investment in agriculture is also not very significant. According to information from the Fiji Trade and Investment Board, the following agriculture and forestry projects were supported by foreign investment: 2005, five projects to the value of \$F1.2 million; 2006, five projects to the value of \$F4.8 million; and 2007, four projects to the value \$F1.6 million. Forestry and sawmilling projects comprised a significant part of these investments. The unimplemented foreign investment projects in those years were: 2005, ten projects amounting to \$F4.3 million; 2006, five projects involving investment of \$F22.25 million; and 2007, 12 projects totaling \$F34.5 million.

Trends in commercial farm production

The 'commercial' sector is defined here as comprising the few large corporate farming enterprises that employ professional managers and those owner-operator farming enterprises whose major activity is not production for

subsistence. Larger-scale, non-corporate, commercial farmers have been operating in dairying, beef cattle and pig raising, and the growing of ginger, fresh vegetables, and dalo. On the whole, these farmers do not appear to be investing in farming; rather they are moving out of the sector. There are only a handful of corporate farming enterprises, primarily in the poultry industry. They are continuing to invest.

As noted above, larger-scale dairying activity is being run down as farmers face the likelihood of land leases not being renewed. The large beef cattle developments established earlier through government assistance no longer exist. As also noted, production from the larger piggeries is declining. Ginger output has been declining rapidly as the main Chinese producers leave the industry. Large-scale chicken enterprises are maintaining production levels. The difference in performance between these and other larger-scale activities was said to be because they rely on imported feedstuffs, which ensures a consistent supply—rather than relying on local inputs. Dalo (taro) output is reasonably robust due to good domestic demand and export markets (based on demand from the Pacific island diaspora in metropolitan markets).

Village sector agriculture

As seen in Table 1 above, the statistics published by the Reserve Bank of Fiji (RBF) show subsistence output at over one-third of total agricultural output and increasing. The figures show subsistence output increasing steadily in constant 1995 dollar terms during 1995 to 2007 (which implies that the volume of output is increasing), with the increase averaging 1.1 per cent over the 1996-2006 period. There is a decline in subsistence output in 2007 that is difficult to explain. In the year following the 2006 coup, it might be expected that there would have been a movement of people to villages from the urban areas because of the loss of low-skilled employment that took place. In that case it might be expected that subsistence output would increase.

The increasing trend in subsistence output appears doubtful for several reasons. First, rural-urban migration has been substantial. According to the 1996 and 2007 census figures, the number of people in rural areas has been declining. The number of indigenous Fijians in rural areas increased from 232,240 to 263,221. But this increase was outweighed by the decline in the number of Indo-Fijians in rural areas (who also have substantial subsistence

production) from 170,783 to 134,075. Further, the number of indigenous Fijians living in urban areas increased much more than the number of indigenous Fijians in rural areas (although the number of indigenous Fijians living in rural areas is greater than the number in urban areas). Thus, the total rural population has been declining and it appears that there is substantial rural-urban migration of indigenous Fijians as well as of Indo-Fijians. So while the indigenous Fijian population in rural areas is still growing, the rate of increase must be slowing. Therefore, it does not seem possible that subsistence output would continue to increase at the rate the RBF statistics show.

Second, with remittances increasing and a large share of the remittances going to the rural areas, where they are partly used to purchase foods, there must be less reliance on subsistence food production. Third, the sales of locally produced foodstuffs in the urban markets are increasing, as there appear to be no difficulties in meeting the demands of the growing urban populations. The increases in these sales imply that some of what was previously consumed as subsistence production is now being sold in the markets.

While it is easy to cast doubt on the estimates of subsistence output, what cannot be denied is that subsistence output is a large component of agricultural output and contributes considerably to the welfare of the people in Fiji. Therefore, considerable attention should be given to subsistence agriculture in evaluating agricultural research priorities.

III. Factors that Affect the Kinds of Research Undertaken and the Adoption of Research Results in Fiji

As noted above, one of the most important factors affecting the realised benefits of agricultural research is the rate and level of adoption of innovations coming from the research. The rate and level of adoption of innovations can be affected by many factors and many of these are specific to the particular country's circumstances. Below, we examine what appear to be the most important of such factors in Fiji and how they determine what research should be undertaken and the adoption of innovations arising from research.

Secure access to land and access to credit

The dual nature of the Fijian economy, with its market-based, largely urban economy existing alongside the traditional, essentially non-market, rural economy has been noted above. The majority of indigenous Fijians live in rural villages in a traditional manner where communal ownership and reciprocity are strongly-held values. An important feature of this part of the economy is the communal ownership of the land, whereby there are usufruct rights to land for individual families but no formal, individual land tenure.

Formal, individual land tenure systems—long-term leases over custom land—were developed in order to make native land available for agriculture, in particular sugarcane farming by Indo-Fijians, and other purposes such as resort hotels. The formal agricultural land lease system, administered by the Native Land Trust Board (NLTB), provided leases for up to 30 years. These leases began to expire in 1997 and there has been a political impasse over the re-negotiation of a leasing system since that time. The impasse over the renewal of the land lease system has led to huge uncertainty over investment in agriculture, resulting, for example, in a large decline in productivity in the sugar industry and the movement of Indo-Fijian farmers out of sugarcane farming.

The absence of a formal, individualised title to native land in the form of long-term leasehold is not necessarily a constraint on the commercialisation of agriculture within the 'village' sector—although it may lead to less than the optimal level of development. Traditional authority structures within the village are able to provide individuals with sufficient security to the use of land to encourage investment and individual effort, allowing farming to take place on a

commercial scale. But this is seldom done. Moreover, the absence of formal title to the land means that the land cannot be used as collateral for loans from commercial banks. Therefore, the amount of credit available to the Fiji farming sector is much less than the optimal level.

Because of the difficulty of access of the village sector to credit, the government has attempted to overcome this problem by extending unsecured loans, primarily through the Fiji Development Bank, a government instrumentality. However, there has been a high failure rate with this lending activity—both in terms of the lack of success of the projects and the poor repayment of the loans extended. Banking officials report that ‘there appears to be a cultural unwillingness to repay debts’. A major factor leading to the poor performance with respect to both the projects themselves and the loan repayments is the fact that because borrowers have not provided security for the loan they have little to lose by not trying to ensure the success of the project or not repaying the loan.

The lack of secure access to land for non-indigenous farmers is manifest in other ways. For example, the lack of development of a vigorous commercial farming sector in Fiji can be traced to the lack of interest in building up and passing on farm assets to the next generation. Commercial farming has been primarily undertaken by the Chinese and Indian communities. The most likely cause of this lack of interest in building up and passing on a farm asset is insecurity over tenure to the farm, as the Chinese and Indian farmers have mainly held leasehold title to native land. Therefore, instead of investing in the land the families have invested in their children’s education. With the limited opportunities for skilled workers in Fiji, this has meant that the children leave Fiji and the parents follow.

The communities of Chinese farmers in Fiji, who have accounted for most of the larger commercial enterprises, have also suffered seriously from loss of life and property through criminal activity. In part for this reason the number of Chinese farmers has declined significantly in recent years and those who remain are not farming as intensively as before. Rather than living on the farm to protect their crops, they are living in town because of the threat to personal security.

The implications for agricultural research of the insecurity of individual tenure to land for both commercial and village farmers are that innovations requiring large, long-lived investments will not be valued. Instead, farmers will value innovations where the investment of their money and time will be paid back over a short time. Hence, innovations in perennial crops or in breeding livestock will not be valued as much as innovations in annual crops.

Respecting contracts

One of the main difficulties experienced by middlemen or traders and processors in dealings with the village sector in Fiji, as well as by government bodies set up to carry out similar functions (such as Fiji AgroMarketing and Food Processors (Fiji) Ltd.), is in ensuring the continuity of supply and the quality of supplies from village farmers. This difficulty appears to stem largely from the lack of respect of the farmers for the contracts that they make with the traders. Firms, such as chicken processors or flower growers, that contract out-growers experience similar difficulties. They contract with farmers to deliver a certain volume of product, after supplying them with inputs, but find that the out-growers may sell the product to someone else offering a higher price. This lack of respect for contracts makes it very difficult for middlemen or processors to carry on a viable business. The fact that the village farmers usually have no commercial assets that they stand to lose as the result of not honouring a contract means that there is little possibility of sanction through the courts.

Cultural obligations

Another difficulty facing the viability of indigenous farming businesses, especially businesses established within the village, is the prevalence of social and cultural obligations (*kerekere*). Attempts to overcome this difficulty through the formation of joint-management groups within the village do not appear to have been successful, as they have proven prone to governance problems. There is still confidence in some quarters in village cooperatives, but experience is such as to not inspire much confidence in this form of enterprise. Experience of management groups among Maori tribes in New Zealand has seen greater success, where the need to ensure good governance and efficient management structures seems to have been understood. Until this point is reached in Fiji, joint ventures between villagers and non-indigenous

entrepreneurs may offer a better means of ‘quarantining’ village businesses from onerous cultural and social obligations. But even this model may not suit agricultural enterprises because outputs are hard to monitor, which could lead to disputes.

This problem with commercialising agricultural activities within the village context reinforces the difficulties that reluctance to invest in long-lived farm assets raises for research.

Law and order

The theft of crop and animal products has become a pervasive problem for commercial farming, leading to a loss of interest in investment in farming. There is a noticeable shift to cassava and dalo and away from higher-valued crops such as vegetables and ginger, even on large farms. This is very likely in part a result of the high incidence of theft, as cassava and taro are more difficult to steal—although they are still subject to theft.

Thus, the Ministry and the Government have to take the impact of poor law and order into account in evaluating the prospects for particular agricultural policies and schemes and the agricultural sector’s capacity to contribute to the economy. Moreover, if farmer preference is shifting away from higher-valued crops because of the high incidence of loss from theft, this also has implications for the kinds of research that will lead to innovations that will be adopted.

Subsistence affluence

It should not be expected that within the village sector there will be the same response to seemingly profitable opportunities as in the market-oriented part of the economy. What has been described as ‘subsistence affluence’ appears to be pervasive. That is, the village communities can live comfortably by devoting only a few hours per week to food production and do not see it necessary to respond to income-generating opportunities, except to pay for essential services such as education and health. What underlies this behaviour is not well understood; but it certainly should not be ignored and should not be expected to change quickly or in response to agricultural policies and schemes that work well under completely different circumstances. This behaviour should also influence decisions made about the kinds of research undertaken. For example,

highly labour-intensive activities will not receive priority within the village context.

Yet the subsistence affluence needs to be protected as it has to be the foundation for an even higher standard of living among the indigenous rural communities. But recent annual reports from the Ministry point to life becoming more difficult for some rural communities as food resources become scarcer with declining soil fertility, soil erosion, and the encroachment of pests and diseases. Moreover, village perennial tree crops such as mandarins, oranges, avocados, and mangoes, which form an important part of their subsistence as well as being a source of cash, are aging and losing productivity and quality. Therefore, it appears important for the Ministry's research program to focus on protecting and enhancing the subsistence basis of the economy through measures such as the protection of the environment, the re-planting of food trees, and improving village farming systems.

Aversion to risk in subsistence societies

As Warner (2007) has noted with respect to Solomon Islands, a key characteristic of the quasi-subsistence livelihood strategies of traditional communities, strategies that have been developed over many years, is their diversity. This diversity in the agricultural activities undertaken is a specific strategy to counter the large risks that production faces in these highly uncertain environments. The benefits from new technology often depend upon greater specialization in farm activities. But, as Warner notes, the communities' risk aversion may make them unwilling to adopt innovations that reduce the diversity of agricultural activities.

Government hand-outs

Successive governments' policies for the agricultural sector have taken the form of hand-out, such as provision of machinery, planting materials, and veterinary services, as well as restrictions on imports and subsidies on inputs. These policies have led to expectations of continued government hand-outs in the farming sector and to farmer dependency on government. As with all form of economic dependency on government, individualism and enterprise is sapped and the dependency is very difficult to reverse.

Another destructive form of dependency that has been encouraged by government policies is that farmers expect the government to provide 'assured' or guaranteed markets. Governments around the world have attempted to provide guaranteed markets and prices, for example, through price stabilisation schemes or marketing boards. But these have proven ineffective and costly and have now mostly disappeared; and in most countries the private sector is now responsible for the marketing and distribution functions for agricultural products.

The continuation of this kind of government intervention in markets has stemmed from a widespread belief among farmers and politicians that private sector traders are somehow cheating the farmers in the prices offered at the farm-gate. But while it is true that the prices paid for the unprocessed products are usually a small percentage of the eventual retail price, allowance has to be made for the costs borne at the various stages of the marketing chain (collection, transport, storage, added-value, risks of loss, etc.). It is generally true, however, that when there is competition among middlemen in the marketing chain they do not receive monopoly profits. It should be the government's responsibility to ensure that there is effective competition among traders and processors, rather than competing against them through Marketing Boards using subsidised inputs and effectively 'crowding out' the private sector. It is not valid for the government to claim that the private traders are too few and/or under-resourced when it is restricting their ability to function effectively by competing against them.²

In order for a healthy, competitive agricultural sector to develop, farmers must be educated to understand that the best way to ensure markets and earn the highest prices is to honour contracts with traders and processors and ensure continuity of supply at the best quality. Traders and processors cannot establish and maintain markets if they cannot honour their contracts with the wholesalers and retailers. Maintaining a market is a 'two way' street between the farmers and the traders/processors.

² See Koko Siga (Fiji) Ltd. (2008) for an extensive discussion of the history of this form of government intervention in Fiji and the false assumptions that underlie it. As regards the assumption that there is monopoly behaviour among traders because of their limited numbers, this paper notes that there are almost 300 licensed produce exporters, of which 'around 50 are consistently active' (p. 11).

The prevailing mind-set of Fiji's farmers is important to bear in mind when evaluating the kinds of research to undertake, in particular in relation the 'size' of the activity/industry to which any resulting innovations will apply and the likely rate and level of adoption of research innovations.

IV. The State of Agricultural Research in Fiji

Government agricultural research and research planning in Fiji has basically been in decline since the two political coups in 1987. The coups, which had a strong anti-Indian bias, led to the emigration of many skilled Indo-Fijians—a process that was reinforced by the coups in 2000 and 2006. As a result of the 1987 coups, most of the senior agricultural scientists employed in the Fijian government left the country permanently. With reduced state funding for research, internationally uncompetitive salaries, and poor research facilities, it has been extremely difficult to recruit and retain replacements.

The few agricultural scientists now employed by the government have been largely used in servicing the provision of 'hand-outs' for farmers, such as in multiplying seeds and seedlings on research stations. Buildings and equipment on research stations are in poor repair. There has been no increase in the operating budget for research for the past eight years; moreover, funds that were allocated for capital projects have been transferred to other projects or schemes within the Ministry. Most of the vehicles held by the Research Division of the Ministry were purchased by donor funds many years ago and now most are old, in poor condition, and very costly to keep in running order.

The impression that one obtains from reading contributions to the *Fijian Agricultural Journal* (which was published by the Ministry for Primary Industry) prior to the coups was that agricultural and agricultural economics research of good quality was being undertaken. The research contributions were similar to those being made in Australia at the same time. The volume and quality of research undertaken since the 1987 coups compare poorly with that carried out in the years preceding the coups. Obviously, the loss of many senior scientists adversely affected the benefits usually gained by younger scientists from mentoring by more experienced colleagues.

Basic or Applied Research?

While there is an important place for private agricultural research in the development of private sector activities, certain forms of public agricultural research are essential. A reasonable argument may be made that research into plant and animal introduction, plant and animal breeding, plant and animal nutrition, agricultural engineering, and farming systems should be undertaken

by the private sector, as these forms of adaptive research are in their interest. However, public research on measures to ensure plant and animal protection against pests and diseases is critical for the protection of Fiji's plant and animal resources. Soil conservation and other forms of research on environmental issues are also forms of 'public good' research where there are substantial external benefits. Basic research that leads to findings that should be available to all without restriction are also forms of research that should be undertaken by the government for the public, as otherwise they will not be undertaken or undertaken at a socially sub-optimal level.

In Fijian agriculture, however, where the industry structure takes the form of many small farming enterprises, there is a case for the government to undertake adaptive research on behalf of farmers that would be undertaken privately if the enterprises were large. It may be argued that farmers should bear at least some of the costs of such research undertaken for their direct benefit. In the case of Australia, this argument has led to research being partly funded by levies on farmers and partly by the government. However, this research funding is additional to research funded by state governments through departments of agriculture/primary industries and research funded directly by the Australian Government through, for example, the Commonwealth Scientific and Research Organisation (CSIRO) and the Australian Bureau of Agricultural and Resource Economics (ABARE). However, given the state of Fijian agriculture, this does not appear to be the time to argue for contributions by farmers towards agricultural research.

Given the dearth of agricultural scientists employed by the government and in particular the dearth of scientists able to undertake the basic research that appears to be needed in many areas, an important part of the Ministry's research strategy should be the establishment of partnerships with other research organisations, both within Fiji and externally. Partnerships should be established with research organisations that employ high-quality researchers and can assist with gaining access to funds from external bodies such as University of the South Pacific (USP), the Pacific Community (SPC), the UN Food and Agriculture Organisation (FAO), the Australian Centre for International Agricultural Research (ACIAR), Papua New Guinea's National Agricultural Research Institute (NARI), CSIRO in Australia and the various state departments of agriculture/primary industry, and Australian and New Zealand universities.

Most of these research organisations will be able to provide the necessary basic research in the various disciplines.

These relationships should be established in a structured way. First, priorities should be set for the research to be undertaken and then the Department should look to establish relationships with the research organisations best equipped to collaborate in research in the particular areas. This kind of collaboration will have several important effects. First, it will ensure that the research undertaken will be of high quality. Second, the experience gained by Fiji's researchers from the collaboration will be very valuable in their development. Third, the collaboration may assist in attracting good-quality researchers to join or remain in the Ministry. Fourth, because the collaboration will improve the quality of the research undertaken and raise the profile of research in the Ministry, it will help in raising external research funds.

Earlier research priority setting

Throughout the 1980s and early 1990s the then Ministry of Primary Industries (MPI) had an association with the International Service for National Agricultural Research (ISNAR) in the Netherlands, with ISNAR giving MPI assistance in research planning. In 1985, following a review of the Ministry's research division in 1982, ISNAR, jointly with a task force from MPI, prepared an agricultural research plan for Fiji (ISNAR and MPI 1985). This was followed up in 1991 by a review of progress in agricultural research in the Ministry (ISNAR 1991).

The 1991 review noted the very damaging impact of the 1987 coups on agricultural research because of the emigration of most of the experienced research staff. Other problems noted included the fact that the share of operating costs in the research budget had only increased from 12 per cent in 1984 to 17 per cent in 1989—well short of the 30 per cent recommended by the 1985 report. With such a small allocation for operating costs, it was difficult to carry out a research program. These and other problems identified are reflected in the following recommendations made in the 1991 review:

- Rebuild the professional capacity of the research staff (primarily through external post-graduate training and overseas experience).

- Adopt a rigorous procedure for setting research priorities. Because of the small research resource base, it was important to concentrate on only the most important areas. Involve the economic and planning section in the setting of research priorities to build in the expected economic impacts of the research.
- Consider a substantial reduction in the number of active research stations (keeping possibly only Koronivia and three others) and consolidate research on the reduced number of stations with a focus on the main research priorities. Use the remaining research stations for other activities for the time being.
- To enhance the relationship between research and extension, undertake joint on-farm trials.
- Establish and maintain strong external linkages to make full use of external knowledge and materials.
- Do not employ researchers on non-research functions such as seed multiplication and laboratory services for health and forensic analysis (which appeared to be taking up research staff time equivalent to 3-4 researchers).
- To enhance the systems perspective of the research program, form inter-disciplinary teams focusing on production systems, e.g., crop and livestock, and inter-cropping farming systems, rather than the commodity-based approach.

For the most part, the problems recorded in the 1991 ISNAR review remain relevant today, as do the recommendations.

V. Setting Agricultural Research Priorities in Fiji

Priorities for research should be established following a compilation of the issues needing to be researched and *ex ante* benefit-cost analysis of the expected rates of return on the various kinds of research. Issues needing to be researched should be established by regular interaction between Departmental research and extension staff. Such discussions were held on a regular basis at one time and this interaction should be re-established. Similar discussions should also be held between Departmental research staff, staff of other research organisations working in Fiji, and farmers and traders/processors involved in the various industries. Those research activities with the highest expected rates of return from the benefit-cost analysis should receive priority.

This process of evaluating research priorities should be undertaken on a regular basis. Consideration could be given to setting up a representative advisory committee to give advice to the Department about research priorities. It could also act as an advisory body on agricultural policies. However, such bodies can become rather static and it may be better to rely on *ad hoc* discussion groups formed from representatives of the various agricultural industries.

The setting of research priorities should also assist in determining priorities for the rebuilding of the research resource base of the Ministry, including priorities given to which research stations to retain and the refurbishment of these research stations. Partnerships with other research organizations will also assist in bringing in external funds for renewal and upgrading of equipment needed for research as well as for the recurrent costs of carrying out research.

The potential areas for research discussed below come from meetings with agricultural scientists, extension officers, traders, and others involved in the agricultural supply chain, as well as from an overview of the agricultural sector. However, because of the lack of reliable data on trends in commodity outputs, value of output, and yield performance, as well as the limited agricultural research undertaken in Fiji over recent decades, it is going to be difficult to make reliable assessments about where research may provide the greatest payoffs.

The following discussion is undertaken within the analytical frameworks for research impact evaluation outlined in section 1. The discussion also takes into

consideration the various economic, social, and cultural factors that may have an impact on the kinds of research undertaken and the rate of adoption of any research outcomes.

The 'size' of the activity/industry

Dalo and cassava are the major locally-grown crops consumed in urban areas as well as in rural, including subsistence, areas. Dalo is also the main non-sugar agricultural export. According to the Department of Agriculture (2008), 900 farmers were involved in farming dalo (*Tausala* variety) for export in 2007; dalo exports averaged around \$F22 million during the 2007-09 period (Fiji Bureau of Statistics 2010). Rice is also a major item in the consumption basket. However, as noted previously, most of the rice consumed is imported and the many attempts over the years to develop an efficient domestic rice industry have proven futile. Therefore, rice research does not appear to deserve priority attention.

Coconuts have always played a major role in the subsistence economy, in the form of coconut oil and coconut meat (copra) and as a refreshing drink. Coconut oil is also exported (around 4,000 tonnes annually), as is a small volume of copra. Coconut products such as virgin coconut oil for uses such as in cosmetics and coconut oil as a source of renewable energy are commercial products, although their commercial viability remains to be proven. However, most of the coconut plantations are now senile and productivity is low. Given its continuing importance in the subsistence economy as a source of food and drink and as a source of cash, the decline of this industry is of concern.

Yaqona (kava) is a major crop in Fiji, consumed as a social and cultural drink. It is also exported, although the volume exported shrunk considerably following health concerns over its consumption in the EU and the USA, and, more recently, Australia. Exports of around \$F4 million were sold in 2009 (Fiji Bureau of Statistics 2010). The main market for this commodity is the local market, with total annual sales estimated at around \$F100 million (Department of Agriculture 2008).

Pineapples and bananas are sold only in the domestic market as they have not been cleared for export. The local market for pineapples in 2007 was estimated at 1,830 tonnes and valued at around \$F2.8 million. The local market for

bananas was estimated at 4,656 tonnes, valued at around F\$6.5 million (Department of Agriculture 2008).

Aside from cassava, the main fruits and vegetables exported are ginger, papaya, mangoes, eggplant, breadfruit, okra, chili, and spices. Total fruit and vegetable exports, aside from dalo, averaged \$F11-12 million during 2008-09. As noted earlier, ginger production has been declining due the withdrawal of the mainly Chinese farmers who have been involved in this industry. There are also disease problems affecting ginger production. Ginger exports reported for the period 2007-09 averaged \$F5.7 million.

Since clearance for export to New Zealand in 1996 and to Australia in 2002, papaya sales to these countries have grown rapidly so that they are now close to 1,000 tonnes annually (McGregor 2007). This fruit is also popular in Fiji, both among local consumers and tourists. Both smallholder and plantation production have expanded. The Department of Agriculture (2008) has estimated that sales to the local market reached \$F7.3 million in 2007. Mangoes, eggplant, okra, chili, and spices are only cleared for export to New Zealand. These commodities are also popular in Fiji but their domestic and export markets are relatively small. With improvements in quality and stability of supply, however, mango consumption by tourists could increase significantly.

The major livestock products produced in Fiji are poultry meat, eggs, and pigmeat. Except for egg and poultry meat exports to other South Pacific island countries, mainly Samoa, Fiji is an importer of these products except for eggs. Poultry meat and egg production is mainly carried on by large corporate enterprises. In 2007, 15,940 tonnes of poultry meat was produced, giving Fiji 95 per cent self-sufficiency in this commodity. Local consumption of pigmeat is relatively high (allowing for the large percentage of people who do not eat pigmeat) and is increasing—with 5 per cent growth from 2006 to 2007 (Department of Agriculture 2008).

As noted earlier, the beef and dairy industries have performed very poorly over the years. At its peak in 1971, slaughtering of beef cattle was around 18,000 head; in 2007 the number slaughtered in abattoirs totaled only 8,000. The total numbers of cattle carried and slaughtered are not well known as, over the years, cattle raising moved away from the large cattle projects towards mainly

smallholder sugarcane farms and some village production. Also, 'bush' slaughtering has increased. A significant part of the recent decline in cattle numbers and the sharp increase in the slaughtering of female cattle is likely to be due to the loss of land leases by Indo-Fijian sugarcane farmers. Domestic beef consumption is mainly dependent on imports.

Despite being active for most of the 20th century and receiving considerable government support in the form of import restrictions and subsidies, the dairy industry supplies only around 25 per cent of Fiji's total milk consumption. Average milk yields are extraordinarily low, on average around 4-5 litres/cow (by comparison, this is about one-sixth of Australia's average and one-eighth of New Zealand's average). This poor performance is attributed mainly to poor nutrition and the lack of introduction of higher-yielding breeds from overseas (Department of Agriculture 2008, Kumar and Reddy 2008). Dairy farming has also moved away from larger holdings to smallholders, because of the uncertainty of the large farmers about retaining their leases.

Goat meat and sheep meat production are also undertaken in Fiji. Goat meat is popular in Fiji and is the most expensive of meats consumed, aside from duck. It is estimated that around 400 farms in the sugarcane areas are raising goats numbering some 280,000. However, the productivity of the activity is considered to be poor and this is attributed to the need for new blood lines. It is also considered that introduction of new blood lines would raise the quality of the meat (Department of Agriculture 2008).

Sheep meat is an important meat import in Fiji. The Department of Agriculture has put considerable resources into the development of a new breed of sheep—the Fiji Fantastic—suited for meat production in the tropics. Three government research stations have been involved in the development of the breed and its multiplication for local use and for export to other Pacific island countries. However, sheep raising is still a very small industry in Fiji, with numbers totaling 9,500 in 2007, which was a 12 per cent decline from 2006—mainly due, it is claimed, to the non-renewal of land leases (Department of Agriculture 2008).

Honey production has done well in recent years. In 2006 around 300 tonnes were produced. In 2007, output increased to 494 tonnes, while the number of hives increased from 9,566 in 2006 to 10,605 in 2007 (Department of

Agriculture 2008). Honey is not able to be exported because of quarantine restrictions; however, given that the industry can become competitive, there is scope for this commodity to expand in the domestic market, as a large quantity of honey is imported.

Considerable government and media attention is given to the possibility of local agriculture substituting for the large imports of foodstuffs servicing the Fiji tourist industry. These imports have grown along with the growth in tourist numbers, with the value of imports (in current dollar terms) increasing from \$F335 million in 2003 to \$F520 million in 2008 (Fiji Bureau of Statistics 2010). Questioning of resort managers reveals that problems with the quality of local foodstuffs and the unreliability of supplies lead them to rely mainly on imports. This situation opens up two areas for research: first, to improve the quality of local products, and second, to improve supply chains.

With regard to research leading to improvement in the quality of local produce, attention would need to be paid to varietal improvement as well as to improvement in farming systems. Consideration of the local farming systems would be important in selecting the activities to receive research attention. For example, while beef imports are an important component of the total imports of food stuffs, the current situation of the beef industry does not lend much support to beef research receiving priority. On the other hand, locally-produced commodities such as tomatoes, bananas, pineapples, and lettuce, which are currently servicing the local market, could conceivably become substitutes for imports if the quality and supply are improved.

Thus, with respect to the size of their domestic and export markets, the commodities that warrant most focus in an evaluation of agricultural research priorities are dalo, cassava, yaqona, coconuts, papaya, poultry, pigs, and goats. Dalo, cassava, yaqona, and coconuts warrant priority attention because of the role that they play in subsistence communities as well as in commercial domestic and export markets. 'Village' commodities that also deserve attention because of the role they play in subsistence are perennials such as mandarins, oranges, and mangoes, which are declining in productivity.

Deserving of lower research priority are ginger and sheep, and the possibilities for substituting for tourist imports: tomatoes, pineapples, bananas, and lettuce. While ginger production has been quite an important activity in the past, the

decline of the main Chinese growers means that the industry's future is not bright. Local mutton consumption is large but consumption is concentrated mainly in the lower-valued cuts, which are supplied by imports. Therefore, it is difficult to see a local sheepmeat industry flourishing in such an environment. The commodities suggested as deserving of attention because of the possibility of substituting for imports that serve the tourist industry should not receive highest priority as presently their sales to this market are negligible and they will have to overcome considerable challenges in order to become established in this market.

By international standards, the average yield per cow in the dairy industry of 4-5 litres per day is very poor and the industry looks to be highly inefficient in economic terms.³ Dairying has been carried out in Fiji for a long time and despite (or because of) it having among the highest farm gate prices for milk in the world, dairy yields have not improved. Globally, it has proven very difficult to establish economic dairying in tropical countries. Australia closed down all dairying in its tropical areas, after trying for many years to achieve yields that would make dairying in these areas profitable. Therefore, it appears unlikely that there is a reasonable probability of findings from research on nutrition and/or breeding, or improvements in farming practices, leading to gains in yields sufficient to result in a viable industry.

Possible research projects in various activities/industries

In this section we look at possible research topics in the various activities or industries selected above as high priority.

Dalo research topics

Dalo (taro) growing is the most important farming industry in Fiji other than sugarcane growing. Improvements in productivity and quality will impact beneficially on both the market economy and the subsistence economy. The Tausala variety is the preferred variety for local consumption and has also done well in export markets. Most farmers are now growing Tausala. This variety

³ From data gathered in a survey of dairy farmers in Fiji (Kumar and Reddy 2008) it is estimated that the average net return per cow per year (excluding revenue from sale of animals or from home consumption of milk and animals) is \$98 for Indian farmers and \$68.50 for Fijian farmers; and the net returns per hectare per year is \$131.55 for Indian farmers and \$41 for Fijian farmers.

grows well on Vanua Levu, and especially on the island of Taveuni,⁴ but does not grow well on the main island, Viti Levu. A challenge for research is to breed a variety that has similar eating qualities to Tausala and can tolerate drier conditions as well as having resistance to taro beetle.

Declining soil fertility was reported to be a problem confronting dalo producers. It is not clear whether the soil nutrition problem is one of declines in major nutrients or shortages in micro-nutrients. Soil testing and fertilizer trials would be needed to determine the answers to the questions.

The taro beetle (*Papuana uninodis*) has spread throughout Viti Levu and onto Ovalau islands, and is now reported to be present on Vanua Levu. Therefore, research appears to be needed to determine the existence of the beetle on Vanua Levu and to find ways of controlling the beetle or to breed resistance to it.

Kava Dieback disease

The value of kava consumption in Fiji is large, reportedly amounting to around \$F100 million a year. Wilting or 'dieback' in yaqona is a problem that has plagued the industry for many years and, while there are many theories as to its cause, as yet there is no conclusive answer. Varietal tests and tests of land suitability have been undertaken by the Department of Agriculture for several years, which suggests that the probability of finding the cause is fairly low. The incidence of the disease is not known; therefore there would have to be a thorough farm survey to gain an accurate idea of how widespread the disease is and how it is affecting output.

Kava consumption was once reserved for ceremonial occasions. However, it has become the social drink of choice for many in the indigenous Fijian and Indo-Fijian communities. The adverse health, economic, and social effects of the existing high level of kava consumption are now considerable. Therefore, while yaqona production is economically a very important commodity and the economic returns to research from increases in its productivity may be considerable, this is a case where the negative externalities of kava consumption may need to be taken into account in the social benefit-analysis.

⁴ A reported 3,600 farmers on Taveuni are growing Tausala dalo, and produced 9,000 tons out of a total 10,795 tonnes produced nationally in 2009 (*FijiSun online* 12/31/2009 <http://www.fijisun.com.fj/main_page/view.asp?id=31911>

Coconut research

Attempts have been made to replant the now largely senile coconut plantations with new varieties, but without much success. The low returns to coconut products and the labour-intensity of coconut harvesting and processing appear to militate against it as a village enterprise, despite its many uses in traditional communities. Without substantial increases in product prices to make coconut growing economically viable, perhaps the best hope is for joint-production activities with other crops. Joint production has been attempted with farming of dalo, yaqona, cocoa, cattle, and sheep and perhaps it is worthwhile persevering with this area of research.

Infestations of rhinoceros beetle (*Oryctes rhinoceros*) and coconut stick insect (*Graeffea crouanii*) are reported in Fiji. However, it is not known how widespread they are and what damage they are doing. These facts would need to be established to see how serious these pests are before making a decision on research to control them.

Overcoming quarantine restrictions

Fiji needs export markets for many of its agricultural products if agricultural industries are to expand. Adoption of new ways of treating fruit and vegetables for export from Fiji has already proved very valuable in overcoming quarantine restrictions, such as with the export of papaya, mangoes and breadfruit. Around the world, quarantine measures have become more stringent and are often used as non-tariff import barriers. Therefore, the establishment of markets for agricultural exports from Fiji has to be supported by research to prove to governmental authorities in prospective markets that imports would not pose a threat to their plant and animal industries. If necessary, this supporting research has to be of a quality that will satisfy a WTO scientific panel that the products should not be excluded on quarantine grounds.

This is an area where it is likely that the assistance of scientists able to undertake basic research will be required. Because of the difficulty of attracting and holding highly-skilled scientists, there will have to be heavy reliance on partner research organizations for any needed basic research.

Satisfying tourist demand for agricultural products

The tourism industry in Fiji is of a size that offers a substantial domestic market for local agricultural industries. To be internationally competitive, the tourism industry has to offer its customers food of international quality. However, a complaint often heard from the industry is that the local agricultural industries are not able to provide products of international standard on a consistent basis. In order to raise the quality standard of the domestic products, plant and animal introduction and plant and animal breeding research appears to be necessary, as well as research into improved farming systems. One way in which better continuity of supply can be achieved is by research to extend the growing season of the commodities. Such research would also be beneficial in establishing overseas markets for these same products.

An issue with the development of the market for mangoes is to improve flowering behaviour and thereby reduce fluctuations in harvests due to seasonal influences. Cultivar testing would be necessary to ensure consistent flowering and fruit setting. Cultivar testing is also necessary to improve the quality of the fruit.

African Tulip Tree

A major weed infestation has developed in the form of the African Tulip tree (*Spathodea campanulata*), which is affecting substantial areas over most of the country (see Box 1 below). The tree has no predator in the Fijian environment to prevent its spread, and so is posing a severe threat to much of the arable land and particularly to land farmed in the Fijian villages. The threat in the villages is heightened by the fact that the African Tulip spreads from air-borne seeds (over a wide area), roots, and cuttings and quickly establishes under the type of minimal cultivation carried out in village gardens. It is apparent in some villages that gardens are being forced further and further away from the village, making food production more onerous. Unfortunately, the wood of the African Tulip is extremely difficult to burn and, moreover, has no commercial value. Once the trees are established, clearing costs run into thousand of dollars per hectare. The spread of the weed is obviously a severe threat to Fiji's biodiversity.

The Department was warned about the spread of this weed around 20 years ago but little research has been done to find predators that will at least keep it under control and it has spread quickly in recent years. Without early control,

substantially more areas of arable land will only be recoverable at great cost. As the African Tulip is also growing in other Pacific countries, consideration should be given to researching its control on a multi-country basis.

Box 5: Spread of the African Tulip Tree in Fiji

The African Tulip tree (*Spathodea campanulata*) was widely introduced throughout the tropics as an ornamental tree. In the Pacific islands, it has invaded agricultural land, forest plantations, and natural forests. It was introduced in Fiji in the 1930s and has been recognized as a problem for around 20 years. But it has spread very quickly over the past ten years. Secondary or re-growth forests previously cleared for agriculture make up more than 20 per cent of the total forest cover. The African Tulip is the predominant tree in these secondary forests. Under the shifting cultivation system practised in traditional villages in Fiji, the tree has quickly invaded fallow areas. Farmers estimate that the time taken to clear one infested hectare manually is around 15 months. Because of difficulties of controlling African Tulip infestations, village farmers tend to leave these areas and clear natural forest areas instead. This practice is resulting in the weed's incursion further and further into the natural forests.

Some preliminary research has been undertaken by the Department over the years in the form of herbicide treatments and investigation of biological control. However, this research has not been sustained. It is likely that an integrated weed management program will be needed for control, which could involve a combination of biological control, chemical control, crop rotation, and depletion of the buried seed banks. Identification of the best form of management will require sustained research of various forms.

Of significant concern, however, is whether the necessary management system will be undertaken by the farming community, especially in the villages where such intensive management of weeds is uncommon. Therefore, the threat to the sustainability of village subsistence and to the biodiversity is significant.

Source: Most of this information was drawn from "Integrated Control of African Tulip Tree (*Spathodea campanulata*)", Research Division, Department of Agriculture, Ministry of Agriculture, Fisheries and Forests, January 23, 2001.

The fact that so little research has been done into the control of African Tulip while ACIAR has funded a study into the biological control of mile-a-minute (*Mikauia micrantha*) because it is considered to be a weed shows the need for comprehensive evaluations of research priorities. Farmers do not consider

mile-a-minute to be a weed but regard it as a useful source of organic material. On the other hand, African Tulip is doing enormous damage to arable areas, particularly in village garden areas.

The production of copra, the traditional cash crop of the outer islands, has experienced continuing decline over recent decades. Several attempts have been made to improve productivity and to diversify the industry, with little success. Copra production varies with price, but the trend in both has been downwards until recently. With the recent sharp increases in international grain and oil prices in 2007 and 2008, copra and coconut oil prices rose. The copra price reached a record high of \$F900 per ton in mid-2008. As a result of the increased price, weekly copra output almost doubled—albeit from a very low base.

Much of the estimated 60,000 hectares of coconut are senile. Cyclones have had a devastating impact on plantations. While efforts have been made to replant with a hybrid variety, there are problems with the quality of the nuts produced. However, inter-cropping of the coconut trees with other crops such as dalo and yaqona has been successful in some areas.

Governments have provided income support to rural communities through the Coconut Industry Development Authority (previously the Coconut Board) and Copra Millers of Fiji Ltd. There is no evidence that these activities have improved the prospects for the development of coconut-based activities in Fiji.

VI. Conclusions

The Department of Agriculture clearly does not have the financial resources needed to undertake all the research that appears to be essential if the agricultural sector is to grow robustly. Therefore, formation of partnerships with other research organizations that employ high-quality researchers and can assist with gaining access to funds from external bodies appears essential. Then relevant external bodies include the University of the South Pacific (USP), the Secretariat of the Pacific Community (SPC), the UN Food and Agriculture Organisation (FAO), the Australian Centre for International Agricultural Research (ACIAR), Papua New Guinea's National Agricultural Research Institute (NARI), and in Australia and New Zealand, CSIRO the various state departments of agriculture/primary industry, and the universities.

Addressing many of the research priorities will require basic research; something that the Department will be able to do only to a very limited extent for the foreseeable future. The main focus of its own researchers should be adaptive research. Most of the research organisations listed above will be able to provide assistance in basic research in the various research disciplines. Priorities should be set for the kinds of research to be undertaken and then the Department should look to establish partnerships with the research organisations best equipped to collaborate in research in the particular areas.

This kind of collaboration will have several important effects. First, it will ensure that the research undertaken will be of high quality. Second, the experience gained by Departmental researchers from the collaboration will be very valuable in their development. Third, the collaboration may assist in attracting good-quality researchers to join or remain in the Department. Fourth, because the collaboration will improve the quality of the research undertaken and raise the profile of research in the Department, it will help in raising external research funds.

References

- Davis, J., J. Gordon, D. Pearce, and D. Templeton, 2008. *Guidelines for Assessing the Impacts of ACIAR's Research Activities*, ACIAR Impact Assessment Series 58, ACIAR, Canberra.
- Duncan, R.C. and C. Tisdell, 1971. 'Research and technical progress: the returns to producers', *Economic Record*, 47(117):124-9.
- Fiji Bureau of Statistics, 2010. *Overseas Merchandise Trade*, Fiji Bureau of Statistics, accessed at
<<http://www.spc.int/prism/country/fj/stats/Economic/trade.htm>>
- Fiji Department of Agriculture, 2008. *Annual Report 2007*, Department of Agriculture, Ministry of Primary Industries, Fiji, accessed at
<http://www.agriculture.org.fj>
- International Service for National Agricultural Research (ISNAR) and Fiji Ministry of Primary Industries, 1985. *Fiji: Agricultural Research Plan*, ISNAR R21, The Hague, Netherlands.
- ISNAR, 1991. *Review of Progress in Agricultural Research in Fiji* (draft), prepared by Peter Goldsworthy.
- Koko Siga (Fiji) Ltd., 2008. *Marketing and Management in Fiji's Agriculture Sector: an overview analysis of marketing issues*, Suva (draft).
- Kumar, S. and M. Reddy, 2008. 'Fiji's dairy industry: a cost and profitability analysis', *Pacific Economic Bulletin*, 23(2):27-39.
- McGregor, A., 2007. 'The export of horticultural and high-value agricultural products from the Pacific islands', *Pacific Economic Bulletin*, 22(3):81-99.
- Warner, B., 2007. 'Smallholders and rural growth in Solomon Islands', *Pacific Economic Bulletin*, 22(3):63-80.