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A REVIEW

Progress of Freshwater Aquaculture in Fiji

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ABSTRACT

Aquaculture is proving to be one of the main sectors for development due to rising global demands for fishery products and the over exploitation of inshore fisheries resources. Fiji's aquaculture sector is already worth several millions of dollars and has the potential and demand to grow further. In addition, the effect of climate change on coral reefs is believed to get worse; therefore, aquaculture on land in ponds is one option for climate change adaptation. This review tries to explain the progress of freshwater aquaculture during the last two decades in Fiji.

The total production from freshwater aquaculture was 20 tons in 1990; however, by 2012 it increased to more than 210 tons. During the last decade, production share of the two species in Fiji has been variable. In the years 2001 and 2002 the highest percentage of freshwater aquaculture production belonged to Tilapia (*Oreochromis niloticus* Linnaeus) 393 tons (83%) and in 2004 freshwater prawn (*Macrobrachium rosenbergii* De Man) saw its highest production reached 40 tons. In 1990, total tilapia fry production in Fiji was 106,620 which increased to 1.1 million in 2013 and the same for freshwater prawn post larvae production; an increase from 8,000 produced in 1990.

The results showed that culture of tilapia has grown noticeably in the past decade. At present, Fiji is yet to acquire ranking of culture species in the world. In addition, coastal and inland waters of Fiji have more potential for aquaculture development. Recently, freshwater prawn and shrimp production have aroused interest from private enterprises. Although freshwater aquaculture of Fiji has shown a significant growth in the last decade, but low fish and prawn density, lack of technical knowledge among farmers, unsuitable feed quality and cost, improper feeding management and financial problem are major limiting factors on aquaculture production in Fiji.

Keywords: Aquaculture development, Freshwater, Fiji, Tilapia, Freshwater Prawn

1.0 INTRODUCTION

Fisheries are the principal natural resource available throughout the Pacific Islands, providing almost 50 % of the total animal protein. In Pacific island countries, the importance of fish in food security is even greater as island populations are heavily dependent on agriculture and fisheries. Fish products originate from two main modes of production: harvesting of wild fish in marine and freshwater and aquaculture.

In 2010, wild capture fisheries and aquaculture supplied the world with about 148 million tons of fish, worth USD 217.5 billion (FAO 2012). Approximately 128 million tons (86%) were used for human consumption. Preliminary data for 2011 indicates that production has increased to 154 million tons, of which about 131 million tons (85%) were consumed as food (FAO 2012). Even though wild fish capture represented 60% of total fish production in 2010, total catch from wild fisheries has remained relatively stable throughout the last three decades. The source of significant growth in the global production of fish since the late 1980s has been aquaculture; since then, it has increased almost twelve fold, at an average annual rate of 8.8%. Aquaculture now accounts for almost half of total fish supply for human consumption (FAO 2010).

In 2010, global production of farmed fish was 59.9 million tons, compared to 55.7 million tons in 2009 and 32.4 million tons in 2000. When farmed aquatic plants and non-food products are included, world aquaculture production in 2010 was 79 million tons, with a market value of USD 125 billion. Aquaculture is also the world's fastest growing food production activity based on animal protein (FAO 2012). However, decline in capture fisheries resources are paving way for aquaculture for food security and poverty alleviation in many countries. Global capture fisheries are not anticipated to increase for the foreseeable future and it is generally recognized that aquaculture must meet future increasing demands for seafood (FAO 2009). In most Pacific Islands, aquaculture is a relatively new phenomenon where it has been attempted and its history goes back less than 35 years. There is no account of traditional knowledge for culturing fish and shellfish; just catching them, except in much specialized instances and areas, thus no great resource of aquacultural skill or infrastructure exists. Therefore this steep development path has perhaps not been taken into account in some development projects, which have often had unrealistic short-term aims and lacked follow ups (Adams *et al.* 2000).

The Republic of Fiji is an island country located in Melanesia in the South Pacific Ocean between latitudes of 18° 00'S and longitude of 175° 00›E. The total area of the country is 18,272 km^2 which includes 332 islands and the coast line stretches for 5,010 km with an economic exclusive zone of 1.3 million km^2 (Oliver *et al.* 2005). Weather condition is typically tropical and changes in temperatures across the seasons are minimal allowing suitable climate for culture of a range of tropical species and different types of aquaculture to be practiced.

Fish farming in Fiji was initiated as there was a general lack of animal protein and then continued for the extensive and semi-intensive aquaculture, utilizing Chinese carp species (*Ctenopharyngodon idella* Cuvier & Valenciennes; *Hypophthalmichthys molitrix* Valenciennes; *Aristichthys nobilis* Richardson), tilapia (*Oreochromis niloticus* Linnaeus), seaweed (*Eucheuma alvarezii* Doty), giant freshwater prawn (*Macrobrachium rosenbergii* De Man), pearls (*Pinctada margaritifera* Linnaeus & *Pteria penguin* Roding) and recently white leg shrimp (*Litopenaeus vannamei* Boone). In the Fiji Islands, aquaculture was not traditionally a widespread practice and the modern industry is just few decades old. The sector has managed to achieve modest success in terms of economic growth and food security. The purpose of this review is to explore the progress and development of aquaculture industry, discussing the opportunities and obstacles to development for consequential benefits for the Fijian economy. The review is limited to freshwater tilapia and prawn production in the past thirteen years and the data

was collected from the comprehensive database and yearbooks of FAO and Fiji Ministry of Fisheries and Forests annual reports. Microsoft office Excel 2010 was used in order to produce statistical work and charts.

2.0 AQUACULTURE IN THE PACIFIC ISLAND COUNTRIES

In the Pacific, aquaculture is a new phenomenon dating back less than 50 years, with the introduction of Mozambique Tilapia from Africa for mosquito control and aquaculture (Ponia 2010). There is no traditional history of culturing fish and shellfish thus aquaculture skills are limited and there is little infrastructure developments in the region. Compared with fishing, aquaculture is currently of little commercial significance (Table 1) in the Pacific with one important exception–black-lip pearl farming which is confined to eastern Polynesia (Adams *et al*. 2000). Development is needed before aquaculture can be considered economically sustainable elsewhere in the Pacific.

Table 1. Value of aquaculture production for 1998 & 2007 per country in USD thousands (Source: Ponia 2010)

Country	1998	2007
American Samoa	-	10
Cook Islands	6,315	2,473
Federated State of Micronesia	-	-
Fiji Islands	217	2,244
French Polynesia	155,290	173,598
Guam	757	1,391
Kiribati	421	17
Marshall Islands	4	128
Nauru	-	15
New Caledonia	16,230	28,835
Northern Mariana Islands	-	205
Palau	-	24
PNG	1,477	1,725
Samoa	-	33
Solomon Islands	214	74
Tonga	141	180
Vanuatu	-	495
Total	**181,065**	**211,646**

Shrimp (*Penaeus* spp.) farming has been a focus of commercial development in several islands over the past 30 years, but with varying degrees of success; Tilapia (*Oreochromis niloticus*) aquaculture has contributed to the subsistence economy in some areas, and seaweed (*Kappaphycus* spp.) is considered a future commercial export (Adams *et al*. 2000). Culture of a number of other marine and freshwater species is still at an experimental stage.

Pacific Island countries now recognize that aquaculture provides one of the few long-term, sustainable ways of deriving benefits from inshore fisheries resources (Adams *et al*. 2000). Profitable aquaculture of penaeid shrimps and blacklip pearl oysters has been established in some areas by commercial interests, enterprises producing for export markets that are firmly established in New Caledonia, Fiji and Solomon Islands and applying technology developed originally in Japan, Taiwan and France. Pearls are the region's most valuable commodity. In 2007, the industry was valued at USD 176 million (Ponia 2010). Crustaceans made up the second most valuable commodity in 2007, valued at USD 31 million - mainly from marine shrimps but with some contribution from freshwater species (Fig. 1).

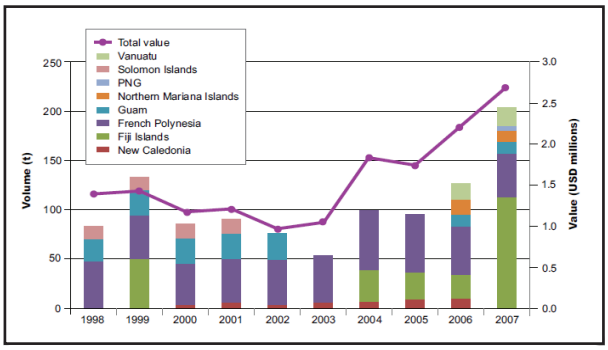

Figure 1. Crustacean production and value in Pacific Islands from year 1998 to 2007 (Source: Ponia 2010)

The crustacean species farmed are blue shrimp (*Litopenaeus stylirostris* Stimpson), giant tiger shrimp (*Penaeus monodon* Fabricius), white shrimp (*Litopenaeus vannamei*), giant freshwater prawn (*Macrobrachium rosenbergii*), monkey river prawn (*Macrobrachium lar* Fabricius)

and red crawfish (*Cherax quadricarinatus* Von Martens) (Ponia 2010). Recent industry growth in Fiji has been due to freshwater prawn *M. rosenbergii* whereas French Polynesia is concentrating solely on marine shrimp (Ponia 2010). New shrimp farms in Vanuatu, Northern Mariana Islands and Guam have also contributed to peak production in 2007 of 204 tons worth USD 2.7 million. There are major opportunities for import substitution in the region, for example in marine shrimp.

French Polynesia imports around 500 tons but produces only 50 tons and Fiji's consumption is around 900 tons of which it imports around 600 tons. High cost of feed and poor supply of juveniles is the major impediments to meeting demand compared with the low price of imported shrimp (Ponia 2010). In 2007, 1,230 tons of edible products were sold locally, mainly consisting of marine shrimp and other commodities. In 2007, production unit analysis was carried out in countries that were major producers of pearl, shrimp and tilapia. It was estimated there were 3,200 farm units providing livelihood benefits to 9,290 persons involved in aquaculture (Table 2).

Table 2. Number of farm units and persons involved in aquaculture in five Pacific Island countries (Source: Ponia 2010)

Country	Farm Units	Persons
Cook Islands	80	450
Fiji Islands	50	280
French Polynesia	530	5,000
New Caledonia	40	560
PNG	2,500	3,000
Total	3,200	9,290

3.0 AQUACULTURE DEVELOPMENT IN FIJI

3.1 History of Aquaculture in Fiji

Aquaculture in Fiji dates back to 1940 when the possibility of freshwater fish culture was first presented. Hall (1949) suggested there was a general lack of animal protein in Fiji thus fish farming was a need. In 1949, first stock of Tilapia (*Oreochromis mossambicus*) was brought to Fiji and stocked at Sigatoka Agriculture Station (Villaluz 1972; Uwate *et al*. 1984). In 1954, a total of 54 fingerlings were imported from Malaysia by Dr. W. J. Payne (Holmes 1954) This species was initially introduced to provide animal protein for pig stocks however, possibility of using Tilapia for human consumption was also examined (Holmes 1954; Payne *et al*. 1954). In 1962, Fiji government introduced the Inland Fisheries Programme that included fish culture.

In 1970, the United Nations Development Programme (UNDP) sponsored a project to assist the PICs in fisheries development called the South Pacific Islands Fisheries Development Agency (SPIFDA) with the objective to examine potential of aquaculture in the region. In the same year, the Fiji government had in its budget a five year aquaculture development programme with the aim of producing molluscs for local and tourist market as well as to provide livelihoods for local people (Uwate *et al*. 1984). In 1974, the Fiji government initiated a follow up activity to the SPIFDA program to develop fish and oyster culture in the country (Uwate *et al*. 1984; Eldredge 1994). One objective of the Fisheries Division was to carry into the commercial phase the culture of aquatic plants and animals, in addition to weed control. In 1981, freshwater, brackish water and marine sites for aquaculture development were identified (Uwate *et al*. 1984).

Aquaculture in Fiji was still far from being established; there was no private industry nor was there any stable source of seed, attributed to inadequate training and limited local resources. The UNDP/FAO projects assisted in initiating brackish water aquaculture and marine shellfish culture. By 1981, three freshwater prawn farms and seven fish farms were in operation and the Fisheries Division was providing technical advice on fish and prawn farming (Uwate *et al*. 1984). Major aquaculture facilities were constructed in July 1968 at Lami fisheries with four ponds which were stocked with aquatic macrophytes and grass carp. In 1948, an experimental pond was established at Naduruloulou which later in 1975 was expanded due to space limitations at Lami. The

primary function of Naduruloulou Research Station was to culture and spawn grass carp, this station was perceived to be the 'Fiji Freshwater Aquaculture Program Center' and in 1983 a freshwater prawn hatchery was established with the help from Japan International Cooperation Agency (Uwate *et al*. 1984). In 1973, fish culture ponds were constructed at Raviravi, Ba, as part of a Fiji Agricultural Department mangrove reclamation scheme. Culture trials were initiated on rabbit fish, mullet, milkfish and tilapia for demonstration of their commercial feasibility (Uwate *et al*. 1984). However, after five and half years of research, the government of Fiji and France Aquaculture established a joint shrimp farming project which later was terminated. In 1982, commercial culture of shrimp was established for the first time in Fiji at the Raviravi farm. However technical difficulties reduced production of *P. monodon* seed which later saw introduction of *P. stylirostris* in 1984. In 1990, an Australian group took over the farm and focused on *P. monodon* which later in 1991 saw the farm being closed and sold by the owners (Bueno 2014).

3.2 Introduced aquaculture species

The table below lists record of introduced aquaculture aquatic animal species in Fiji for food security and poverty alleviation.

Table 3. Introduced freshwater aquaculture finfish and shellfish species in Fiji

Species cultured	Scientific name	Year	Country of Origin	Purpose	Source
Tilapia	*Oreochromis mossambicus*	1949 1954	Malaysia Malaysia	Pig feed & subsistence aquaculture	Hall 1949; Holmes 1954; Van Pel. 1955 Gulick 1989; Adams *et al*. 2000; Villaluz, 1972; Rabanal *et al*. 1981; Uwate *et al*. 1984; Gillett 1989; Andrews 1985; Maciolek 1984; Annual report 2006
	O. niloticus (Chitralada)	1988	Thailand	Pig feed & subsistence aquaculture	Annual report 2006
	O. niloticus	1954 1968 1979 1993	Malaysia Israel Israel Taiwan	Pig feed, culture & subsistence fishery	Lewis & Pring 1986 Uwate *et al*. 1984; Annual report 2006 Vereivalu 1989; Andrews 1985; Maciolek 1984.

	O. niloticus (GIFT strain)	1997	Philippines	Improving & support for industry expansion	Annual report 2006; Nandlal *et al*. 2014
	O. aurea (Blue tilapia)	1985	Taiwan	Research	Lewis & Pring 1986; Nandlal *et al.* 2014; Andrews, 1985
	O. hornorum / O. urolepis (Wami tilapia)	1985	Taiwan	Research	Nelson & Eldredge, 1991; Lewis & Pring 1986; Nandlal *et al.* 2014
	O. mossambica & *O. niloticus* (Red tilapia)	1954 1984	Taiwan Philippines	Consumer preference	Annual report, 2006; Gulick, 1989
	Tilapia zilli (Redbelly tilapia)	1957	Hawaii	Culture & distribution	Andrews 1985; van Pel 1955
	Poecilia mexicana (Mexican molly)	1982	Western Samoa	Food source & mosquito control & baitfish	Ryan 1980; Andrews 1985; Gulick 1989
Carps	*Cyprinus carpio* (Common carp)	1937 1968	New Zealand Malaysia	Pond culture & pituitary extraction	Gulick, 1989; Andrews, 1985
	Ctenopharyngodon idellus (Grass carp)	1968 1975	Malaysia China Japan	Biological control of the weed infested water bodies & Pond culture	Gulick, 1989; Andrews, 1985; Vereivalu, 1990; Annual report, 2006
	Aristichthys nobilis (Bighead carp)	1968 1982 1985 1988	Malaysia China	Pond culture & vegetative control Polyculture with Silver carp	Gulick, 1989; Andrews, 1985; Vereivalu, 1989; Annual Report, 2006
	Hypophthalmiothys molitrix (Silver carp)	1968 1985	Malaysia	Pond culture & vegetative control Polyculture with Bighead carp	Gulick, 1989; Vereivalu, 1989; Andrews, 1985;
	Puntius gonionotus (Tawes or javanese carp)	1968	Malaysia	Pond culture and to provide pituitary material	Gulick, 1989; Andrews, 1985; Ryan, 1980;
	Carassius auratus (Goldfish)	1998	Malaysia Japan	Ornamental purpose	Annual report, 2006
Shellfish					

Crustacean	*Macrobrachium rosenbergii* (Freshwater prawn)	1975 1980 1993 1996 1997 2008	Hawaii Taiwan Tahiti Tahiti Vietnam, Malaysia & Indonesia	Develop farming technology for small scale farmers Genetic improvement research	Andrews 1985; Vereivalu 1989; Annual report 2006; Hurwood *et al*. 2014; Singh 2011

3.3 Ecosystems and Aquaculture production systems

Fiji freshwater aquaculture is dominated by different systems of culture mainly, subsistence (extensive) and artisanal (semi-intensive) culture practices (Fig. 2).

Extensive aquaculture: extensive aquaculture is practiced in many suburban and rural areas as back yard farming across the country. Farmers utilize low-input low-yield culture systems based upon small earthen ponds with water source mainly from direct rainfall, underground water, streams and drains. Tilapia and carp production in earthen ponds is the main form of extensive production. System relies on fertilization to produce natural feed for cultured species at low stocking density and harvestable animals are used only for household consumption (Andrew *et al.* 2003).

Semi-intensive aquaculture: Tilapia and prawn production in earthen ponds is the main form of semi-intensive production. Farmers utilize medium-input medium-yield culture systems based upon earthen ponds, tanks, raceways with gravity flow inlets and outlets system and cages. Water sources are mainly from streams, drains, or rivers. Most of the tilapia and prawn production is from village-level and individual operations. System relies on fertilization to produce natural feed and/or supplementary commercialized feed (but with a significant amount of the fish diet supplied by natural feed) and are typical components of integrated crop-livestock-fish farming systems. In 2000, tilapia and prawn production was valued at FJD 918, 000 whereas in 2010 a total of 193 farmers produced 207 tons valued at FJD 1.58 million (Annual reports 2000 & 2010).

Intensive and super intensive aquaculture: Fiji has very limited intensive and super intensive aquaculture farming practice. This is mainly due to lack of technical expertise, skilled human resource and costly equipment contributing to reduced farmer interest. Intensive systems have all the fish nutritional requirements provided by a nutritionally complete pelleted feed with little or no nutritional benefits from natural feed produced in the pond. Therefore, more intensive systems using pelleted feeds are exceptions in freshwater aquaculture (MFF 2004).

Integrated farming systems: Integrated farming systems are practiced by smaller farmers farming fish in either monoculture or polyculture system along with livestock and/or agricultural crops. This system offers great efficiency in resource utilization, as waste or byproduct from one system is effectively recycled. It also enables effective utilization of available farming space for maximizing production that has brought about considerable benefits to rural families including food security. However, the integration of aquaculture with terrestrial livestock and crops has only made minor progress. In regards to the semi intensive farming system found in most parts of Fiji, it seems that further development and expansion of this system is feasible, however, there is a need for science-based advice to improve

yields. One good example of this model is Montfort Boys Town a religious institution that vocationally trains young men who might otherwise become a social problem. The farm is well-laid out with freshwater and labor is provided by the trainees whereby harvest is entirely for their consumption. Scientific and technical advice provided by Naduruloulou Freshwater Aquaculture Research station (Bueno 2014).

Management strategy: employed in extensive, semi-intensive and intensive culture system are monoculture (all male), polyculture (carp/tilapia or carp/prawn), monosex culture, mixed sex culture and integrated farming monoculture (using farm-made feed). Management strategy depends on farmer's resources, site characteristics, environmental conditions, socio-economic factors, technological know-how, and market demand in the locality (Nandlal 2012).

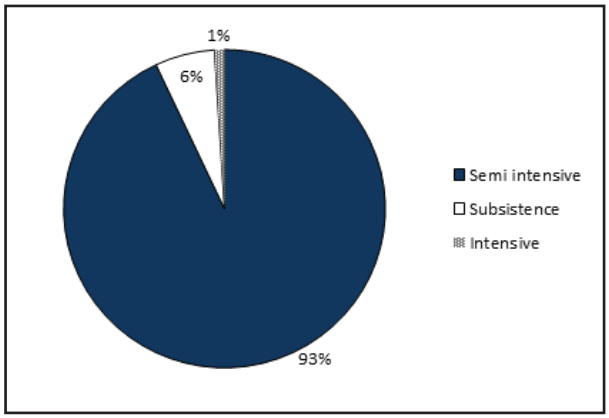

Figure 2. Percentage of farmers involved in subsistence, semi-intensive and intensive aquaculture (Source: Teri & Pickering 2009)

3.4 Aquaculture research and development

The shift from semi-commercial to commercial agriculture is contributing towards achievement of greater production in Fiji. Research and development over the years help facilitate of more advance and technologies to progress species stock quantity, quality and culture system (Table 4). Thus more research and funding is needed to boost the industry to greater heights.

Research in genetic improvement and stock identification of tilapia saw its production significantly increasing from 1993 and a significant expansion of the local tilapia culture industry occurred on the main islands (Fig. 3). Capacity building in hatchery and grow-out phases saw improvements in tilapia husbandry and production systems, broodstock management and production, supply of fingerlings and increase in number of farmers and their profit. Improving freshwater prawn culture stock quality and nutrition saw improvement in broodstock management; hatchery operations and post larvae supply production more than doubled addressing inconsistent and inadequate supply to farmers. Without Aquaculture research in Fiji some of the challenges faced were higher cost of seed production, an estimated 20% increase in mortality reducing number surviving at harvest, lower average size at harvest and no proper daily feeding schedule. However, with aquaculture research increased survival translated into improvement in production per hectare of pond for the country. A good example in Fiji was the genetic improvement and stock identification of tilapia in Malaysia and Fiji research that increased pond production per hectare per year from 3000 kg to 3600 kg (Fearn *et al*. 1994). In addition, relative performance of three exotic strains with different genetic backgrounds from Malaysia, Indonesia and Vietnam, evaluated against the 'local' strain in Fiji saw introduction of genetically diverse strain being selected (Hurwood *et al*. 2014).

Table 4. Research and development in freshwater aquaculture species

Year(s)	Research and development	Source
1976 - 1984	*Ctenopharyngodon idellus* (Grass carp) feed & spawning trials were conducted	Richards 1993
1982-1987	JICA assisted research & development of *Macrobrachium rosenbergii* (Freshwater prawn)	Richards 1993
1993 -1996	Genetic improvement & stock identification of tilapia in Malaysia & Fiji	Nandlal *et al.* 2014
1997 -2001	Genetic improvement of cultured tilapia & red claw in Fiji & Australia.	Nandlal *et al.* 2014
2004 -2005	Feed Research on Prawn & Tilapia (Preparing Farm-made fish feed: Improve Tilapia & Prawn feed quality)	Annual report, 2006. Nandlal *et al*. 2014
2005 -2006	Hormonal-feed trial on GIFT tilapia (All male tilapia)	Annual report 2006
2005 -2006	Prawn Genetics/Quarantine Program	Annual report 2006
2006	Genetic Management & Improvement in Aquaculture	Annual report 2006
2005 -2007	Grass Carp Breeding & Rearing Project	Annual report, 2006
2008 -2011	Freshwater prawn aquaculture in the Pacific: Improving culture stock quality & nutrition in Fiji.	Hurwood *et al.* 2014; Nandlal *et al.* 2014 Singh, 2011
2009 -2011	An assessment of the extent of genetic introgression in exotic culture stocks of tilapia in the Pacific	Nandlal *et al.* 2014

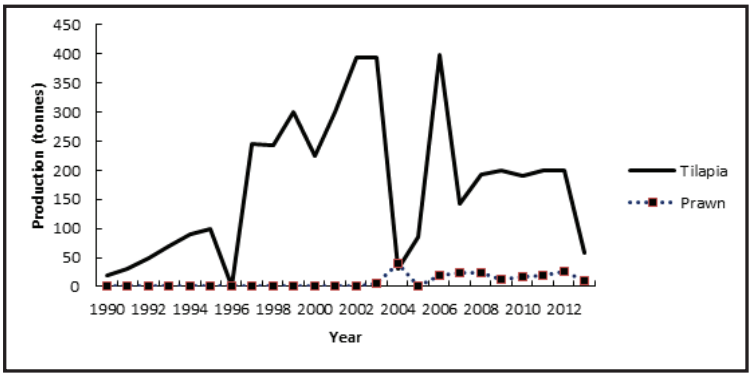

Figure 3. Culture trend of tilapia and freshwater prawn in Fiji from 1990 to 2013 (Source: Fiji Fisheries Annual Reports 1990 - 2013).

3.5 Status of tilapia and prawn culture

According to FAO (2014) global food fish productions from inland aquaculture and from mariculture were at the same level of 2.35 million tons in 1980. However, inland aquaculture growth has since outpaced mariculture growth, with average annual growth rates of 9.2 and 7.6%, respectively. In addition, inland aquaculture has steadily increased its contribution to total farmed food fish production from 50% in 1980 to 63% in 2012. Of the 66.6 million tons of farmed food fish produced in 2012, two-thirds or 44.2 million tons were finfish species grown from inland aquaculture (38.6 million tons) and mariculture (5.6 million tons). Although finfish species grown from mariculture represent only 12.6% of the total farmed finfish production by volume, valued at USD 23.5 billion and representing 26.9% of the total value of all farmed finfish species. In 2012, farmed crustaceans accounted for 9.7% or 6.4 million tons of food fish aquaculture production by volume but 22.4% or USD 30.9 billion by value.

Mollusc production of 15.2 million tons was more than double that of crustaceans, but its value was only half that of crustaceans (FAO 2014). The rapid growth in inland aquaculture of finfish reflects the fact that it is a relatively easy-to-achieve type of aquaculture in developing countries when compared with mariculture. It now accounts for 58% of farmed food fish production globally. Freshwater fish farming makes the greatest direct contribution to the supply of affordable protein food, particularly for people still in poverty in developing countries (FAO 2014). Globally, Asia and especially China has the greatest freshwater aquaculture production in relation to land area, although some European and African countries have also significantly

contributed (Bostock *et al*. 2010). The farming of tilapias, including Nile tilapia and some other cichlid species, is the most widespread type of aquaculture in the world. FAO has recorded farmed tilapia production statistics for 135 countries and territories on all continents. The true number of producer countries is higher because commercially farmed tilapias are yet to be reflected separately in national statistics however; in 2012 *Oreochromis niloticus* production reached 3.1 metric tons valued at USD 5.3 million.

Fiji has an established tilapia culture industry in both the private and public sectors. Tilapia and prawn farming typically utilizes ponds, concrete raceways, pens and cages and cultured in a mix of systems, from extensive to intensive (Bueno 2014). In 2012, estimates of 139 farms were commercial and semi-commercial with 86 farms being backyard or subsistence type. The majority of freshwater aquaculture is pond based using semi-commercial methods that rely on controlled eutrophication for their productivity, using a wide variety of organic and inorganic fertilizers as well as supplementary feedstuffs (Bostock *et al*. 2010). In 2007, aquaculture production was valued at USD 1.7 million from a production of 247 tons and 48,100 pieces (Gillett 2009). In 2003 aquaculture production was 424 MT valued at FJD 1.9 million; out of which tilapia production was 393 tons and prawn was 6 tons.

Tilapia has undoubtedly seen great success over last thirteen years, production rising from less than 20 tons in 1990 to more than 200 tons in 2012 (Fig. 3). Total tilapia fry production in the country in 1990 was 106, 620 which increased to 1.1 million in 2013 with farmer numbers rising from 123 in 1990 to 190 farmers in 2013 (Annual reports 1990 & 2013). Total freshwater prawn post larvae production in 2013 was around 1.1 million that were utilized for stocking 35 farmers which was an increase from 8,000 produced in 1990 mostly for feed trials and exporting to Samoa. Freshwater prawn production figures reflect the history of species following introduction and experimental phase indicating that the sector is gradually moving from experimental stages to production phase. Furthermore, production of farmed freshwater prawn for Fiji from 1989 to 1992 ranged from 1 – 6 MT, from 1993 to 1996, 85 – 93 MT and in 1997 to 1998, 40 MT (FAO 2000; New and Valenti 2000). However, freshwater prawn farming has never been boosted in Fiji till 1998. According to Fisheries department the supplier of this wrong information is unknown (J. Vasuca pers. comm., 2011). Freshwater prawn was not produced at the government hatchery from 1991 to 1997 until introduction of *M. rosenbergii* from Tahiti was made in 1998. Annual production dramatically increased from USD 0.2 million in 1998 to USD 2.2 million in 2007 (Ponia 2010; Singh 2011). In addition, the development of tilapia and prawn farming into large scale industry for export market are plagued by feed cost being too high and the limited reach of Extension services to farmers.

Even though aquaculture in Fiji dates back to 1940 a major reason for slow aquaculture development has been small populations with expensive access to large markets and healthier diet availability to people. In addition, aquaculture industry is lacking regulations that can safe guard environment and investors. In addition, aquaculture research and development efforts are lacking in technical assessment. Majority of rural indigenous population still lack access to basic infrastructure and social services. Most rely on substance farming as the main means of attaining a livelihood. Therefore, an important aspect is the encouragement of greater self-sufficiency and motivation amongst the rural population. This involves using locally available resources, adopting efficient and cost effective methods of production and encouraging collective discipline for development of both the industries.

Fiji's future fisheries development plans aim to increase fish production, improve the welfare of fishers and farmers, promote exports, increase fish consumption and provide greater food security. The per capita availability and consumption of fish is expected to increase to 35 kg/year and production will have to increase proportionately. Although aquaculture has been practiced for forty years in Fiji, the major increase in production developed in the

last ten years. Aquaculture is recognized as an important source to meet future fish demand. A number of schemes have been instituted by state and central sectors to increase brackish-water, freshwater and mariculture fish and crustacean production from ponds. However, the private sector is yet to emerge as a major player in aquaculture investment, particularly in crustacean and fish farming.

CONCLUSION

Aquaculture remains a young, emerging industry in Fiji, and if managed well, holds very substantial promise for growth in economic returns and employment opportunities. Fiji has geographical advantages that can ensure expansion not possible in many other parts of the world. Fiji having abundant inland and marine waters has a good potential for aquaculture. In recent decades, aquaculture contributions have increased noticeably. However it is still associated with various problems such as low density in fish and prawn farming, lack of technical knowledge among farmers, unsuitable feed quality, improper feeding management, low water quality, financial problem, and low cultural species diversity. Improving on these limitations would certainly enhance aquaculture production in Fiji.

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RESEARCH PAPER

Nausori Market Produce Demand Throughput Survey

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ABSTRACT

Nausori Town's strategic location is a gateway of agricultural, forestry and fisheries products from the three major provinces of Tailevu, Rewa and Naitasiri supplying their produce to "market vendors" in Nausori Municipal market. There is no proper survey to indicate the types of crops, their quality and their supply base conducted in the past few decades to assist the Town Council in their decision-making. This market survey was arranged by the Nausori Town Council and Fiji National University's College of Agriculture, Fisheries and Forestry, to have some ideas of activities happening in the marketplace regarding the exchange of different goods between the wholesalers, retailers and the final customers. Currently, the council is having difficulties in making sound decisions due to the lack of information of the marketplace. Thus the results from this survey should assist them in their decision-making for their new municipal market.

Keywords: Market research, niche markets, market segmentation, wholesaling, retailing, distribution, products, price, promotion, distribution, Nausori, Fiji.

1.0 INTRODUCTION

The purpose of this paper is to present the market survey findings, especially in relation to "Market Produce Demand Throughput" in the market town of Nausori in the province of Tailevu, Republic of Fiji. The survey should provide a certain level of exchange of goods and services between suppliers, wholesalers and retailers in the Nausori Municipal Market for a certain period of time. Identifying the amount of different products especially in the agricultural sector should provide some indications on what has to be produced at the farm level.

It should be recognized that building the new proposed municipal market will create more space that will satisfy the vendors. This will create a huge challenge for the suppliers and the Council as well as other stakeholders in the region especially Tailevu, Rewa and Naitasiri farmers. These suppliers need to produce enough to meet the demand of the customers fulfilling the need of the space provided in the New Market. The main objectives for this study were as follows:

1. To identify current volume of produce traded in the market based on the outflow of produce, sales of goods for a given period;
2. To promote trading and commercial exchange of goods, and service for the local communities;;
3. To consolidate linkages between Nausori Town and its' peri-urban and rural communities; and
4. To provide platform for providing micro-enterprise initiatives.

2.0 MATERIALS AND METHODS

2.1 *Survey*

While selecting an appropriate method of collecting primary data, due consideration was placed on the accuracy and reliability of the data within the time frame and budget availability by the Nausori Town Council. Since, the target audiences were busy during peak hours like Saturday's and evenings, appropriate time during less peak hours was targeted for producing better response results. The two main methods used for data collection were mainly personal interviews and survey questionnaires. This survey was conducted from July to the end of August, 2013.

2.2 *Questionnaire Design*

Questionnaire design is a critical component for this kind of research in order to acquire useful information. Most of the questions were provided by the Town Council and the research team re-designed the questionnaire to suit the SPSS (Statistical Package for the Social Science, version 17) research software for analysis developed by J.C. Sheridan and G.S. Lyndall (1999). The questionnaires were divided into 5 major parts (1) Demography, (2) Types of vendors, (3) Produce sold, (4) Income and (5) Problems encountered.

The following activities were undertaken:

- Preparation of Survey Questionnaire. The council has a good idea of what they intended to achieve from this survey. They were planning for a long time to conduct this survey but lack of expertise caused this delay. The survey team members together with the Town market manager, Mr Pita Tamanikaisawa redesigned the questionnaire to suit the software used for analysis.

- A total of 554 questionnaires were prepared and 10 students and 1 staff from the College of Agriculture, Fisheries and Forestry of the Fiji National University conducted the survey.

- Vendors interviewed were from different status, some involved on regular basis (Monday-Saturday), Friday only, and Saturday only, were interviewed.

- In addition, interviews were also conducted early morning on Saturday (3am) targeting the wholesalers.

The analysis was carried out with the use of SPSS program version 17 for windows. Analysis includes frequencies and cross-tabulation analysis.

3.0 RESULTS AND DISCUSSION

3.1 *Demographic Section*

Nausori Market Vendors are mixed with different ethnic groups providing fresh, dried and value-added produce of vegetables, root crops, fish, etc. to sustain the daily needs of individual customers.

The Nausori Market Vendors genda distribution were 65% female and 35% male. The ethnicity groups were 70% i'taukei, 29% Indo-Fijian and 1% Chinese. The religion with Hindus 24%, Methodist 18%, Pentecostal 6%, Muslim 1%, LDS 1%, Catholic 0.4%, undecided 50%. The age group with 48 years old and above 44%, 43-47 years 12%, 38-42 years 15%, 33-37 years 10%, 23-32 years 9%, 23-27 years 4%, 18-22 years 2% and undecided 4%.

The survey recommends that the nature of the business is suitable for female. Based on our survey, the council should target more ladies and create a business environment to attract them in the new marketplace. Christians and Hindus are dominant religion with i'taukei dominates the ethnic group followed by Indo-Fijian and Chinese descent. It is exciting to see young vendors being interested in the business. This creates business opportunities for youths to establish themselves as market vendors.

3.2 *Province, Tikina and Villages*

Nausori town is surrounded by three major provinces Tailevu, Naitasiri and Rewa. Majority of the vendors belonged to Tailevu (45%), followed by Naitasiri (13%), Rewa (9%), Nadroga (2%), Ra (1%) and Others (30%) includes (Bua, Macuata, Lomaiviti, Namosi, Lau, (etc) whom have lived around the Nausori area.

3.3 *Tailevu Province*

Tailevu province comprises of 22 districts and 144 villages of which 17 districts and 56 villages are involved in trading in the marketplace. The 17 districts from Tailevu Province with Bau districts 23%, Vugalei 20% and the rest below 10% (Fig. 1). Individual villages in the districts of Tailevu Province what they sell in the marketplace can be determined. An example is Bau district where Logani is the main village trading in Nausori market (Table 1). Various produce that Logani vendors are selling in the marketplace will be discussed further in the report.

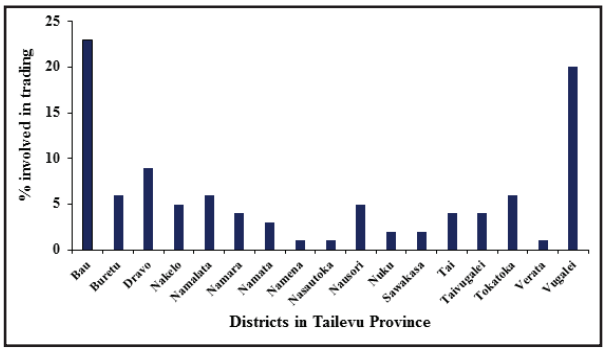

Figure 1. The 17 Districts in Tailevu Province involved in trading in the Nausori Market

Table 1. Villages in the Bau District trading in the Nausori Market

Villages in Bau District trading in the Nausori Market	Proportion (%) of total market traders from Bau District
Logani	41.2
Nakoroivau	11.8
Cautata	8.8
Namuka	8.8
Ovea	8.8
Kiuva	5.9
Others	5.9
Naqeledamu	2.9
Natila	2.9
Bau	2.8

Some of the villages maybe seen inactive, but further research is needed to identify their activities. It could be possible that they are selling their produce direct to Suva or other locations like Lami, Makoi, Nasinu or Nakasi markets. Based on the findings, four districts and 88 villages could be targeted by the council to encourage in trading in the new market.

In addition, the council could work closely with other stakeholders to motivate other villages in the Bau district to be actively involved like Logani village. The district is few kilometers to the Nausori Town and thus could cater produce much fresh produce to the customers' dining table.

3.4 *Naitasiri Province*

Naitasiri Province has around 17 districts and 88 villages with only 5 districts and 14 villages actively selling in Nausori. Most vendors came from Naitasiri District (67%) followed by Viria (23%), Vuna (5%) and Waidina and Nabobuco with 2% each. The two main villages in Naitasiri District trading in Nausori market were Naganivatu and Waitolu (Fig. 2).

Naitasiri Province has the advantage of selling in Suva marketplace due to high customer demand. This resulted in less vendors coming to Nausori. More research is needed to identify the activities of different villages. The council should promote the marketplace in these villages to be involved as market vendors.

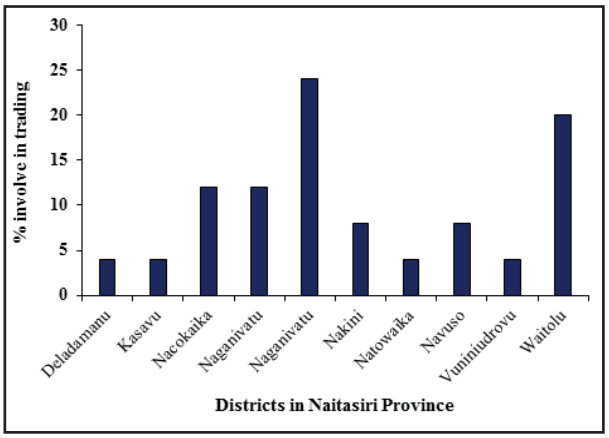

Figure 2. Villages in the Naitasiri District trading in the Nausori Market

3.5 *Rewa Province*

Rewa Province has 10 districts and 53 villages with 7 districts and 17 villages actively involved in Nausori market. Most vendors came from Noco District (43%) followed by Toga (28%), Rewa (13%), Burebasaga (7%), Dreketi (4%) and followed by Vutia and Nakasi with 2% each. The two main villages in Noco District trading in Nausori market were Lokia (75%) and Tavuya (25%).

3.6 *Provinces vs Ethnic groups*

Ethnic groups' lives in the three major provinces and actively involved as market vendors contributed in the development of Nausori market place. Indo-Fijians spread within the province where 48% lives in Tailevu, 35% in Naitasiri, 12% Rewa and 1% in Nadroga and Ra (Fig. 3). Chinese have a very small percentage with only 1% live in Tailevu that different ethnic groups produce crops suitable to customers of particular ethnic groups. For example, bean produce mainly by Indo-Fijian and dalo by i'taukei because such ethnic groups use these types of crops as their major daily food.

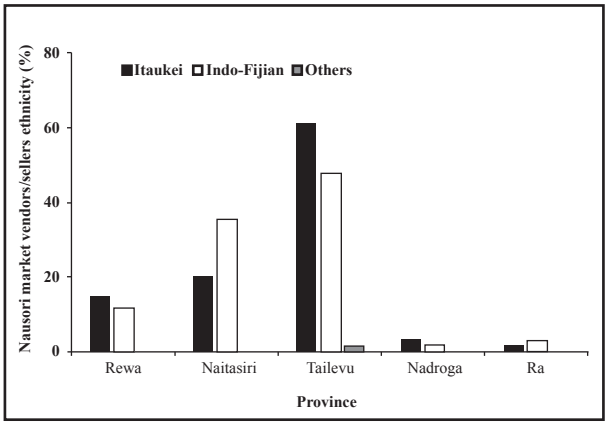

Figure 3. Nausori market vendors/sellers ethnicity and province where they are residing.

3.7 *Produce*

The climate and weather pattern within the major provinces provides suitable condition to grow vegetables and other crops especially root crops. About 15 major products traded in the market; with 34% vegetables, 30% root crops, 24% fruits and the rest below 4% (Fig. 4). These include grog, sea water fish, sea food, fresh fish, cooked food, groceries, spices, jewelries, handicrafts, food court, poultry and tea room.

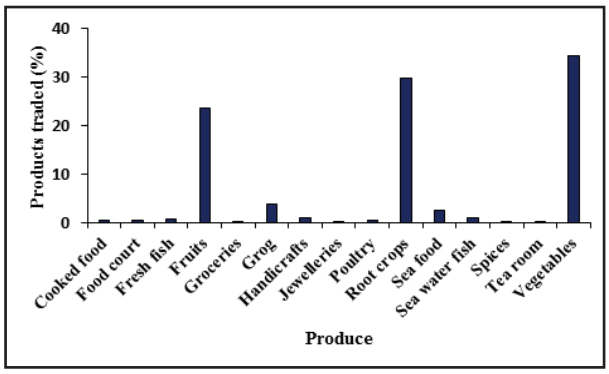

Figure 4. Products traded at Nausori Market

The products traded are good indication of what customers consumes as their daily menu.

- Vegetables, root crops and fruits are healthy and readily available.
- Further survey is needed to look at these products on weight basis. Vegetables were found to be cheaper compared to fish and meat.
- Family size could be another indicator of customers buying these agricultural produce. On an average, Fijian family about 6 members excluding extended family members.
- Other factors may include the way Fijians cook these foods. Vegetables maybe easy to cook reducing the use of gas and electricity.

3.8 *Vegetable Section*

The research managed to identify 33 different types of vegetables traded by the vendors. Vegetables represent 34 per cent of the total produce and from the total percentage of which the top five were chillies-bongo (*Capsicum frutescens*) 13%, cucumber (*Cucumis sativus*) 11%, Chinese cabbage (*Brassica chinensis*)11%, long bean (*Vigna unguiculata*) 10%, and eggplant (*Solanum melongena*) 10%. This indicates that such vegetables are easier to produce from small medium and large scale farmers. Vegetables plays vital ingredient to Fijian families daily diet. According to Ravinesh Chetty (Fiji National NCD's project coordinator); planting and eating once own vegetables will help to prevent Non-Communicate Disease in the country (www.globaltimes.cn., 2012). Majority of the suppliers for vegetables from Tailevu (63%), followed by Rewa (18%), Naitasiri (14%), Nadroga (3%) and Ra (2%).

Logani village is close to the market and actively involved in trading. Vendors from the village sell vegetables which includes Chinese cabbage (27%), cucumber (27%), taro leaf (27%), fresh bean (9%) and ota (*Athyrium esculentum*) (9%). These vegetables could also be traded by villagers in Bau district close to Logani. They could produce fresh vegetables at competitive prices taking advantage of their land availability, location and good transport

- Various kinds of vegetables are traded by the vendors. It is important that the suppliers produce these different types of vegetables year around.
- More Itaukei especially at village level be encouraged in vegetable farming and supply them to vendors in the as a source of income to their families.
- Suppliers from Nadroga and Ra plays are vital during rainy seasons which affect the producers from Tailevu, Naitasiri and Rewa. These two provinces could act as "support suppliers" to the marketplace such unfavourable weather.
- Other farming techniques needs to be identified developed like in-house vegetables sheds in Joes' farm and other low-cost input techniques.
- Niche marketing could also be adopted such as sale of organic vegetables.

3.9 *Root Crops Section*

This study managed to identify 10 major types of root crops traded in Nausori Marketplace. Root crops represent 30% of the total produce and from the total percentage of which the breakdown of different types of root-crops are as follows: dalo (*Colocasia esculenta*)-other varieties (41%) followed by cassava

(*Manihot esculenta*) (39%), ginger (*Zingiber officinale*) (8%), sweet potatoes (*Ipomoea batatas*) (4%), yams (*Dioscorea alata*) (3%) and dalo (*Colocasia esculenta*)-tausala (2%), dalo-ni-tana (*Xanthosoma sagittifolium*) (0.7%), tivoli (*Dioscorea nummularia*) (0.5%), kawai (*Dioscorea aculeate*) (0.3%) and via (*Cyrtosperma merkusii*) (0.2%). Most root crops come from Tailevu (56%) followed by Rewa (20%), Naitasiri (16%), Nadroga (4%) and Ra (4%).

As previously discussed, 144 villages identified in Tailevu Province with only 56 villages actively involved in selling their products in Nausori market. Root crops can stay longer after harvesting compared to vegetables. Taro and ginger could be exported if production from the three provinces exceeds local demand. Other root crops could be produced in large scale especially via, sweet potatoes and yams. These species have low risks during hurricane session and takes short period to mature.

Traditionally, the root crops are part of the Fijian diet together with vegetables. Due to close proximity to local and export market facilities and suitability of environment to production of the 10 root crops, it is vital that these provinces produce them in large scale.

3.10 *Fruit Section*

A total of all 16 fruits being traded in Nausori marketplace. Fruits represent 24% of the total produce and from the total percentage of which the top 10 fruits were: coconuts (*Cocos nucifera*) (16%), ripe/green banana (Musa sp.) (14%), citrus (13%), pumpkin (*Cucurbita maxima*) (9%), vudi (8%), duruka (*Saccharum edulis*) (8%), mandarin (*Citrus reticulata*) (6%), papaya (*Carica papaya*) (4%), watermelon (*Citrullus lanatus*) (4%) and jackfruit (*Artocarpus heterophyllus*) (4%). Most of the fruits are produced by Tailevu Province in the Nausori municipal market.

Fruits play a vital role in people's diet together with vegetables and root crops. It is important that different types and varieties of fruits are available at all times in the market. Identifying right kinds of fruits to match the climate in the three provinces is vitally important. This will boost the production of these fruits, and thus assist in meeting the customer demands.

3.11 *Yaqona or Kava (Piper methysticum) & Tobbacco Section*

The product is different from other products as suppliers are mainly outside the three main provinces. Most kava suppliers are from the provinces of Lomaiviti, Bua, Kadavu, Macuata and Cakaudrove. Kava section is made up 4% of the total produce of which; waka (kava roots; 37%), pounded lewena (stem; 16%), mixed pounded waka and lewena (16%), pounded waka and raw lewena (13%) and. Tobacco is also traded at about 5%.

Kava is a potential product to be traded in large scale in Nausori market supplying local communities and individuals. It is also an export commodity.

3.12 *Seafood Section*

Seafood made up of 3% of the total produce traded of which the top five sea food traded at Nausori Market were crabs (38%) followed by prawns (*Macrobrachium lar*; 22%), lobsters (*Panulirus penicillatus*; 9%), nama (*Caulerpa racemose*; 9%), lairo (*Cardisoma carnifex*; 5%) and kaikoso (*Anadara cornea*; 4%).

Seafood serves as vital nutrients with crabs and prawns playing a major part of the people' diet and thus it is important that constant supply is needed. Some of these seafoods such as lobsters have high potential opportunities in the international market.

Most of the seafood that entered Nausori Market come from the provinces of Tailevu and Rewa. Villages in the two provinces could be identified and developed to provide consistent supply of these products to the new town market in Nausori.

3.13 *Ocean-fishes Section*

Deep sea-water fish made up 1% of the total produce traded with diversity of sea-water fish of which the top three sea-water fish traded at

Nausori market were kawakawa (*Epinephelus polyphekadion*; 19%) followed by saqa (*Caranx ignobilis*; 14%), followed by damu (*Lutjanus campechanus*), sabutu (*Lerthrinus obsoletus*) and ulavi (*Cetoscarus bicolor*) with 10% each. Sea water fish is highly demanded product for all Fijians. Kawakawa is highly demanded fish species due to the taste and can be traded in local and export market. Vendors trading fishes came mostly from within Tailevu (76%), Rewa (14%) and Ra (10%) provinces.

It is obvious that most of the fish suppliers are selling to other markets. More fish suppliers are coming from Ra. The upgrading of Kings Road provides opportunities for Ra suppliers to sell their produce in Nausori market. It is important that the Department of Fisheries works closely with the council in trying to attract suppliers to provide consistent supply to Nausori market.

3.14 *Freshwater Fishes Section*

Fresh water fishes recorded about 1% of the products sold in the market of which the top three traded at Nausori market were kai (*Batissa violacea*; 35%) followed by prawns (aquaculture) (17%) and followed by tilapia and shrimp with 12% each.

Prawns, shrimps and grass-cup are potential freshwater fish. There is demand for these fishes and the three provinces can be encouraged to produce them.

Aquaculture be promoted in the three provinces especially Naitasiri and inland Tailevu. Kai should also be cultured as high demand on a daily basis and weekly basis for vendors too.

3.15 *Handicraft Section*

Handicraft represents 1% of the total produce of which the top three handicraft item traded were coconut-leaf broom (39%) followed by coconut virgin oil (22%) and flowers (9%). The survey identifies that 99% female itaukei are involved in the handicraft production. Products like virgin oil, flowers and voivoi (*Pandanus caricosus*) have potential opportunities for itaukei women in the three provinces to be involved in. Support from Ministry of Women, Itaukei Affairs and Youths is essential in promoting the product.

3.16 *Cooked Food Section*

Cooked foods represent 0.5% of the total produce sold at Nausori market of which the top three cooked food was roti curry (36%) followed by cooked cassava with fish and cooked taro with fish with 18% each and cooked octopus, dairo and jam with 9% each. All cooked food were sold by the itaukei women. This provides opportunity to these women to increase their sales and identify other potential products which they could sell in the new market.

Proper place should be provided for vendors in selling these products for health reasons. The place should be highly hygiene where customers could also sit and eat.

3.17 *Spices*

Spices represent 0.3% of the total produce traded of which the highest species being sold was haldi (43%) followed by masala (29%) and then jeera and cardamon with 14% each. About 70% Indo-Fijian sold the product and the rest itaukei with Naitasiri Province mainly supplying the product.

3.18 *Food court Section*

Food court represent 0.5% of the total produce of which the major food being sold was bila (cassava product made from soaking cassava for several days, wrapping and boiling) (64%) followed by fruit juice (18%) and cassava pie and vakalavalava (roasted grated cassava with coconut cream) at 9% each. The products are so unique because they add-value to root crops like cassava. It is important that further research be undertaken to identify the consumer demand for these products. Tailevu Province mainly supply bila.

3.19 *Jewelries Section*

Jewelries represent 0.2% of produce traded of which the main item being sold was earing (40%) followed by necklace, ornaments and chains with 20% each. The age group that mainly traded the product is between 23-27

years by both Itaukei and Indo-Fijian women vendors.

3.20 *Poultry Section*

Poultry products represent 0.5% of the total produce of which the main item being sold was eggs (40%) followed by live chickens (30%) and followed by mill mix, ducks and growers at 10% each. Most of the vendors trading these product were aged 38 years and above with 80% Indo-Fijian. Live chickens and ducks needed a special place to trade them. Currently, they are all located in one place and the hygiene and safety of the vendors is crucial. Other live animals like goats could also be introduced in the new marketplace if a special place is allocated for them. Special chicken feed distribution store be located inside the new market is recommended.

3.21 *Tea Room Section*

The different products sold in the tea room with 50% bakery products, 25% tea and 25% coffee. The tea room plays important role in providing hot drinks to vendors early in the morning especially those from far villages. Varieties of baked products and other breakfast menu like eggs, fried sausage or healthy menu should attract more customers to the tea room.

3.22 *High Turnover (Produce)*

Some of the reasons vendors receive high turnover of goods traded and also revenue collected were high customer turnout (23%), price (21%), seasonal crops and high supply of produce with 18% each, festive season (12%) and promotion (8%). Customers, is the key to the success of the Nausori market. The council needs to work closely with other stakeholders to attract economic development in the town. This will stimulate employment opportunities attracting people to settle in Nausori town region and buy from the municipal market. The council needs to identify the festive season and the seasonal products consumed during such festive session. They should work closely with suppliers to produce the products at a competitive price. This can only be achieved if all stakeholders contribute in the planning processes.

3.23 *Low turnover (Produce)*

Vendors have reported that low turnover in sales of produce at Nausori market were mainly due to natural disasters (41) followed by low customer turnout (22%), off season fruits (14%), followed by damage caused by excessive rain (12%), festive season (6%) and price (4%). The council needs to be provided with information from the National Disaster Management Office, when the disaster could occur and work closely with stakeholders in how to minimize the risk. Joes' farm is a good model farm that could minimize the risk during natural disasters and provides consistent supply of produce.

3.24 *Disaster Recovery Time*

The recovery time after tropical cyclone disaster showed that majority of farmers (33%) took them 3-4 months; 31%, 1-2 months; 21% more than 4 months and 15% less than a month to recover after cyclone disaster. This indicates that 54% of the farmers require more than 3 months to recover after tropical cyclone disaster. Majority of respondents (72%) indicated that natural disaster caused low supply of produce to the Nausori market. It is important that the Nausori Town Council work closely with other stakeholders in designing strategies to reduce this recovery period. Selecting short-term crops such as kumala to cultivate after cyclone disaster is essential.

3.25 *Income*

The Nausori market vendor's weekly income showed that majority (55%) of respondents earned less than $100, 20% earned $201 to $400 and $401 to $500, respectively and 16% earned $101-200, 5% earned over $500 and 4% earned $401-500. I'taukei dominated all ranges of weekly income but at decreasing trend from those earning less than $100 to over $500 (Fig. 5). However, Indo-Fijians weekly income increases from less than $100 to $401 to $500.

The study identifies that the age group above 48 years dominate the weekly income at all sales level by 30%. Interestingly, 18-22 years started to be involved as market vendors. The research also identified that reserved vendors from Monday to Friday and Saturday sellers only

dominate the income sale at all levels. Most vendors are earning less than $200 per week. This is important to have the core reserved vendors in the new market so that the market is fully occupied. Saturday sellers only also earn a lot especially less than $200 per week. This is a good indication that they brought with them enough produce to sell and return home with the day's earning enough to feed their families and meet other expenses. Most of the Saturday sellers are from the villages whom could be selected for reserved vendors from Monday to Saturday.

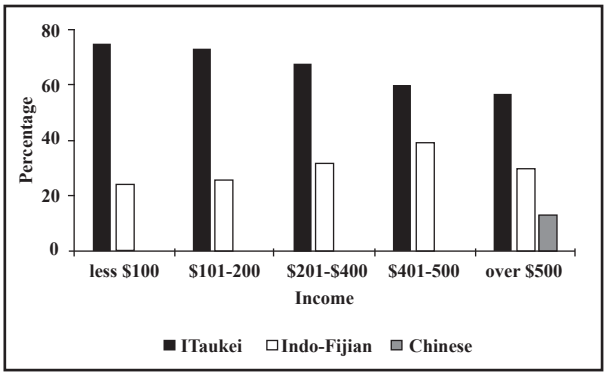

Figure 5. Weekly income of Nausori Market vendors

3.26 *Wholesaling and Retailing*

The wholesaling activities occurred in the marketplace indicate 62% of respondents have (more than 80% involvement), 15% (1-30% involvement), 12% (51-80% involvement), 12% (31-50% involvement). This indicates that most suppliers sold their produce to vendors and return home. The retailing activities indicate that > 48% involved in 100% retailing, 21% (1-30% retailing), 18% (31-50% retailing) and 13% (51-90% retailing). Most of these vendors bought produce from wholesalers and resell them.

3.27 *Transportation*

Most vendors either hired vehicle (38%) or use public bus (37%) followed by private vehicle (16%) to transport their produce to Nausori market. Most fishermen use boat to transport their fresh fish to the market. Transportation is a vital component of delivering produce to the markets. The council could seriously tap into assisting suppliers transporting their products to the market. Good transportation network will result in fresh produce sold in the market. Transportation within the marketplace is also crucial.

3.28 *Produce Conditions*

Customers bought produce from Nausori market vendors largely due to its freshness (33%) followed by price (29%), followed by variety of produce for sale (23%), followed by access to local produce (9%) and support of local agriculture (6%).

The freshness and condition of the produce, competitive price and variety of produce provide a competitive advantage of Nausori market. This is a marketing tool in positioning Nausori marketplace to customers on daily basis.

3.29 *Vendors*

Vendor Types: Vendors operates in the marketplace involve Saturday's sellers only (27%), reserved vendors (25%), daily vendors sells Monday to Friday (12%), Reserved vendors only of Friday, and reserved vendor Saturday only (12%), Monday to Saturday (10%), 2% others (any day).

Most of the sellers only comes in on Saturdays; sell their produce and return to their villagers. Some of these sellers could be encouraged to sell in the 6 days per week; provided there is space for them in the new market. The Town Council needed lot of reserved vendor whom are able to occupy the whole space in a week providing good income for the council.

Time of trade: Majority of vendors (45%) started trading from 6-8am followed by 4-5am (30%), 15% after 9am and 10% at 3 am. This indicates that the early morning starts are the wholesalers bring their products outside the market and selling them to retailers. The rest of the vendors just setting up for the day's trading before the customers arrive.

Other Locations: Some of the vendors also selling in other locations with; 39% Suva market, 17% at home, 14% Makoi, 8% nearby villages, 7% outside town, 5% Korovou, 3% export, 2% each at school delivery, other shops in town, Nakasi and Centrepoint, respectively. The exciting finding is some are exporting overseas especially products like pounded

kava. Other location provides opportunities for vendors to increase their sales in a week and also allows produce like vegetables to be sold while still fresh.

Number of Stalls: The number of stalls owned by vendors indicate that 42% owned only 1 stall, 41% owned two stalls, 9% owned three stalls, 6% owned four and 2% owned more than 5 stalls. Majority of vendors (83%) owned 1-2 stalls. This indicates that most vendors do not carry lots of produce in a given day. They just sell enough to meet their daily financial needs and also not many wholesalers supplying them with the produce.

Length of Time: Length of time vendors spent doing business in Nausori Market indicate that majority (33%) have spent 1-5 years, 23% spent 6-10 years, 17% more than 21 years, 12% spent 16-20 years, 8% spent 11-15 years and 7% less than a year. This indicates that most vendors just taken up the business in less than 10 years with 40% five years or less. The Town Council is creating employment opportunities for people as market vendors.

Vendor Status: Market vendors source their produce with majority (57%) from own farms, followed by 19% buying from other farmers, 16% produce from village gardens, 6% buys from wholesalers and 2% fishing and selling. This indicates that most of the vendors lives around the Nausori region and they plant their own produce. This is one reason why vegetables in Nausori market are fresh with competitive price.

Distance travel: Distance travel by vendors to the market with majority (51%) indicated they travel 0-5 km followed by 6-10 km (34%), 11-20 km (12%) and 21-50 km (3%). This indicates almost 85% of vendors travel less than 10 km to Nausori market. The short distance travel with good roads helps reduce post-harvest losses.

General comments: The vendors clearly indicate that majority (35%) want the new market, 17% stated that not enough space, 14% indicated the wash room and toilet facilities needs to be improved, about 10% stated OHS needs improvement. Other comments include a special shed for livestock sales, proper unload area, closing hour to be extended, changing rooms to both men and women, proper benches and tables allocated, stall fees to high, proper disposal of rubbish, overcrowding and drainage system to be cleared at all times and effective security system to prevent stealing.

3.30 *Average produce traded*

The average produce sold in a week at Nausori market indicate that majority (24%) were cassava (2-5 bags) followed by 15-20 bundles dalo (10%), followed by 10-40kg okra (7%), followed by 1-5 bundles dalo and >5 bunches of banana at 6% each. This indicates that Fijians are eating more cassava and taro. This indicates the amount of produce to supply on weekly basis to fulfill the need of the consumers.

3.31 *Average number of customers*

The average number of customers bought goods from their stall indicate that majority (51%) (11-20 customers) followed by 1-10 customers (29%) followed by 21-30 customers (14%) and more than 30 customers (6%). This indicates vendors have their customer base buying products from them on weekly basis.

There is a need to identify these customers by carrying out a consumer behavior research. The research will provide a better indication of the demographic of the customers buying produce in the market. The council should work closely with the vendors in trying to retain their existing clients.

3.32 *Pricing*

The price difference between wholesalers in Suva market and Nausori market indicate that apart from cassava, it is cheaper to buy produce in bags in Nausori market compared to Suva market (Table 2).

3.33 *Topography*

Farmers interviewed indicated that majority (64%) farming on flat plains while 33% cultivating on hilly mountains and rolling hills. This indicates that some farms are on low flat plains which may have risks of flooding, causing loss to crops. Suppliers or farmers having farms which have low risk to flooding should be encouraged to cultivate land with proper agricultural practices in hilly mountains to reduce soil erosion and other environmental impact should be prepared and disseminated by the Ministry of Agriculture.

Table 2. Pricing of selected commodities at Suva and Nausori markets

Produce	Nausori wholesaler price	Suva wholesaler price
English cabbage	17	20
Cauliflower/bag	20	25
Eggplant/bag	15	20
Fresh bean/kg	50	60
Tomatoes/crate	50	60
Butter bean/kg	1.54	3
Pawpaw/crate	50	60
Dalo/bag (50 kg)	30	45
Cassava/bag	30	30

Source: Suva price taken from Fiji Sun, July, 23/2013

3.34 *Cross-Tabulation*

Ethnicity and Types of vendors: The main aim for cross tabulation is to find the relationship between different *Ethnicities and the Types of Vendors*. This should assist the researcher in identifying which Ethnic group dominates in a particular day in a given week. The chi-square test indicates that Pearson Chi Square value is 86.967 with $P < 0.0005$. In other words, there is evidence of a significant association between ethnic groups and types of vendors. "Saturday vendors only" are dominated by (i'taukei) since, they brought in their produce once a week to sell and return to their villages. Most of the vendors from "Monday to Saturday" are Indo-Fijian. They do not have look for their products as wholesalers sell their produce to them as retailers.

The council could identify the frequent "Saturday only vendors" whom could be encouraged to be Monday to Friday vendors. They could fully occupy spaces during the mid-weeks.

Income vs Type of Vendors: Finding the relationship between Income and Types of vendors is important for the Nausori Town Council. The Chi-square test shows that a Pearson-Chi Square value is 392.57 which indicate a significant relationship between the income per week and the types of vendors. Majority of "Saturday vendors only" earns around FJ$200.00 or less. Vendors who are staying longer in the market during the week earns more than FJ$200.00. The council could identify and encourage "Saturday vendors only" by providing stall for them to also operate as "Monday-Friday Vendors".

Income vs Length of Time: Finding the relationship between Income and Length of Time is important for the Town Council. The Chi-square test shows that a Pearson-Chi Square value is 79.19 which indicate a significant relationship between income and length of time spent as market vendor. A vendor with less than five years spent trading at Nausori market earns less than $300 compared to vendors spent more than 20 years earning more than $500.

4.0 CONCLUSION

The measure of strength of the Nausori Municipal Market is "how well it is served and supported by the suppliers" in all areas from agricultural produce, fisheries and other commodities. Vegetables were the major produce traded in Nausori market followed by Root Crops and Fruits. Vegetables in high demand were bongo chillies, chinese cabbage, cucumber, eggplants, long beans, taro leaves, bele, fresh bean, ota and capsicum. Root crops in high demand were dalo-other varieties, cassava and ginger while coconuts, banana ripe, lemon and mandarin are fruits in high demand.

- Upgrading of the King's road provides opportunities for vendors to trade their produce to Tailevu Province;
- I'taukei (70%) dominates the ethnic groups operating as vendors followed by Indo-Fijian (29%) and Chinese (1%). Around 85% of vendors

travel less than 10 km to the market and around 62% acted as wholesalers bringing the produce and sell them to market vendors/retailers.

- Around 40% of vendors below 5 years with 7 percent less than a year in the business and 17 percent over 21 years with earning from 100 dollars to 500 dollars and more in a week;

- "Saturday only" vendors are dominated by i'taukei. The Indo-Fijian and Chinese with stays longer in the marketplace trading;

- Young vendors aged 18-22 make up 7 % is a promising sign for the Council to create employments as "entrepreneurs" in the new market;

- Identifying "niche markets" like Organic foods and targeting such niche markets. Customers who are concerned about what they eat to be healthy will advocate free of artificial chemical spray.

ACKNOWLEDGEMENTS

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RESEARCH PAPER

Properties and Potential Uses of *Parinari insularum*

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ABSTRACT

Research and development on Lesser Known Species (LKS) is essential to determine the best use of tree species which would not only be used as an alternative to commonly demanded tree species meaning reduced pressure in their harvest but could also be used to generate income in areas where they are found. The Timber Utilization Division of the Department of Forestry is now into its third year of researching into LKS. Two LKS that were recommended for study in 2014 were *Parinari insularum* (A.Gray) and *Trichospermum richii*, (A.Gray) Seem., locally known as Sa and Mako, respectively. This paper focuses on research conducted on *P. insularum.*

Keywords: Lesser Known Species, *Parinari insularum*, utilization, Fiji

1.0 INTRODUCTION

The research on Lesser Known Species continues to be one of the fundamental roles of the Department of Forestry's Timber Utilization Division (TUD) at Nasinu, Fiji in which the tree species' properties and potential uses are determined. The year 2014 was the third year for this on-going project namely Research and Development on Wood and Non-Wood Species Project and the target species for the year was *Parinari insularum*, locally known as Sa.

Parinari insularum species normally grow in dense or open tropical forests (Keppel and Ghazanfar, 2011). The barks are quite rough while the heartwood is pink to reddish brown in color and is also difficult to distinguish from sapwood. A strong sweet odour is emitted from the outer flesh of its ripe fruit (Keppel and Ghazanfar, 2011). The objective of this study was to assess the physical and technical features of *P. insularum* and to determine its potential use.

2.0 MATERIALS AND METHODS

2.1 *Extraction of Parinari Insularum*

Four (4) *P. insularum* trees were identified at Wailase, Sawani, Naitasiri Province. The Diameter at Breast Height (DBH) and length of each tree were measured. An access road was constructed to the extraction site. A total of 12 logs were extracted from Wailase (Table 1). Discs for density determination were removed from the tree at 3m interval for trees with shorter lengths and 6m interval for those with longer lengths. The discs were labelled and properly wrapped with glad wrap to prevent moisture from being absorbed or released from the discs. The discs were taken to TUD laboratory for processing.

Table 1. Extracted Logs with their measurements

Log #	Length (m)	Diameter at Breast Height (DBH) (cm)	Volume (m^3)
Log 1	2.7	65	0.895
Log 2	2.7	54	0.618
Log 3	2.1	54	0.481
Log 4	3.9	42	0.540
Log 5	3.9	56	0.960
Log 6	2.1	70	0.808
Log 7	3.9	45	0.620
Log 8	2.7	31	0.204
Log 9	2.7	29	0.178
Log 10	4.5	33	0.385
Log 11	5.1	43	0.740
Log 12	3.9	38	0.442

2.2 *Density Measurement*

The discs were cut diagonally from the pith to the outer layer and numbered accordingly for basic density and moisture content assessments. The green weight of each piece was measured and recorded in grams (g) and were then subjected to saturation process. The basic density (1), air dry density (2), green density (3) and moisture content (MC) (4) were measured.

$$(1)\quad basic\ density\left(\frac{kg}{m^3}\right) = \frac{oven\ dry\ weight\ (kg)}{green\ volume\ (m^3)}$$

$$(2)\quad air\ dry\ density = \frac{weight\ at\ 12\%\ MC}{volume\ at\ 12\%\ MC}$$

$$(3)\quad green\ density = \frac{green\ weight}{green\ volume}$$

$$(4)\quad Moisture\ Content\ (MC) = \frac{initial\ weight - oven\ dry\ weight}{oven\ dry\ weight} \times 100$$

2.3 *Sawmill Conversion*

The diameter, length and the input volume of the logs (5 & 6) (Timber Industry Training Center, 2012) were measured and recorded. The logs were then graded and defects were counted and recorded.

$$(5)\quad Log\ volume = \frac{(\pi)\ r^2 \times Length}{10,000}$$

(6)

$$\text{Sawn timber volume} = \frac{\text{Length x Width x Thickness}}{1{,}000{,}000}$$

The bark was removed and logs squared and sawn length wise. The sawing pattern used depends on the size of the log diameter. The 'round sawing' method was used for big diameter logs while the 'through and through' method was used for logs with small diameter Dranibaka and Tabua, 2013). Timber sizes ranged from 50 x 25mm to 200 x 50mm with lengths ranging from 0.6m to 4.5m. The sawn pieces were numbered correlating to the log number. The characteristics of each sawn piece were recorded, from which the output recovery was calculated (7).

(7)

$$\text{Recovery} = \frac{\text{Output (sawn timber)}}{\text{Input (logs)}}$$

2.4 *Grading*

The logs were graded according to the National Grading Rules for Fijian Timbers (Metric Version). These rules were designed to cover sizes, shapes and quality of timber required for light building construction and general purposes, including joinery and dressing (Yabaki, 1986). The timbers were graded according to the 'Finishing Grade' which is the Fiji F-Select, Fiji F-Standard and Common Grade. All timber pieces below one meter in length were graded as shorts.

2.5 *Dipping*

Twenty (20) timber pieces with lengths of 1.0m and dimensions of 100x25 mm were selected for the dipping process. The chemicals used in this process were Antiblusapstain and Vascol (Arch Wood Protection (Fiji) Limited). There were three (3) different concentration percentages of each of Antiblusapstain and Vascol used to determine the most effective concentration to reduce mould, stain and decay (Table 2)

Table 2. Concentration of Antiblusapstain and Vacsol tested

A - Antiblu - 1%, Vacsol - 0.4%	**B** - Antiblu - 1.5% Vacsol – 0.4%	**C** - Antiblu – 2.0 % Vacsol – 0.4%	Control
5 samples	5 samples	5 samples	5 samples

2.6 *Air Drying of Green Sawn Timber*

A total volume of 2.576m³ was air dried at the TUD drying shed. The average moisture content attained after 3 weeks was 23%, upon which the timber were further dried in the kiln to 14% MC.

3.0 RESULTS AND DISCUSSION

3.1 *Analysis Results*

Parinari insularum has a green density of 1,125kg/m³ with moisture content of 69%. The average density of *P. insularum* was 751kg/m³ at 12% moisture content (Table 3). *Parinari insularum* is classified as medium hardwood species which is in the range of 580-800kg/m³ density at 12% moisture, which is in the same class as Damanu (*Calophylum vitiense* Turril A.C. Sm.), Mavota (*Gonystylus punctatus* A.C. Sm.) and Rosawa (*Gmelina vitiensis* (Seem.) A.C. Sm.)

Table 3. Density and Moisture Content of *Parinari insularum*

Moisture Content	69%
Basic density	670kg/m³
Relative Density	722kg/m³
Green density	1125kg/m³
Density @12% MC	751kg/m³

3.2 *Sawmill Percentage Recovery*

It was quite difficult to rip *P. insularum* due to its strength and structure, despite using a new stellite blade. The saw blades were sharpened regularly to cater for the sawing process. A lot of time and energy was spent on ripping a single log, to which we opted for the portable sawmill, to rip the remaining *P. insularum* logs.

There was no difficulty in ripping the *P. insularum* logs using the portable mill since it has a wider kerf compared to the stellite blade. The sawmill recovery percentage for *P. insularum* was 48% with log input of 6.871m³ and Output of 3.282 m³.

3.3 *Grading*

The total grade recovery for the 12 logs processed indicated that 20% were F. Select, 36% F. Standard, 25% Common and 19% Shorts (Table 4).

Table 4. Total Grade Recovery for the 12 *Parinari insularum* logs

Grade	Volume	Recovery (%)
F.Sel	0.395	20%
F.Std	0.729	36%
Common	0.493	25%
Shorts	0.373	19%

Mould was visible in samples A and Control after the third month of dipping trial. The percentage of stain in samples B and C were constant after the fifth month of assessment, whereas a rapid increase occurred for the control samples.

3.4 *Green Treatment*

Ten green *P. insularum* timber samples (total volume 0.05m³) were selected for Green Treatment at Amraz Earthworks Company at a solution strength of Tanalith NCA 3.0 % (H3). All samples submitted for treatment and analysis passed H3 treatment.

3.5 *Natural Durability Trial*

Natural durability of a timber is determined by using graveyard trial. In this trial, 20 *P. insularum* wood stakes, 25mm x 25mm in section, 30cm in length are inserted to the ground so that half of the length of the stake is buried. The average time taken for this stakes to fail is used to assign a natural durability rating. The graveyard trial was assessed after six (6) months. Twenty stakes were installed in Nasinu and 10 in Lololo, Lautoka.

Figure 1. Graveyard stakes installed at Lololo, Lautoka.

Table 5. Dipping assessment of *Parinari insularum* at an average of 1 month interval

Dipping Assessment Date	A Antiblu- 1.0% Vacsol- 0.4%			B Antiblu- 1.5% Vacsol- 0.4% (Recommended)			C Antiblu- 2.0% Vacsol- 0.4%			Control		
	M (%)	S (%)	D (%)	M (%)	S (%)	D (%)	M (%)	S (%)	D (%)	M (%)	S (%)	D (%)
16/10/2014	-	-	-	-	-	-	-	-	-	-	-	-
18/11/2014	-	-	-	-	-	-	-	-	-	-	-	-
22/12/2014	5	-	-	-	-	-	-	-	-	5	-	-
29/01/2015	5	7	-	5	4	-	5	5	-	10	10	-
27/02/2015	10	15	-	7	10	-	7	10	-	10	15	-
24/03/2015	15	20	-	15	10	-	10	10	-	10	15	-
23/04/2015	15	25	-	10	10	-	15	10	-	20	25	-
28/05/2015	15	25	-	10	10	-	20	10	-	25	25	-
25/06/2015	10	30	-	5	10	-	15	15	-	20	30	-

(M = Mould, S = Stain, D = Decay)

3.6 *Potential Use*

Parinari insularum, with a density of 751kg/m^3 at 12% MC, a hardwood timber, is useful in high strength structural applications such as bearers and roof beams. It can also be used in external applications such as decking. It is currently being trialed at TUD for house posts (Fig. 2).

Figure 2. *Parinari insularum* on trial for house posts at Timber Utilization Division, Nasinu.

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RESEARCH PAPER

Intensive Taro (*Colocasia esculenta)* cultivation and Soil Dynamic on Volcanic Andosols of Taveuni, Fiji

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ABSTRACT

This study evaluated the impacts of taro (*Colocasia esculenta*) cultivation on selected soil indices under the continuous cropping system in Taveuni. Soil samples were collected from taro cultivation sites and forest sites, both sites adjacent to each other. Laboratory analysis was carried out to ascertain physical and chemical parameters. The mean of each of these soil indices was used for comparison and t-test was also used to determine the significant difference that exists in each soil parameters. The result revealed that the level of liable C, organic carbon, Olsen phosphorus, calcium and magnesium were higher in soils under forest sites as compared to sites under taro cultivation. However, there was no significant difference in total nitrogen and potassium (K), though a slight increase in K was found in taro sites due to frequent application of high K blend fertilizers. Higher bulk density was observed in taro cultivation sites and the reasons could be decline in the organic matter, which has positive impact on the bulk density. Planting of cover crops, mixed cropping and mulching among others were few techniques recommended to maintain soil fertility and health for sustainable production.

Keywords: taro (*Colocasia esculenta*), forest, Taveuni, adjacent, soil indices.

1.0 INTRODUCTION

Soil is a fundamental resource on which human populations are dependent for food, fuel and fibre. Land use shifts and its sustainability is an important part of global change. It is through this response of the plant-soil system that climate change will have its main impact on humankind. Furthermore, it is in the tropics that the demands of developing human populations are most tightly linked to climate- and soil-determined limits. Paradoxically, it is in this zone and on these topics that our capacity to respond scientifically is weakest (Swift 1984).

Mineral nutrition played a significant role in improving crop yields in the 20th century, with its role becoming increasingly larger in the 21st century. As a result of increasing demand for food and fibre, natural land covers, particularly tropical forests are being degraded or converted to cropland at an alarming rate (Islam and Weil 2000). Soil fertility decline is a major problem confronting crop production in Taveuni Island, Fiji. This is caused by crop nutrient removal and losses through soil erosion and leaching. These are the major threats that taro production systems in Taveuni are facing (Kumwenda *et al.* 1996). Soil erosion is obviously the most visible and sometimes most destructive form and has received considerable attention in Fiji's land use policy (Prasad 1996).

Studies conducted by Nye and Greenland (1960) observed that calcium declined from 1.57 to 1.15 me/100 g and nitrogen declined from 0.06 to 0.05 % following a forest clearing for two years in Trinidad. Similar study in Calabar South farmland, Nigeria estimated annual depletions of soil fertility at the rate of 32 kg nitrogen, 5 kg phosphorus and 18 kg potassium/ha (Eni *et al.* 2010). In 2002, about 85 % of cultivated land had nutrient mining rates at more than 30 kg nutrients (NPK)/ha yearly and 40 % had rates greater than 60 kg/ha yearly (Eni *et al.* 2010). Long term data obtained from the field indicates that intensive farming can cause yield reductions of 60 % and more in some parts of Calabar South environments. Even under best variety selections and management practices, yields are stagnated (Eni *et al.* 2010).

Taro is Fiji's largest agricultural export after sugar (FAO 2012). Fiji's annual taro export for the last few years has been around 10,000 tones, earning about FJD 19–20 million annually with about 65% going to New Zealand and the balance to Australia and the USA (McGregor 2011). Taveuni accounts for 70% of Fiji's taro exports (Sun Fiji Newsroom 2009).

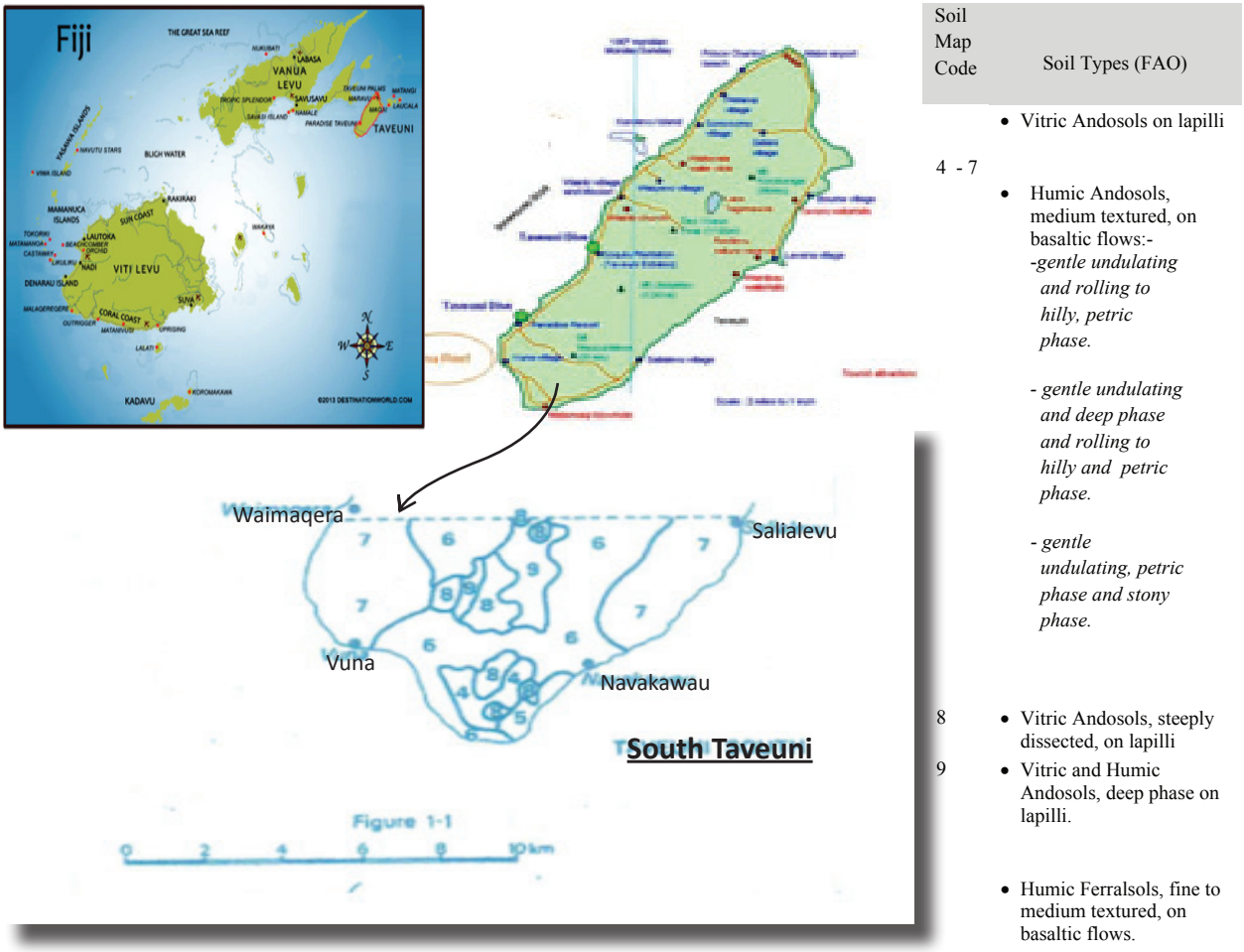
This study evaluates the selected physical and chemical indicators of soil under intensive cultivation of taro and less disturbed forest soil of Taveuni.

2.0 MATERIALS AND METHODS

2.1 *Study area*

The study was carried out on the Southern part of the Island of Taveuni, Fiji whereby taro is planted on large scale for export purpose. Almost all farm operations are done manually. Study site is located at 16.95°S and 179.95°E. The area is made up of series of hills and plains with elevations ranging between 180 and 210 masl. Soil types of the study site are Humic Andosols, Vitric Andosols and Humic Ferralsols (Fig. 1).

The climatic condition of the area is characterised by wet and dry periods with most rains falling during the rainy season from November to April. Average annual rainfall over the area is about 2,500 – 4,000 mm (Fiji Met 2014), the highest being recorded in the months of December and March. Average temperature in the area is 27.3ºC. The vegetation is tropical rainforest characterized by high species diversity and marked stratified grasses that form the under storey layers in this forest. The main agricultural activities in the area are taro and yaqona (*Piper methysticum*) farming.



Soil Map Code	Soil Types (FAO)
	• Vitric Andosols on lapilli
4 - 7	• Humic Andosols, medium textured, on basaltic flows:- *-gentle undulating and rolling to hilly, petric phase.* *- gentle undulating and deep phase and rolling to hilly and petric phase.* *- gentle undulating, petric phase and stony phase.*
8	• Vitric Andosols, steeply dissected, on lapilli
9	• Vitric and Humic Andosols, deep phase on lapilli.
	• Humic Ferralsols, fine to medium textured, on basaltic flows.

Figure 1. Map of Fiji and Taveuni Island showing the study area at South Taveuni with corresponding soil classification with reference to soil map code and types (FAO 2012).

2.2 *Soil Sampling and Nutrient Analysis*

Soil samples were collected randomly from twenty sample points in each of the land use type, the intensive cultivated area and less disturbed forest soils. Both sites are adjacent to each and falls within the same climatic region, relief, parent materials and soil types. This makes comparison of soil indicators between the two land use types possible. Thus any difference observed between the soils under cultivated site and undisturbed site will be accounted for by differences in nature of the plant cover.

The soil samples were collected from 0-15 cm depth of the topsoil with soil sampling augur and filled in the labeled zip-lock plastic bags. Soil samples were sent to Fiji Agricultural Chemistry Laboratory at Koronivia Research Station for physical and chemical analyses. The samples were air-dried and carefully sieved with 2 mm diameter mesh after which standard laboratory techniques were used to determine the target analytes.

Soil samples were analyzed for bulk density. The chemical indicators comprised measurements of EC and pH H_2O (1:5 w/v) using EC 300 and EUT Tech pH meter, respectively; and determination of CEC by 1 M NH_4OAc percolation (pH 7.0) (Blakemore *et al.* 1987). Organic C using the wet digestion method (Walkley and Black 1934); Total N using semi-micro Kjeldahl method (Blakemore *et al.* 1987); available P by Olsen *et al.* (1954) described by (Blakemore *et al.* 1987); exchangeable cations by 1 M NH_4OAc (pH 7.0) leaching extraction method described by Daly *et al.* (1984).

The method of statistical analysis adopted was pair-wise t-test the Genstat statistical software package (VSN International Ltd. 2011), to determine the significant differences that exist in the soil indicators of taro and forest sites. The means of the soil parameters examined for each of the sites were calculated.

3.0 RESULTS AND DISCUSSION

3.1 *Soil nutrient analysis and bulk density*

The bulk density analysis reveals that there was significant difference in bulk density between the taro cultivation sites and the forest sites (Fig. 2). The bulk density was greater in the cultivated site than the forest site (Fig. 2). This concurs with the observation of Dalal (1982) that bulk density increases with increase in the period of cultivation.

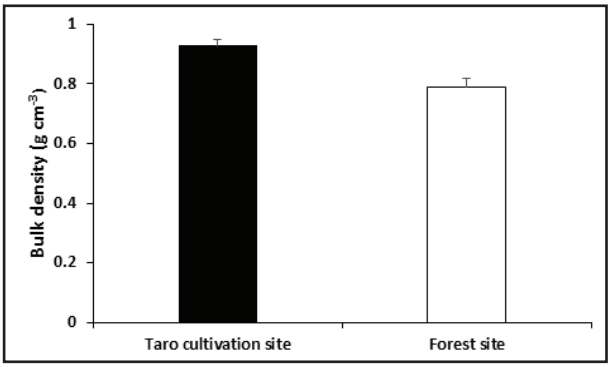


Figure 2. Bulk density of soil under both intensive cultivation and forest area

3.2 *Soil nutrient analysis – chemical projections*

The result of the analysis shows that organic carbon in soil under taro system had mean value of 6.2% compared to 11.6% under forest sites. There was significant difference in the soil pH between the two land use types. Total nitrogen, available phosphorous, exchangeable magnesium and exchangeable calcium were higher in soil under forest than the soil under taro cultivation while exchangeable potassium was higher in soil under taro cultivation (Table 1). This study shows that soil pH, available phosphorus, exchangeable magnesium, exchangeable calcium, liable carbon and organic carbon varied significantly (Table 1).

Table 1. Chemical indices of soil under both intensive cultivation and forest area

Chemical indices	Land use type		P- values
	Intensive cultivation	forest area	
Soil pH	5.6	5.9	<0.001**
Liable Carbon	1.12	1.37	<0.05*
Organic Carbon	6.16	11.6	<0.001**
Total Nitrogen	0.37	0.91	0.07
Olsen Phosphorus	4.52	8.48	<0.001**
Exchangeable Potassium	0.42	0.38	0.430
Exchangeable Calcium	4.61	9.15	<0.001**
Exchangeable Magnesium	2.85	4.12	<0.001**

* Significant ** highly significant

Woodruff (1949) observed that when forest soils are brought under cultivation and cropping, organic carbon content generally declines because the amount of organic materials returned to the soil decreases sharply. The drop in soil pH was observed in taro cultivated sites. This could be partially attributed to frequent application of nitrogenous fertilizers which causes soil acidification. Lungu and Dynoodt (2008) reported that long-term annual applications of urea resulted in significant increase in soil acidification and decreased exchangeable bases in soil.

The lower organic matter content found in taro cultivation was due to improper rates of nutrient applications and poor soil management practices and this could have contributed towards surface erosion and leaching. Further, the characteristics of Taveuni soils are such that it allows high infiltration, causing fast leaching of active cations. Higher level of calcium was observed in forest sites. It is however glaring that magnesium concentration was higher in the forest plot than maize plot. This may be attributed to organic matter diminution and more so, more magnesium would undoubtedly be utilized by cultivated crops and some may be washed off by surface erosion following the exposure of forest by burning and tree felling (Adejuwon and Ekanade 1975). The higher concentration of potassium in taro cultivated area suggests frequent application of NPK, 13:13:21 ratio fertilizer, a common practice by farmers to gain maximum production per unit area.

4.0 CONCLUSION AND RECOMMENDATION

The impact of continuous cropping of taro can be clearly observed from the analysis results. Despite the importance of taro as a major food source and income security of Fijians, it still degrades both the physical and chemical properties of soil. It is therefore, concluded that massive taro production as mono-cropping diminish the soil nutrient especially the organic matter and soil pH which is the basis of the nutrient status of the soil in Taveuni. .

Poor soil management practices and inappropriate fertilizer application rates have aggravated the situation of soil degradation and fertility problems in Taveuni. The heavy rainfall in the study area is another major factor causing leaching of essential nutrients; hence planting of cover crops would prevent leaching. The relatively low organic matter content discovered in the study area can be improved by mulching so that the soil can be cultivated for many years with good yield. Finally, mixed cropping should be adopted. This would allow growing of different crops on the same plot of land at the same time especially leguminous plants, which can help in fixing atmospheric nitrogen.

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SHORT NOTE

Effect of Five Mulches on the Yield and Quality of Tomatoes (*Solanum lycopersicum*) in Fiji

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ABSTRACT

Tomatoes were planted under five different mulches at Sigatoka Research Station, Fiji to study their effects on the quality of fruit and yield. The treatments were: Control, Sugarcane tops, Black Plastic, Guinea grass and Coconut fronds. Different mulches had varying effects on the parameters measured. There was no significant difference in the days to 50% flowering and days to 1st harvest of the crop. Significant difference was observed in the fruit diameter and weight per fruit in different treatments. Mulch treatment with sugarcane tops recorded the largest fruits followed by guinea grass. Unmulched treatment or control recorded the lowest fruit size.

It was also observed that treatments with sugarcane tops recorded the highest dry root weight followed by guinea grass. There was no significant difference between the treatments on yield however; treatments with sugarcane tops recorded the highest yields followed by guinea grass. Mulched treatments when compared to unmulched treatments recorded significantly higher yields. Sugarcane tops and guinea grass are environment friendly mulches, which can be used in organic farming to improve fruit quality and yields in tomatoes. Further experiment needs to be carried out on different rates of application of sugarcane tops inorder to identify the best rate.

Keywords: Tomato (*Solanum lycopersicum*), mulch, sugarcane, guinea grass, coconut fronds

1.0 INTRODUCTION

Agricultural productivity in the Pacific must improve in order to increase rural income and meet the demand for food in both rural and urban areas. Yields and aggregate production of food and export crops have remained stagnant or have fallen. Previous production increases were achieved largely by bringing in new land into production, but this will no longer work because uncultivated land is no longer freely available.

The factors that limit food production on the small farms are virtually unlimited in number and variety. The small farmer does not have enough land to produce more; or family labour is scarce; or his family feels a competing need for cash income from non farming pursuits: the possibilities are endless. Productivity can be increased through improved varieties and better management practices.

In Fiji, many farmers are using black plastic as their main medium for mulching crops. This is an inorganic material and does not contribute much to the soil and also acts as a form of pollution after its utilization period. The plastics are removed from the fields and are either dumped on the side of the field or burned to get out with.

Large amounts of sugarcane tops become freely available during the cane harvesting season (June to December) in Fiji. Farmers can use this as one of the mulching materials for their crops. Using of organic materials for mulching will return organic matter to the soil as it is removed and hence increase and sustain soil productivity.

Without regular organic matter addition, soils become drained of essential plant nutrients and are unable to absorb or retain water. As their structure is weakened, soils are much more susceptible to the forces of wind and water erosion. Application of organic mulch to soil can alleviate some of the problems of decreasing soil fertility faced by farmers of the country. Mulching offers a number of benefits:

It controls weeds (a good layer of mulch shades the soil and prevents weeds from germinating), conserves soil moisture (it creates a barrier against the drying effects of sun and wind) Weeds can increase evapotranspiration of soil moisture by 25% in a summer day. In contrast, mulches will increase soil water by increasing percolation and retention, reducing evaporation, and reducing weeds. An early study demonstrated that a layer of straw only 1.5 inches thick reduced evaporation by about 35% compared to bare soil (Chalker-Scott, 2007), fertilizes soil (as mulch breaks down, it releases essential plant nutrients to the soil), builds soil structure (as mulch breaks down, it also makes the surface soil permeable and increases its water holding capacity and stops soil erosion (it protects soil from the erosion forces of wind and water). It shields soil from heavy raindrops and slow runoff water that flows over the soil surface.

2.0 MATERIALS AND METHODS

2.1 *Study site*

The trial was established at Sigatoka Research Station, Fiji in May, 2014. According to Lesile and Seru (1998), the soil is classified as alluvium derived from basic and intermediate rocks. They mentioned that the soil has high base saturation and it is near neutral to slightly acid. They further mentioned that organic matter status is low and deficiency in nitrogen and potassium below 20 cm depth.

Raised beds of 0.2 m high and 1.5m in width and 6 m in length were made. Tomato variety Alafua Large were raised in the seedling trays and were transplanted in the field at 3 leaf stage. Two rows of tomatoes using the spacing of 1.0m between rows and 0.5m within rows were planted in a bed. Seedlings were raised in the seedling trays and were transplanted in the field at 3 leaf stage. Poultry manure at the rate of 10 tonnes per hectare was applied and worked in the soil 2 weeks before planting. 200 kg/ha of NPK 13:13:21 was applied as basal on the day of planting and urea at the rate of 100 kg/ha was applied 2 weeks and 4 weeks after transplanting in 2 split applications. The crops were staked after 3 weeks from transplanting and were regularly pruned and frequently irrigated to avoid any water stressed.

2.2 *Experimental Design*

The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replications and five treatments. The treatments were sugarcane tops (20kg/plot), black plastic (1 sheet fully covering the plot), Guinea grass (10kg/plot), Coconut fronds (15kg/plot) and control (nothing added, all weeds removed from the plot). ANOVA was carried out using the Minitab statistical package version 10.3 of 2002.

3.0 RESULTS AND DISCUSSION

The mulches had varying effects on the different parameters measured in the experiment. There was no significant difference between the mulches in days to 50 % flowering and days to 1st harvest of the crop. Significant difference was observed in the fruit diameter of different treatments. The control plots had the smallest fruits (smallest fruit diameter) when compared to the mulched treatments. Fruit diameter recorded from the black plastic mulch was not significantly different from guinea grass and coconut frond mulches but it was significantly different from the sugarcane top treatment.

The control recorded the lowest duration of fruiting but was not significantly different from the coconut frond treatment. It was however, significantly different from the black plastic, sugarcane tops and guinea grass mulches. The longest fruiting duration was once again recorded from the sugarcane top mulches but however it was not significantly different from the black plastic and guinea grass mulches.

Highest amount of dry roots was obtained from the sugarcane top treatment but it was not significantly different from the dry root weight of guinea grass mulches. However, it was significantly different from the rest of the treatments. There is some collaboration effect between the dry root weight and the yields obtained from the treatments. The control recorded the lowest dry root weight and it also had the lowest recorded yield. Similarly the sugarcane tops recorded the highest dry root weight and it also had the highest recorded yields. The same applies to the rest of the treatments.

Weight per fruit recorded from all the treatments was significantly different between each other. Plots mulched with sugarcane tops produced the largest fruits. The highest yields were recorded from sugarcane top treatment followed by guinea grass treatments.

Control treatments gave the lowest yields, however there was no significant difference between all the treatments. Significant difference was obtained when the mulched treatments were compared with control. This suggested that there was an increase in yields in tomatoes grown under mulches when compared to unmulched conditions.

Table 2.0 Effect of the Five Mulches on Plant Performance, Fruits Quality and Yield of Tomato*

Mulch Type	Days to 50% Flowering	Days to 1st Harvest	Fruit Diameter (cm/fruit)	Fruiting Duration (Days)	Dry Root Wt. (g/plant)	Wt. per Fruit (Grams)	Yield (t/ha)
Control (unmulched)	35.5 a	97.8 a	5.1 c	18.0 c	2.6 d	82.9 d	9.4 a
Sugarcane Tops	35.0 a	98.0 a	6.8 a	23.3 a	7.0 a	135.9 a	14.1 a
Black Plastic	36.5 a	98.5 a	6.4 ab	23.0 a	4.3 b	102.1 c	12.5 a
Guinea Grass	37.5 a	98.8 a	6.5 ab	21.0 ab	6.6 a	123.0 b	13.0 a
Coconut Fronds	35.3 a	97.8 a	6.2 bc	20.0 bc	3.4 c	93.4 c	9.6 a

*Means in the same column followed by same letters are not significantly different at P = 0.05 using and LSD value.

4.0 CONCLUSION

Different types of mulches have different effects on the quality of tomatoes produced. It was observed from the experiment that tomato plants mulched with sugarcane tops recorded larger fruit size and had extended pickings. The second best mulch was the guinea grass. Sugarcane top becomes readily available to farmers in the country during the cane harvesting season and the guinea grass is always available to them freely. Both of these mulches are organic and beneficial to the soil. It was also observed that treatments mulched with these two materials also had extended rooting systems giving better quality fruits and higher yields.

Most farmers in the country are using black plastic to mulch their crops. Apart from it being expensive, it is also an inorganic material contributing to environmental pollution. It was confirmed from the experiment that crops mulched with black plastic gave smaller fruits in terms of diameter and weight per fruit as compared to organic mulches. A seven year organic mulch study in India showed that the superiority of organic mulching compared to black or transparent polyethene mulch or bare ground was partly due to improved soil, water and temperature conditions that resulted in improved flowering, pod production and yield of groundnut (Ghosh et al. 2006).

ACKNOWLEDGMENTS

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SHORT NOTE

Sawmilling and Density Study of *Eucalyptus deglupta* (Blume)

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ABSTRACT

The depleting level of our indigenous resources has encourage the process of lesser-known species by local saw millers and due to their unknown properties they are marketed under a common group commonly known as Medium Light Hardwoods (MLH). The report contains a detail research into general physical properties and characteristics of *Eucalyptus deglupta* (Blume). From the present research, it was found that mature *E. deglupta* is suitable for light construction of furniture and light joinery and it is classified Under the Medium Light Hardwoods class, in timber classification.

Keywords: *Eucalyptus deglupta*(Blume), Medium Light Hardwoods (MLH)

1.0 INTRODUCTION

The decision to plant Eucalyptus species as one of the alternative plantation species resulted from studies of several un-replicated species trials established during the late 1950s to the 1960s (TUD, 1968). These trials showed that on burnt over grasslands in the dry zone, *Pinus caribaea* (Barrett and Golfan) which was under research along with other exotic species gave very satisfactory growth and in addition had the ability to cope with a wide variety of sites including those low in major nutrients.

In 1953, seeds of seven eucalyptus species including *Eucalyptus deglupta* (Blume) was imported into Fiji with other exotic hardwoods and planted for research purposes (TUD, 1968). Eucalyptus species cultivated in those early trials was as vigorous and rapid growth rate as *P. caribaea*.

Eucalyptus deglupta is an exotic species to Fiji and is planted at almost all the plantation reserves of the Forestry Department, which includes Nukurua in Tailevu, Korotari in Macuata, Naboutini in Serua and Colo-i-Suva in Naitasiri. *Eucalyptus deglupta* is the only species of the genus Eucalyptus growing easily in the north and south of Viti Levu and is adapted to high rainfall and temperature throughout the year. Tree height is about 35-80m tall with straight boles. Bark type is smooth, decorating in long strips. Juvenile leaves is stalked and adult leaves is ovate lanceolate. Wood coloration is dark to reddish brown, more like a coarse grain forest than a *Eucalyptus* species. Unlike *E. deglupta*, other eucalyptus species are susceptible to diseases (Alston, 1982).

The present study aimed to determine the log density and wood properties of trees and sawmill output recovery of 50 year old *Eucalyptus deglupta* stand at Nukurua, Tailevu Province.

2.0 MATERIALS AND METHODS

2.1 *Eucalyptus deglupta* site and sampling

Ten 50 year old *E. deglupta* trees were harvested and removed from a Eucalyptus stand at Nukurua Plantation and transported to the Forestry Department's Timber Utilisation Unit, Nasinu for processing in June, 2005 (Fig. 1).

Figure 1. *Eucalyptus deglupta* logs held in stock before sawmilling at the Department of Forestry's Timber Utilisation Unit, Nasinu

2.2 *Density Measurement*

The Diameter of Breast Height of each tree were measured with the length to determine the merchantable volume of the trees. Density discs were cut at base, and at 6-meter intervals of logs. These discs are then labeled and grouped respectively. The discs were covered properly with plastics bags to prevent moisture from being absorbed and released from the discs. All discs were taken to Nasinu laboratory for testing. At the Nasinu laboratory, the discs were cut diagonally from the pith to the outer layer and numbered accordingly for basic density and moisture content assessments (Table 1). Green weight of each piece was recorded and all samples were then subjected to saturation process. The volume of these saturated pieces were then measured and recorded. The pieces are then oven dried, weighted, waxed, and measurements were taken on its volume by water displacement method over a top pan balance.

Test was also conducted on timber drying characteristics. Suitable boards were selected from the stacks. Density disc were cut from at least 500mm from the ends to test moisture content percentage using oven drying method (Table 1). The ends of the sample boards were

coated with paint so that it does not dry rapidly than the rest of the stack. They are then inserted within the stack and weighed every week until it reaches it fiber saturation point. Shrinkage test was conducted with the use of veneer caliper and oven. Measurement was taken on radial, tangential and also longitudinal.

Table 1. Formulas used for calculation of moisture content and density determination

Moisture content = $\frac{\text{green weight – oven -dry weight}}{\text{Oven- dry weight}} \times 100$

Basic density = $\frac{\text{oven- dry weight}}{\text{Volume}} \times 1000$

Relative density = $\frac{\text{oven- dry weight}}{\text{Oven -dry volume}} \times 1000$

Green density = $\frac{\text{green weight}}{\text{Saturated volume}} \times 1000$

Density @ 12% M.C = Basic density x 1.12

3.0 RESULTS AND DISCUSSION

3.1 *Density and Moisture content*

The average basic density for the ten selected trees was 490 kg/m^3. The relative density was 549 kg/m^3. Density at 12% moisture content was calculated to be 549 kg/m^3. The average moisture content of the ten freshly felled treeswas 88% (Table 2).

The average tree height of the ten trees was 30 meters with the merchantable length ranges from 3.3-6.0m. Shrinkage test is not very reliable because dimensional changes were not taken into consideration. The density of wood is affected by several factors. These factors include variability in the seeds origin, the site, soil type and the maturity of trees at the time of harvest. This is very much reflected by the *E. deglupt*a immature trees that were tested at 15 years after planting and produced basic density of 340 kg/m^3 and air-dry density of 420 kg/m^3 (Forestry, 1981).

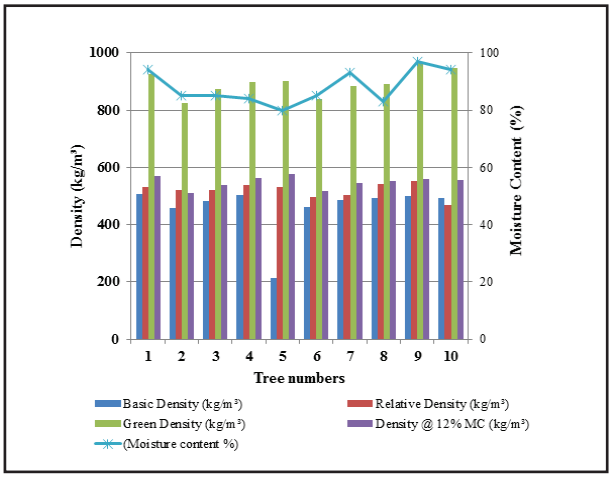

Figure 2. Graph density assessment and moisture content of ten 50 years old E. deglupta tree species.

The increased basic density of the 50 years

Table 2. Summary of 10 *E. deglupta* tree moisture content and density

Tree Number	Average Tree (mc %)	Basic Density (kg/m^3)	Relative Density (kg/m^3)	Green Density (kg/m^3)	Density @ 12% MC (kg/m^3)
1	94	508	533	926	569
2	85	457	521	823	512
3	85	483	521	872	540
4	84	503	537	899	563
5	80	215	533	902	576
6	85	460	498	840	516
7	93	485	505	883	546
8	83	493	541	891	553
9	97	499	553	963	559
10	94	494	470	947	554
Average	88	490	521	895	549

old trees that were tested in this report justifies the upgrading of strength group of the timber obtained (Fig. 2). In comparison with local species, the basic density of *E. deglupta* (490 kg/m^3) (Fig. 2) is comparable to Bauvudi (*Palaquium fidjiense* Pierre ex Dubard) (460-490 kg/m^3) (TUD, 1989), Kauceuti (*Bleasdalea vitiensis* A.C Sm) (430 kg/m^3) (TUD, 1989) and Kaudamu (*Myristica castaneifolia* (A.Gray)) (490 kg/m3) (TUD, 1989).

3.2 *Sawmill Recovery*

Total log input was 21.162m^3 with a log output of 10.206m^3 that was 48% recovery 25-35% sawdust and slabs. About 17% consist of rot, insects infestations, wane split etc. A total of 17 logs with lengths ranging from 3.3-6.0 m were processed. The study has shown that most *E. deglupta* tree species are within the diameter range of 50-55cm.

Since timber is a product of biological growth, several factors could contribute to the difference in the moisture content and the wood density of each tree. Such factors includes anatomical characteristics of fibre length, cell diameter and thickness and environmental factors such as temperature, precipitation and wind. Thus, age of the trees, position and location also have influence on the growth of trees and it affects the tree diameter during its growth period.

3.3. *Shrinkage and Timber Drying*

Moisture content depends on the relative humidity of the surrounding atmosphere. The moisture content ranges between 0% and fiber saturation point of 25-35%. The moisture content influences the wood dimensions in three directions – longitudinal, radial and tangential (Table 3). Its increase or decrease causes the swelling or shrinkage of the wood. The longitudinal change is very small and can be neglected.

The dimensional changes in radial and tangential direction, however related to the initial length, are considerably high and confine the use of wood in outdoors and in places of permanently varying relative humidity. Besides the dimensional changes the anisotropy of swelling is an important factor affecting the dimension stability and causing warping, twisting, cupping and crack in timber.

Table 3. Shrinkage Tests Dimensions after Oven Dry

Tree Number	Radial	Tangential	Longitudinal
1	1.5	6.5	1.0
2	1.0	3.0	Nil
3	1.5	4.0	0.5
4	2.0	8.5	0.5
5	1.5	6.5	Nil
6	1.5	5.5	1.0
7	1.5	5.0	2.0
8	2.0	6.5	1.5
9	2.5	4.5	1.0
10	1.3	6.5	1.0
Average	1.6	5.7	1.1

3.4 *Monitoring Moisture Content during Air Drying*

Moisture content has marked effect on woods density. Wood in use may vary in moisture from not more than a few percent in the heated interior of buildings in cold climates to the virtually fully saturated condition that might be found in other parts of the country. Where shipping weights, material handling equipment requirements or dead load on structures must be calculated, the density value of interest must include the effect of both weight and volume. As the moisture content increases to the fiber saturation point, the weight increases and as a result of swelling so does the volume. The moisture content losses ranges from 11 to 25 %.

4.0 CONCLUSION AND RECOMMENDATION

Wood is a hygroscopic material. Its moisture content depends on the relative humidity of the surrounding atmosphere (TUD Training Manual, 1981). Density is an important factor influencing almost wood properties and strength. There are linear correlations between density and strength. The average density for the ten selected trees was 489.72 kg/m^3 for basic density, 548.68 kg/m^3 for density at 12 % moisture content and 894.56 kg/m^3 for green density. The average mill log volume of the ten trees was 10.21 m^3, estimated to be 70 % of the total volume if harvested up to the merchantable wood.

This initial objective of this research was to determine the density and structural properties of *Eucalyptus deglupta* however due to the limitations experienced during the study, measurements were restricted only to the density and shrinkage tests. Mechanical stress testing methods was not conducted due to lack of appropriate equipment. Eucalyptus is classified as Light Hardwood species which is in the same class as Dakua Salusalu (*Decussocarpus vitiensis*), (Seem) Kauvula (*Endospermum macrophyllum*) (Pax and K. Hoffm (TUD, 1989).

These densities were measured from cookies cut from individual trees. From the density calculated *Eucalyptus* should be suitable for production of sawn timber, veneer and plywood. They can also be used as construction material and as supporting elements of furniture and other wood products. Studies on mechanical stress are necessary not only on *Eucalyptus deglupta* but also on other Lesser Known Species (LKS). Recommend for the shrinkage and bending test to be conducted with consideration to its dimensional changes.

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Evaluation of marcotting techniques of Breadfruit (*Artocarpus altilis)* variety "Bale kana' for rapid multiplication of planting materials in Fiji

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SUMMARY

The main objective of this study was to evaluate the effects of different 'techniques' on the breadfruit variety 'Bale kana' to improve planting material production by using the technique of marcotting based multiplication in the Fiji Islands. Two experiments were established at one trial site because of the young age and small sizes of the mother trees available at the time.

The first experiment evaluated the effects of four (4) different marcotting media on the onset of first root; volume of root mass at harvest; time required to harvest of marcotts; and percent success. Results showed that marcotting media had significant effects on the onset of the first root; volume of root mass at harvest; time to harvest; and the total number of successful marcotts. Results also showed that marcotting Medium 2 consisting peat moss with 10% sphagnum moss and liquid rooting hormone, although not significantly different from the Control Medium provided the highest percentage of root mass at harvest, earliest harvest of marcotts and the highest total number of successful marcotts.

The second experiment aimed to determine the effects of branch size and branch location (high and low) on the onset of roots; percent volume of root mass at harvest; time to harvest of marcotts; and percent success. Results showed that the large branches (3.5 to 4.5 cm in diameter) performed better than branches less than 3.5cm in diameter ($P<0.05$). The onset of the first root growth in big branches was 10 days earlier; marcotts from big branches produced 3.2 times more root mass at harvest; and 2.2 times more successful marcotts. However, branch size did not affect time to harvest of marcotts when the root ball are fully formed. There was also no effect of the location of branches on the mother trees. This study has revealed better techniques in improving multiplication of breadfruit planting materials in the Fiji Islands for improved commercial nursery practices.

Keywords: marcotting, 'bale kana variety', Fiji

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