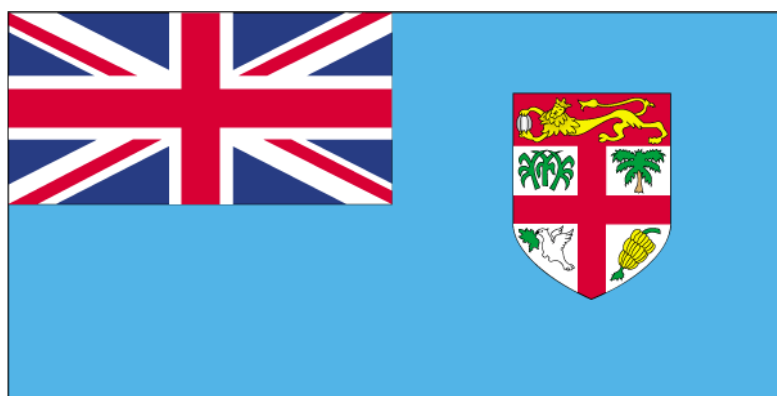


Country Pasture/Forage Resource Profiles

FIJI



by
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1. INTRODUCTION

The Republic of Fiji, an archipelago with a land area of 18 333 km², supported a population of 792 000 (derived from SPC 1998) or 931 741 (according to the World Factbook July 2008 estimate and an annual population growth rate of 1.388%) on 105 islands, composed of 46.2% ethnic Fijians, 48.6% Indo-Fijians and 5.2% of Chinese or European origin. Latest SPC data (SPC, 2008) indicate a mid-2008 population of 839 324, a 2010 population projection of 850 105 and an estimated annual growth rate for 2008–2010 of 0.6%. Fiji's 840 islands lie between 12° (Rotuma) and 22° S (Ono-i-lau) and 175° and 178° E – this bounded area covers 650 000 km² of which 3% is land. Viti Levu and Vanua Levu (see Figure 1) cover 10 388 km² and 5 535 km² respectively (Leslie 1997).

Between 1990 and 1996 the economy grew at 2.7%. In 1996 exports were valued at A\$837 million and imports at A\$1 172 million (SPC 1998). In 1995 sectorial contributions to GDP (A\$2 620 000 000) were: agriculture (20.1%) mining (2.6%), industry (13.8%), commerce (17.2%), public service (4%), construction (4.7%) and other (25.5%). Sixty percent of the population is rural; agriculture provides nearly 50% of the nation's employment (MAFF&A, 1996). An estimated 95 000 rural households support 500 000 people. Of these, 15 000 raise pigs (average 15 per household), 65 000 raise chickens (average 30), 24 000 raise goats, 100 raise sheep and 43 000 raise cattle (39 000 multi-purpose draught/meat/milk, 1 800 commercial beef, 2 200 dairy – 215 registered commercial dairies). Ethnic Fijians have no religious restrictions on livestock species; Hindus keep ruminants and pigs; Muslims keep only ruminants. Hindu retailers rarely sell pork for fear of offending Muslim customers.

Statistics on ruminant numbers, beef, veal, sheep, goat meat and milk production, cattle imports and beef and veal imports for the period 1997–2007 (FAO Database 2009) are shown in Table 1. In 1996 the dairy industry was 27.4% self-sufficient in total milk fat equivalents (but the total declined to 18% by 2001, according to Rokomatu, 2001). There were 215 registered dairy farms (179 supplied 11 900 000 litres of fresh milk to Rewa Cooperative Dairy Company in 1996). Smaller, low producing, dairy farms of the 215 registered will leave the industry but the rest, if improved pasture, herd recording, culling, genetic improvement programmes are implemented, will remain competitive against imports.

Goat production, which is traditional and important, rose from 650 to 840 tonnes carcass in 1986–1996 with per capita consumption of goat meats at 1.2 kg/year. The fledgling mutton industry is expanding, carcass production was 36.0 tonnes in 1996 when there was 7 600 head and 1 600 new breeding stock purchased from government farms. Hindus are the major mutton consumers. Farm gate price of a sheep carcass is about FJD \$2.50 per kg – 1.66 times the price of beef. Per capita consumption of boneless sheep meats fell from 7.4 in 1993 to 5.7 kg in 1996.

According to Macfarlane (FAO, 1998), in 1996 Fiji imported 1 525 tonnes boneless beef (66% for local consumption, 33% for canning), 424 tonnes fresh cream and milk (FJD 660 000), 3 208 tonnes of dairy products as milk fat equivalents (FJD 20 500 000), 4 360 tonnes boneless mutton and 145 tonnes canned sheep meat (approx. FJD 12.5M) and 81 tonnes goat meat. Figures from the FAO database indicate for 1998 that Fiji imported 890 tonnes of beef and veal (value USD1 346 240), 7 408 tonnes of dairy products and eggs (USD12 604 000), 20 tonnes of fresh milk (USD19 040), 9 500 tonnes of mutton and lamb (USD10 600 000) with total meat imports of 13 630 tonnes. In 2005 corresponding imports were 1 300 tonnes of beef and veal, 7 918 tonnes of dairy products and eggs, 880 tonnes of fresh milk, 9 300 tonnes of mutton and lamb, with total meat imports of 13 840 tonnes. Reddy (2001) indicates that total meat consumption in Fiji has increased considerably over the years and will continue to do so (per capita meat consumption was 19 kg in 1981 and 28.7 kg in 1996) with imports increasing to supplement the rather stagnant local production.



Figure 1. Map of Fiji

Table 1. Fiji statistics for ruminant numbers, beef, veal, sheep, goat meat and milk production, cattle imports and beef and veal and lamb imports for the period 1997–2007

Item	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Cattle nos. (,000)	350.0	344.6	330.0	335.0	340.0	320.0	310.0	310.0	310.0	310.0	315.0
Sheep nos.	6 718	7 000	7 000	7 000	7 000	6 000	6 000	5 000	5 000	5 500	6 000
Goat nos. (,000)	230.3	235.0	237.2	240.9	245.8	250.0	250.0	260.0	240.0	260.0	270.0
Beef and veal prod. (mt)	9 120	9 310	8 595	8 767	8 941	8 550	8 360	8 360	8 360	8 400	8 400*
Sheep meat prod. (mt)	34	30	30	30	32	27	27	23	23	25	26
Goat meat prod. (mt)	927	930	935	934	971	1 010	800	1 200	930	1 110	1 150
Milk prod. (,000 mt)	57.8	57.0	55.0	56.0	57.0	57.5	57.5	50.0	57.0	57.5	58.0
Cattle imports nos.	-	-	-	42	-	-	-	148	41	255	n.r
Mutton and lamb imports (mt) (,000)	9.4	9.9	11.0	11.3	9.6	8.8	8.4	8.3	9.3	10.3**	n.r
Beef and veal imports (mt)	930	890	1 670	1 690	1 340	1 430	1 310	1 370	1 300	1 179	n.r
Cow milk fresh imports (mt)	220	220	220	50	33	527	34	1 210	882***	814	n.r

Source: FAO statistics 2009

n.r. = no record; No data for 2008

* Total meat production in 2007 was 25,531 mt (beef, chicken, duck, goat, pig, sheep and turkey)

** Other meat imports in 2006 included 1948 mt of chicken meat, 192 mt of pork/pig meat and 54 mt of turkey meat

*** Also imported in 2005 were 6 446 mt of other milk in the form of whole dried (4201 mt), condensed (2086 mt) and evaporated (159 mt) milk

Land use

The principal types of land use are: open grazing 2 700 km² including 950 km² of roadsides, compounds and sugar cane residues, 280 km² grazing under coconuts or forest trees, 380 km² of crop or fallow under coconuts, 1 950 km² ha of arable and tree crops other than coconuts, 1 000 km² of plantation mahogany and Caribbean pine. Fifty-nine percent of Fiji, 10 850 km², is nominally covered with natural forest

Ethnic and Indo-Fijian farming systems differ. Ethnic Fijians live in nuclear villages and each household farms a definite block of land; households are often economically inter-dependent (Chandra, 1983). Indo-Fijians live independently of each other with no economic inter-dependence between households. Sixty-nine percent of the population lives on Viti Levu while Vanua Levu and Taveuni contribute 20% and the Eastern Islands 10%. Farm size varies as follows: 2.81 ha Western, 2.54 ha Central, 11.29 ha Northern and 3.09 ha Eastern Districts. Smallholder systems, in some cases with several households per farm, range from subsistence through semi-commercial to highly commercial. The plantation sector involves up to 25 estates with coconuts, often with beef cattle, and the larger dairy farms (over 50 cows). The government has several large farms for livestock research and breeding stock distribution.

2. SOILS AND TOPOGRAPHY

Major topographic features

Topographically Fiji is divided into three major classes: plains and valleys; low mountains and hills and high mountains. These landforms are either depositional – littoral or fluvial, erosional – fluvial erosion, mass movement or volcanic.

Major soil types and soil fertility constraints

Maps showing soil type distribution can be produced from a geographical information system (GIS) based at Koronivia Research Station. Sixty-five percent of soils have developed on steep slopes (over 21°), 20% on gently undulating and hilly land (4–21°) and 15% on flat land (under 4°) (Leslie 1997).

Table 2. Distribution of land classes in Fiji (km²)

Land class	Viti Levu	Vanua Levu	Other islands
Flat land	1 664 (16%)	831 (15%)	366 (15.5%)
Undulating and hilly land	1 768 (17%)	720 (13%)	354 (15%)
Steep, mountainous land	6 968 (67%)	3 989 (72%)	1 640 (69.5%)
TOTAL	10 400	5 540	2 360

(From Chandra, 1983)

Lowland (below 600 m, mean annual temperature over 22 °C) soils are formed on beach sands, marine marshes, poorly and well drained alluvia, highly organic parent material, acidic and non-acidic terraces and peneplains. Soils from lowland rolling and hilly terrain are formed from young and weathered volcanic materials, volcanic ash over reef limestone, calcareous tuffs and marls, and from basic, intermediate and acidic geologies. Upland soils (over 600 m, mean annual temperature 15–22 °C) are formed on recent poorly and well-drained alluvia, raw volcanic materials and basic rocks (Leslie, 1997). Low available soil N, P, sulphur, potassium, copper, molybdenum are the most likely limiting chemical attributes of grazing land soils.

The most fertile soils are in the floodplains of the Sigatoka, Rewa, Nadi, Ba, Navua and Labasa rivers and are generally derived from basic volcanic parent material. Responses by pasture to N, P and K have been obtained in dairying areas of the Rewa floodplains (Chand, pers. comm; FAO 1996). Most grazed native grasslands are on “nigrescent – dark top soil” soils and ferruginous latosols or “talasiga” soils. For maximum pasture production the former is usually marginal in available phosphorus (10–14 ppm) and sulphur and the latter is deficient in nitrogen, phosphorus, potassium, sulphur and sometimes molybdenum.

3. CLIMATE AND AGRO-ECOLOGICAL ZONES

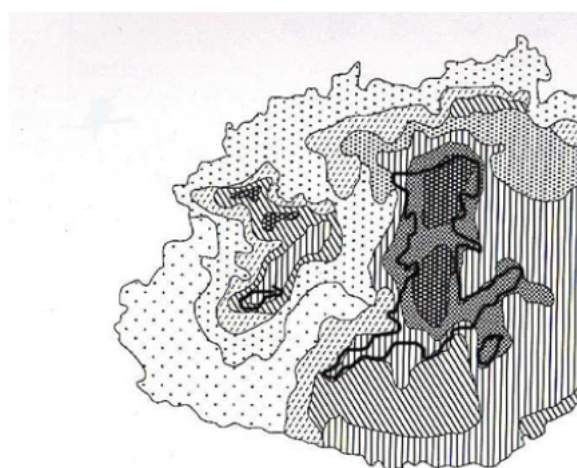
General climate – effects of topography

Fiji is on the southern boundary of the tropics so the southeast trades are the predominant rain-bearing influence. The south, east and central areas of the major islands receive the highest rainfall and north and west areas the lowest. Rainfall increases fairly consistently with altitude. Rainfall distribution for Viti Levu and Vanua Levu is shown in Figure 2.

Rainfall is heaviest from November to April; 61% of “Wet Zone” and 77% of “Dry Zone” rain falls in this period. The “Wet Zone” has 237 rainy days/year and the “Dry Zone” 128. Monthly rainfall variability is greatest in the ‘dry zone’, which suffers a 4–6 month drought every five years (Chandra 1983) and the ‘Wet Zone’ experiences a drought every ten years. This variation in rainfall distribution is reflected in variation in soil moisture availability by month between representative sites as shown in Figure 3. Annual sunshine hours range from 2 507 in the dry zone to 1 883 in the wet. Flooding associated with cyclones and depressions is a problem for dairying in the “Wet Zone” and cropping in major alluvial areas. Most grazing areas receive 2 500 mm rainfall or less.

Temperature fluctuations are moderated by proximity to the sea; monthly maxima rarely exceed 32 °C and minima 18 °C. The highest rainfall site, at 836 m altitude, Nadirivatu on Viti Levu is 7 °C cooler than at sea level. Cyclones are relatively common (a major cyclone every four years); the effect of topography on temperature is not a major factor in determining land use.

Distribution of rainfall: Viti Levu



Distribution of rainfall: Vanua Levu

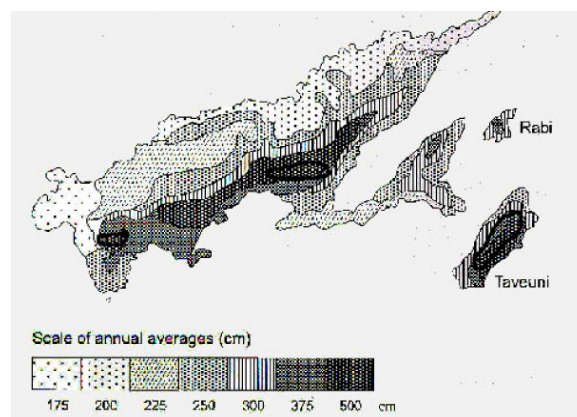


Figure 2. Agro-ecological zones based on rainfall classes within altitude classes for Viti Levu and Vanua Levu

(Adapted from Leslie 1997)

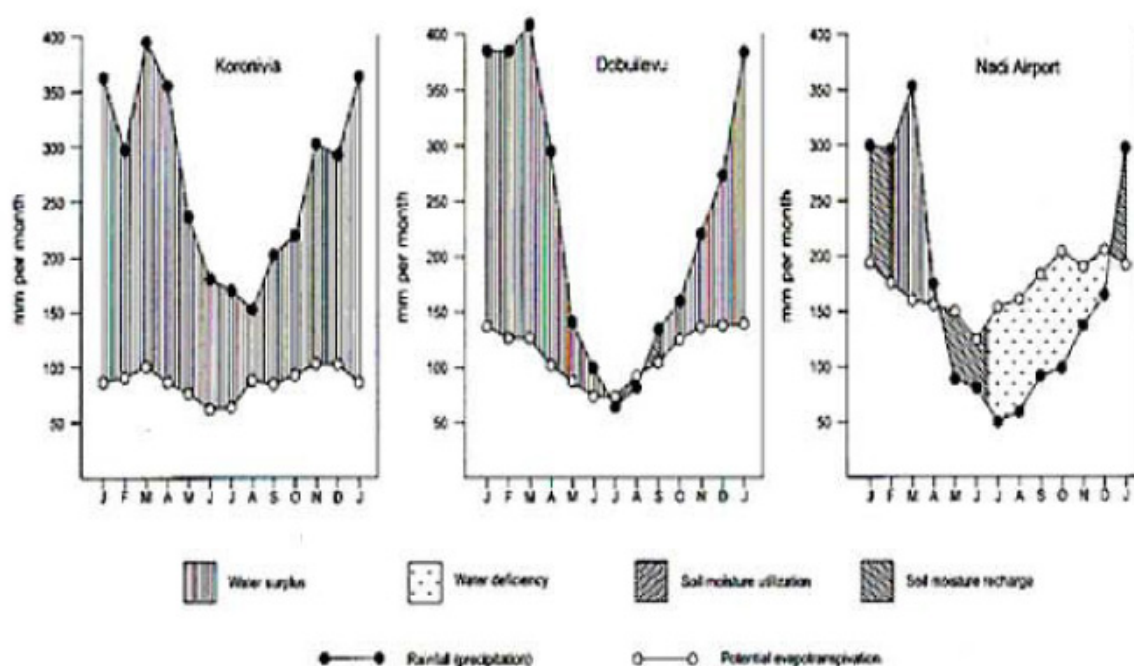


Figure 3. Soil moisture balances for contrasting areas of Viti Levu
(From Leslie 1997)

Agro-ecological zones based on climate and topography

Practical agroecological zonation in Fiji is most simply reflected by various rainfall groups within altitude classes as shown in Figure 2.

Land below 600 m is composed of coral atolls, coastal, alluvial and gently undulating lowlands and gently undulating hills; and above 600 m steep, undulating to heavily dissected, mountains.

Major agricultural activities in each zone

In the Wet Zone, receiving greater than 3 000 mm/year rain, coconuts, ginger, cassava, taro, yaqona (kava), bananas and plaintains, breadfruit and coffee along with dairy and beef cattle, poultry and pigs are produced. In the Intermediate Zone receiving 2 000–3 000 mm/year vegetables, cocoa, passion-fruit, maize, some sorghum, tobacco, watermelons, sweet potatoes, Irish potatoes and turmeric are grown; beef cattle and horses are raised. In the Dry Zone receiving less than 2 000 mm/year, sugar cane, irrigated rice, upland rice, pulses such as mung (*Vigna radiata*) and pigeon pea (*Cajanus cajan*), yams, citrus, masi, pineapples and mangoes are grown with goats, sheep and beef cattle the predominant livestock. Sugar and irrigated rice are usually monocultures, other crops are rotated. The production of roots, bananas and pineapples usually involves a fallow. Grazing livestock are kept on either natural or improved pastures, sometimes under coconuts and citrus, and in association with sugar and rice - on residues and along field margins.

4. RUMINANT LIVESTOCK PRODUCTION SYSTEMS

Scale, type and potential of ruminant enterprises

There are 1 825 specialist beef producers with 30.5 animals per farm; three properties have more than 1 000 cattle each. The commercial beef herd is distributed: 27% Central, 56.9% Western, 14.1% Northern and 2% Eastern Divisions. Commercial beef farmers have about 1 100 working bullocks. There are 2 041 dairy farmers with 13.1 cattle each; only 215 are registered for commercial supply to Rewa Co-operative Dairy Company. There are 190 000 cattle on 39 000 farms (classified as non-commercial

beef or dairy -1 to 3 animals per household) or draught bullocks (48 500) working on farms. Many cane farmers use 2–4 oxen, mainly Brahman or Brahman cross, for draught and ultimately for sale. Cane farms are a major source of low quality beef.

Approximately 24 000 smallholdings run more than 200 000 goats. There were 6 000 sheep on five government stations and 1 500 with 60 small farmers, but numbers have declined. Small stocks are attractive because of higher potential returns, shorter production intervals and lower capital investment than cattle. The avoidance of beef by about 40% of the population on religious grounds influences livestock enterprise selection. Smallholder and plantation livestock producers interact and derive mutual benefit. Commercial farmers need better access to improved bulls.

There is considerable potential for expanding the grazed area by about 1 000 km² and for improving its productivity through introducing legumes, fertilizer use and better management as well as using locally available feeds during dry periods (FAO, 1998); Aregheore, 2001; Singh, 2001).

Feeding systems

Ruminant feeding systems rely predominantly on tethering and enclosed grazing, with some cut and carry feeding. There are no feedlots. Commercial dairy cattle receive a lot of supplementary feed.

Current and potential integration of livestock in farming systems

Cattle graze 27 000 ha under coconuts. Sheep graze puero (*Pueraria phaseoloides*) based pastures under coconuts on Taveuni. Over the next 15 years this gross area is not projected to change although an additional area of 38 000 ha of land is available for inter-cropping or pastures.

Most notably almost all farms, including 23 000 sugar farms, use oxen for draught and meat at the end of their useful working life. With the rationalization of the sugar industry the number of draught oxen is likely to fall. With the movement from burnt to green-cane harvesting, more trash must be ploughed in or fed to livestock; on mechanized farms on alluvial soils, the use of round balers may be an option. There is some rotation of lands for maize, taro and cassava with pastures as a fallow crop; fallows could be improved by incorporating legumes and the use of creeping legumes (e.g. *Arachis* spp) during the cropping cycle. Sheep are integrated with citrus production on Batiri on Vanua Levu.

Goats are traditional and numbers remain relatively constant and high; since sheep have begun to develop, greater integration with tree crops is likely. Given annual losses from fire in *Pinus caribbaea* forests of F\$1 600 000 annually, the use of evergreen, poorly combustible, low, creeping pastures on forest boundaries and grazing to reduce fuel loads in *Pennisetum polystachyon* environments may increase.

Production limitations

The main constraints to ruminant production are nutritional; indicators are low weaning 45% and low average growth rates of 0.25–0.3 kg/head/day. However, good smallholders obtain 75%–100% weaning percentages and the best estates achieve 85% and with weaning at 4 months at 100 kg in the “dry zone” or 6 to 7 months elsewhere at 135 to 150 kg live weight and produce a 400 kg steer at 18 to 24 months. From Figure 2 it is clear that there are long dry spells in the Western and parts of the Northern Division. Well adapted, introduced grasses and deep rooted shrub and tree legumes could improve the quality, quantity and reduced seasonality of forage on offer but need high management levels. Farms do not match pasture species with specific fertility requirements or tolerances, to their soils types. This should be a focal area for future advisory, extension and farmer training. The principles of grazing management are not understood – the most basic are allowable levels of pasture use and the minimum forage biomass required for a pasture to sustain productivity and compete with weeds.

Overgrazing and uncontrolled fire, reduce production through weed invasion or causing species shifts to less palatable and lower quality grasses. Wide boundary strips of low growing, drought tolerant and fairly evergreen pasture plants could restrict fires that are often lit for hunting. Regular burning contributes to N and S losses from grazing systems whereas planned and timely fire is an important tool in converting natural to improved pastures and in controlling woody weeds.

It is not sufficiently appreciated that forages differ widely in nutritive value and freedom from anti-nutritive factors. Some fodder shrubs have tannin types and contents, which restrict, rather than enhance,

protein availability to the ruminant. High-sodium grasses such as *Brachiaria humidicola*, Para and *Setaria* can complement other species low in Na. Manuelli (pers. comm. Animal Health and Production Division) has reported that, in rotational grazing systems, sheep can only graze Signal for two weeks. Apart from mycotoxins in *Brachiaria decumbens* (signal grass) causing hepatic dysfunction it has been established in Papua New Guinea (S. Low, pers. comm) that saponins, particularly in the young leaf contribute to depressed weight gains and even weight loss.

Socio-economic limitations

The influence of religion on choice of livestock is mentioned above. There are three main types of tenure – state (9%), freehold (8%) and native (83%). Most agricultural freehold land, covering 40% of existing coconut areas, is controlled by interests descended from early coconut planters. Native land is subdivided into native lease land and native reserve land; the Native Land Trust Board controls its management. The former can be leased, by lessees of any ethnicity; the latter can only be used by ethnic Fijians. The ownership of native land by Mataqali or clans is well known and inter-clan or inter-family disputes over land ownership are rare; lack of certainty of land tenure is rarely a constraint to an ethnic Fijian making a decision about expanding a grazing enterprise. A lessee would be reluctant to establish or expand grazing on a lease of less than ten years and this is a major recent restricting factor in agricultural development. Established farmer lessees regard the current maximum lease of 30 years as insufficient for investment in development.

If commercial grazing enterprises are to expand costs must be kept to internationally competitive levels through careful business planning, increased unit area productivity and reliable market access. Commercial ruminant production will continue to concentrate in productive areas within economic freight distances of markets. Unit costs of production could be reduced by expanding output per unit area through cost-effective pasture improvement and targeted supplementary feeding. Making meat more readily available and affordable in rural areas, on the bone, and using lower quality cuts, is one approach to increase the market share of meat. Examples exist on Taveuni and Vanua Levu.

Extension/training/information systems

Extension, training and technical support is the responsibility of the Animal Health and Production Department. An FAO Regional Pasture Improvement Project (1994–95) showed that targeted training leads to significant community farmer-group activity, when a minimal level of resource and organizational support is provided. This led to noticeable pasture improvement. Farmer groups led to increased pasture improvement in some areas – e.g. the Vanua Levu Livestock Association. The Animal Health and Production Division maintain a regular field day programme – all training opportunities must involve a steady stream of new farmers. The Secretariat of the Pacific Community provides access to some regional pasture resource and livestock management information and can help in establishing links with regional countries.

5. EXISTING AND POTENTIAL PASTURE RESOURCES

Grazed native and improved pastures

The national cattle herd grazes 125 000 ha of unimproved *Pennisetum polystachyon* (Mission grass), 43 000 ha of naturalised/native pastures including *Dicanthium caricosum* (Nadi blue), *Ischaemum indicum* (Batiki), *Axonopus compressus* (carpet), *Paspalum conjugatum* (T-grass) and an unquantified area of roadsides and recently harvested cane fields. There is a further 175 000 ha of ungrazed *Pennisetum polystachyon*. There are 89 000 ha of coconuts, 38 000 ha of which require replanting. The major areas for improved animal production under coconuts are in the southern Vanua Levu and Taveuni areas. The Animal Health and Production Division estimate that there are 6 200 ha of improved pastures, some without sufficient legume, including *Brachiaria decumbens*, *B. humidicola*, *B. mutica*, *Setaria* and Guinea grasses. A feed industry services the dairy, pig and poultry industries based on imported grain

and protein meals, local but erratically supplied copra meal, and molasses and mill-run. Singh (2001) notes that supply of adequate and good quality nutrition is very much a seasonal problem in the dry zone during the cold months since the dominant grass, Nadi blue (*Dichanthium caricosum*) sets seed and makes poor growth.

Macfarlane (FAO, 1998) suggested current and 15 year potential of Fiji pasture and forage based feeding systems (Table 3).

Other forages and fodders

Limited areas of fodder crops such as *Pennisetum purpureum* (Elephant grass), *Tripsacum laxum* (Guatemala grass) and *Lablab purpureus* are grown,

mainly for dairy cattle. Several large dairies have made silage from Para grass-based pastures and from maize. During severe droughts some farmers use failed cane crops as fodder. Some dairy farmers use meal from dal (split pulse) processing as well as copra meal and molasses.

Table 3. Current and 15-year potential of Fiji pasture and forage based feeding systems

	Current (ha)	15 year potential
Native mission grass (<1 800 mm), open	124 000	62 500
Native mission + legume	0	37 500
Native mission (>1 800 mm), open	9 000	4 500
Naturalised nadi blue grass (<1 800 mm), open	24 000	12 000
Naturalised nadi + legumes	0	12 000
Naturalised batiki, open	12 000	3 000
Naturalised batiki + legumes	0	3 000
Improved grass, no legume	5 000	0
Improved grass + legume	1 000	41 700
Native pasture (>1 800 mm), under coconuts	26 000	18 000
Improved grass and legume under coconuts	1 000	9 000
Pasture with crops and forestry	1 000	11 000
Crop residues/roadsides	95 000	70 000
TOTAL	298 000	319 200

Limitations to the use of forage resources

The key limitations are:

- long dry periods;
- overgrazing leading to permanent weed ingress and loss of productive pasture composition;
- undergrazing in some areas;
- specific areas of major phosphorus deficiency and widespread nitrogen deficiency;
- widespread sodium deficiency and locally significant copper and sulphur deficiency reducing forage quality;
- low digestibility of *Pennisetum polystachion* and other native pastures;
- low legume content of most pastures;
- lack of locally produced seed and vegetative planting material;
- uncontrolled fire dramatically reducing dry season dry matter on offer to grazing animals and threatening young tree survival; and
- inadequate use of protein and energy supplements during the May–November dry season.

Crop residues and agro-industrial by-products

Quantities available are available and although presently underutilized could play a larger role in the future. Aregheore (2001) has provided details of the technical composition of materials available and reports on trials on use in goat feeding trials.

Rokomatu (2001) has detailed some of the constraints to feed production in Fiji, particularly the dairy industry.

6. OPPORTUNITIES FOR IMPROVEMENT OF PASTURE RESOURCES

The key to expanding pasture carrying capacity rests largely in rehabilitating and improving of existing grazing – intensifying production within sustainable limits, in both open and under-coconut situations.

Mixed grazing of cattle and small ruminants has some potential for expanding production from native pastures while reducing fire hazard for young trees.

Native pasture resources under 2 000 mm rainfall can be improved cost effectively by incorporating adapted legumes. Sowing inoculated seed of *Stylosanthes scabra* (Seca, Siran), and *S. hamata* (Verano and Amiga) into ash of recently burnt *Pennisetum polystachion* grassland is a sound technique but not widely used. Large areas could be covered easily and cheaply by teams on horseback. Legume overseeding, if complemented by incorporating adapted grasses such as *Brachiaria humidicola* (involving 15–20 person days/ha) can increase carrying capacity from 0.3–0.5 to 1.2–2 animal units/ha depending on rainfall (1 500 mm–2 500 mm) and soil moisture deficits. Native pastures in the over 2 000 mm rainfall areas can be improved by introducing legumes such as *Desmodium heterophyllum*, *Arachis pintoii*, and Glenn and Lee cultivars of *Aeschynomone americana*.

Better grazing management, more legumes in all-grass swards and strategic use of herbicide; slashing and manual weeding would reduce weeds. Many pastures have 30–50% weeds; this reduces carrying capacity accordingly. Strategies for rehabilitating weedy pastures vary depending on the degree of infestation. For serious infestations the most cost-effective technique in seasonally dry areas is a hot burn combined with pasture improvement. In other situations the establishment of smothering legumes such as siratro (*Macroptilium atropurpureum*) can smother undesirable weeds like *Sida*. Careful management of the *Samanea saman* (rain tree) so that it does not become too tall or become a weed is important. In any pasture improvement, other than for trees, a wide range of legumes should be sown to allow for variations within paddocks and seasonality in production patterns. The legumes previously mentioned need further evaluation under grazing in the major production areas.

Greater use should be made of tree legumes and shrubs, especially in the dry season (Singh, 2001), including *Leucaena leucocephala*, *Gliricidia maculata*, *Erythrina* species (drala) and *Calliandra calothyrsus*.

Encouraging proven small and large farms to grow selected legume seed would improve the reliability of seed supply. Support for establishing smallholder-based forage nurseries for planting material would assist farmers in their improvement programmes.

Better forage-livestock integration into cropping systems would increase overall productivity. The use of stylos, *Arachis pintoii* and *Desmodium heterophyllum* on bunds would improve the nutrition of draught animals. Legume fallow after intensive crop production would assist soil nitrogen regeneration, improve weed control and increase the fodder supply.

Requirements for maintaining critical levels of soil nutrients need to be more clearly established so that sustainable high productivity can be maintained in areas where farmers can market their product readily. Extension should encourage farmers in areas that require minimal inputs to sustain acceptable levels of pasture productivity.

7. RESEARCH AND DEVELOPMENT ORGANIZATIONS AND PERSONNEL

The majority of research and development on pasture, and improved animal feeding is undertaken by the Animal Health and Production Division and is centred around Sigatoka Research Station (1 800 mm) in the Western District and Koronivia Research Station (3 000 mm) in the Central District. The Principal Research Officer, Mr Shiu Chand is at Sigatoka (Mr. Shiu Chand, Senior Research Officer (Pastures), Sigatoka Research Station, P.O. Box 24, Sigatoka, Fiji).

Brachiaria humidicola pasture programmes have focused on dairy production and responses to energy supplementation and have been directed by Mr Tomasi Tunabuna (Research Officer (Pastures), Koronivia Research Station, Ministry of Agriculture and Fisheries, Fiji). Nawaicoba Research Station is the centre-point for work on sheep. These programmes are directed by Principal Animal Production Officer, Mr Peter Manuelli (Principal Animal Production Officer, Animal Health and Production Division, MAFF, Vatuwaqa, Suva, Fiji). Other contacts include: Ms. Alma Vuniwaqa, Research Officer

(Dairy), Koronivia Research Station, Ministry of Agriculture and Fisheries, Fiji; Mr. Philip Alifereti, Senior Agricultural Officer (Beef), Ministry of Agriculture and Fisheries, Fiji).

Fiji College of Agriculture incorporates pasture management, animal feeding demonstrations and applied research output into its teaching under the direction of Mr Rattan Singh.

Rewa Dairy Cooperative provides advisory support and sells key inputs to dairy farmers.

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[It was edited by J. M. Suttie and S.G. Reynolds in 1999/2000 and slightly modified by S.G. Reynolds in October 2005, June 2008 and January 2009.].