

**FINAL REPORT FOR FIJI'S UNITED STATES  
COUNTRY STUDIES CLIMATE CHANGE PROGRAM**

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## **Introduction**

This is the final overview and report of the US Country Studies Program in Fiji which comes under the Climate Change Program. Even though we have promised to submit all of the Reports as at between the mid September 15-20<sup>th</sup> 1997, there were two major projects that have really gone out of our control to submit in time, namely the Greenhouse gas inventory and the Ovalau Integrated Resource Management which is due to some unforeseen circumstances, we were not able to disclose them on time. However we are very confident that the two reports will be submitted toward the end of this month ( GHG Inventory ) and ( OIRMP ) toward the first week of next month October, 1997.

Included in this report are all of the final versions of the draft report forms that were sent earlier this year in April,1997. They are as follows; Vulnerability and Adaptation Assessment of Suva Peninsular Area, A Review of the Types of Coastal Protection Structures Used in Fiji Today with a Comment on their Effectiveness, Oral Literature Survey of Ovalau Island, Land Capability and Classification Study of Ovalau Island and The Coral Reef Survey of Ovalau Island.

However I have also included in this summary the final overview of the Greenhouse Inventory and the Ovalau Integrated Resource Management Plan.

## The Greenhouse Gas Inventory

This Greenhouse Gas Inventory for 1991 was developed from 1995 to 1997. Several factors caused delays in the process of developing this inventory. One of the major causes was the difficulty of obtaining information from other government organisations and the private sector. It is recommended for the development of future inventories that a Cabinet Memorandum will first be prepared to formally arrange for the assistance of other government organisations and that subsequently a working group is set up involving the major organisations that need to provide information. Important for that working group will be that the key government officials and private sector contact persons, actual involved in data collection (like the ones mentioned in the references and the source documents) will be members.

This inventory describes in detail which assumptions were made, which should facilitate the development of any future inventories.

Uncertainty estimates have been roughly estimated and for that reason shouldn't be taken too seriously. The authors have included these estimates because they believe that the estimates nevertheless provide useful information.

Different greenhouse gases contribute differently to global warming. Scientist have estimated the relative contribution of greenhouse gases to global warming by estimating the Global Warming Potential (GWP). The concept of GWP has been developed to allow scientists and policy makers to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. The GWP of a greenhouse gas is the ratio of global warming from one kilogram of a greenhouse gas to one kilogram of carbon dioxide over a period of time. While any time period can be selected, the 100-year GWP's are recommended by the Intergovernmental Panel on Climate Change (IPCC). GWP's are available for the gases described in table 1 as provided in the source document "Steps in Preparing Climate Change Action Plans: A Handbook".

Table 1: Global Warming Potential (GWP) for different greenhouse gases over a 100 year time period.

Gas	GWP (100 Years)
Carbon dioxide (CO <sub>2</sub> )	1
Methane (CH <sub>4</sub> )	24.5
Nitrous oxide (N <sub>2</sub> O)	320

A summary of the results of this Greenhouse Gas Inventory is provided in table 2.

Table 2: Summary of the results of this Greenhouse Gas Inventory.

Greenhouse Gas Source and Sink Categories	CO <sub>2</sub> Emissions (Gg)	CO <sub>2</sub> Emissions x GWP	CH <sub>4</sub> Emissions (Gg)	CH <sub>4</sub> Emissions x GWP	N <sub>2</sub> O Emissions (Gg)	N <sub>2</sub> O Emissions x GWP	NO <sub>x</sub>	CO
<b>Energy</b>								
Fuel Combustion	779	<b>779</b>	NE	NE	NE	NE	NE	NE
Traditional Biomass Burned for Energy	(1295)	(1295)	2.8	<b>69</b>	0.041	13	1.5	39
Fugitive Emissions from Fuels	NO	NO	0.039	0.94	NO	NO	NO	NO
<b>Industrial Processes</b>	35	35	NE	NE	NE	NE	NE	NE
<b>Solvent and Other Product use</b>	NE	NE	NE	NE	NE	NE	NE	NE
<b>Agriculture</b>								
Enteric Fermentation	NE	NE	14	<b>354</b>	NE	NE	NE	NE
Manure Management	NE	NE	2.3	56	NE	NE	NE	NE
Rice Cultivati	NE	NE	1.1	26	NE	NE	NE	NE

on								
Agricultural Soils	NE	NE	NE	NE	NE	NE	NE	NE
Prescribed Burning of Savannas	NE	NE	NE	NE	NE	NE	NE	NE
Field Burning of Agricultural Residues	NE	NE	2.8	<b>68</b>	0.069	22	2.5	58
Other	NE	NE	NE	NE	NE	NE	NE	NE
<b>Land Use Change and Forestry</b>								
Changes in Forest and Other Woody Biomass Stocks	-507	-507	NE	NE	NE	NE	NE	NE

Greenhouse Gas Source and Sink Categories (continued)	CO <sub>2</sub> Emissions (Gg)	<b>CO<sub>2</sub> Emissions x GWP</b>	CH <sub>4</sub> Emissions (Gg)	<b>CH<sub>4</sub> Emissions x GWP</b>	N <sub>2</sub> O Emissions (Gg)	<b>N<sub>2</sub>O Emissions x GWP</b>	NO <sub>x</sub>	CO
Forest and Grassland Conversion	1350	1350	1.81	44.3	0.0124	3.97	0.449	15.8

Abandonment of Managed Lands	NE	NE	NE	NE	NE	NE	NE	NE
Other	NE	NE	NE	NE	NE	NE	NE	NE
<b>Waste</b>								
Solid Waste Disposal on Land	NE	NE	6.6	<b>160</b>	NE	NE	NE	NE
Wastewater Treatment	NE	NE	0.037	0.91	NE	NE	NE	NE
Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE
Other Waste	NE	NE	NE	NE	NE	NE	NE	NE
<b>Other</b>	NE	NE	NE	NE	NE	NE	NE	NE

NE: see explanation of abbreviations

With the use of these GWP's the major (estimated) sources of greenhouse gases in Fiji have been determined (see table 2). The sources are in order of decreasing importance:

- 1) CO<sub>2</sub> emissions because of Forest and Grassland Conversion,
- 2) CO<sub>2</sub> emissions because of Fuel Combustion,
- 3) Methane emissions because of Enteric Fermentation,
- 4) Methane emissions because of Solid Waste Disposal on Land,
- 5) Methane emissions because of Traditional Biomass Burned for Energy (off site burning of wood and bagasse),
- 6) Methane emissions because of Field Burning of Agricultural Residues (on site burning of sugarcane and other plant material),
- 7) Methane emissions because of Manure Management,
- 8) Methane emissions because of Forest and Grassland Conversion (on site burning of wood).

Note that the CO<sub>2</sub> emission from Traditional Biomass Burned for Energy, is not a real net emission. CO<sub>2</sub> produced because of Traditional Biomass Burned for Energy is recaptured again by plants (like sugarcane) and trees. For example growing sugarcane on 1 ha of land will involve a sink of X CO<sub>2</sub>. Sugarcane plants will produce organic matter by using sunlight, CO<sub>2</sub>, water and nutrients. The same amount of X CO<sub>2</sub> will be emitted again when the sugarcane is burned (e.g. as a fuel by the Fiji Sugar Cooperation), decomposed (e.g. decomposing of agricultural residues) and digested (e.g. by humans eating sugar).

Because of the use of biomass to produce energy, Fiji uses relatively little fossil fuels. Note that this activity, Traditional Biomass Burned for Energy, is on the other hand one of the five major sources of greenhouse gases in Fiji because of methane emissions.

Note that the CO<sub>2</sub> emission for Changes in Forest and Other Woody Biomass Stocks is negative. This means that this is not a source of CO<sub>2</sub> but a sink. Because of replanting activities in Fiji, CO<sub>2</sub> from the air is absorbed by new growing trees.

Fiji's contribution to the Global Net Anthropogenic Sources of CO<sub>2</sub> is shown in table 3. It has been assumed that the Net Anthropogenic Sources of CO<sub>2</sub> in Fiji in 1991 do not differ a lot from the sources in Fiji in 1989/90.

Table 3: Fiji's Contribution to the Global Net Anthropogenic Sources of CO<sub>2</sub>

<b>Net Anthropogenic Sources</b>	<b>CO<sub>2</sub> Emissions (Gg CO<sub>2</sub> per year)</b>	<b>Population</b>	<b>CO<sub>2</sub> Emissions per person per year (tonnes CO<sub>2</sub>/person/yr)</b>
<b>World 1989/90</b> (Fossil Fuel Combustion, Gas Flaring and Cement)	<b>22,000,000</b> (range 20,000,000 - 24,000,000)	<b>5,100,000,000</b>	<b>4.3</b> (range 3.9 - 4.7)
<b>Fiji 1991</b> (Fossil Fuel Combustion, Gas Flaring and Cement)	<b>810</b> (range 650 - 970)	<b>744,000</b>	<b>1.1</b> (range 0.9 - 1.3)
<b>World 1989/90</b> Land Use Change and Deforestation	<b>5,900,000</b> (range 2,200,000 - 9,600,000)	<b>5,100,000,000</b>	<b>1.2</b> (range 0.4 - 1.9)
<b>Fiji 1991</b> Land Use Change and Deforestation	<b>840</b> (range 400 - 2000)	<b>744,000</b>	<b>1.1</b> (range 0.5 - 2.7)
<b>World 1989/90 total of both</b>	<b>28,000,000</b> (range +/- 5,500,000)	<b>5,100,000,000</b>	<b>5.5</b> (range +/- 1.1)
<b>Fiji 1991 total of both</b>	<b>1620</b> (range 1210 - 2970)	<b>744,000</b>	<b>2.2</b> (range 1.6- 4.0)

Table 3 shows that the average Fijian citizen is producing less Carbon Dioxide than the average global citizen because of "fossil fuel use, gas flaring activities and cement production". The authors assume that Fiji is doing well in this area because of its use of alternative energy sources like wood, bagasse and hydropower. Electricity generation by hydropower accounted for 382,960 MWh in 1991, which was 83% of the total electricity generation (462,599 MWh) in 1991.

Furthermore the table shows that the average Fijian citizen is producing about the same amount of Carbon Dioxide as the average global citizen because of land use change and deforestation activities. However the data processed in this inventory are not based on the most recent information on forest cover but are based on information from logging licences which might be inaccurate. The real Carbon Dioxide emissions citizen because of land use change and deforestation activities per Fijian citizen might be higher than for the global citizen.

Looking at the emission of the combined anthropogenic sources (fossil fuel use, gas flaring activities and cement production and land use change and deforestation), than it appears that the average Fijian citizen is producing less CO<sub>2</sub> than the average global citizen. However this conclusion might not be correct because of the uncertainty involved in the Land Use Change and Deforestation estimations for the world and for Fiji.

The overall conclusion is therefore that the following activities would reduce greenhouse gas emissions in Fiji most effectively:

- 1) to reduce deforestation by continuing the replanting efforts but also by establishing conservation areas to protect natural forests and by providing people living in rural areas with alternative sources of income to prevent clearing of forests (for agricultural activities or for direct income from logging);
- 2) to maintain Fiji's good performance on energy use by promoting alternative energy uses like hydropower and wood to energy initiatives and to promote energy saving measures;
- 3) to reduce methane emissions because of Solid Waste Disposal on Land by setting up landfill sites in Fiji provided with landfill gas collection systems and by burning this gas;
- 4) to promote that crop residues and residues from forest clearing are not burned on site.

Whether these activities should also have the highest priority is another issue. Other factors should be looked at to see which activities should receive the highest priority in addressing greenhouse gas emissions in Fiji like:

- whether certain activities are feasible economically (can the people of Fiji afford it);
- whether certain activities are feasible socio-economically (like can landowners be asked to stop with clearing forest areas for agricultural purposes when the population is growing);
- whether certain activities are feasible technically (like is burning of agricultural residues necessary from the viewpoint of pest control).

On the other hand, Fiji is a country that is likely more vulnerable to climate change than other countries in the world. A sea level rise for example could destroy islands in the Lau group and other atoll islands in Fiji. A climate change could also result in more cyclones. For that reason any reduction of greenhouse gas emissions in Fiji, no matter how small, could have a political impact on the international community. From that point of view any measure to reduce greenhouse gas emissions could be pursued.

Other sources of greenhouse gases, than the ones estimated, do occur in Fiji but have not been estimated. The other sources of greenhouse gases that the authors are aware of include emissions from:

- other industrial processes than cement manufacturing,
- solvent and other product use,
- agricultural soils,
- burning of grassland,
- abandonment of managed lands,
- sources from coral reef degradation (other than coral sand used by the cement factory),
- and burning of waste.

It is recommended that in the future more data are developed on activities in relation to burning of grassland, abandonment of managed lands, and sources of greenhouse gases from coral reef degradation (other than coral sand used by the cement factory) and burning of waste to estimate the relevance of these sources for Fiji compared to the main sources of greenhouse gases already known.

Furthermore for the greenhouse gas sources for which the authors provided estimations, Methane (CH<sub>4</sub>), Nitrous Oxide (N<sub>2</sub>O), Nitrogen Oxides (NO<sub>x</sub>) and Carbon Monoxide (CO) were not always estimated and many other greenhouse gases like Non-Methane Volatile Organic Compound (NMVOC's) have never been estimated.

For most of these source no estimation methods have been provided by the IPCC Guidelines, for others no data were available in Fiji (like burning of grassland and abandonment of managed lands).

Ozone Depleting Substances (like chlorofluorocarbons, hydrochlorofluorocarbons, halons, methyl chloroform and carbon tetrachloride) were not included in this inventory but were estimated and reported in 1993 because of Fiji's obligations under the Montreal Protocol. Table 1 shows the results from that inventory (Fiji Country Programme).

Table 1: Consumption of Ozone Depleting Substances in Fiji in 1991

Ozone Depleting Substances	1991 consumption in tonnes
CFC 11	<b>12.237</b>
CFC 12	<b>28.130</b>
CFC 115	<b>2.920</b>
Total CFC's	<b>43.287</b>
Halon 1211	<b>1.226</b>
Carbon tetrachloride	<b>0.203</b>
Methyl chloroform	<b>6.038</b>

## EXPLANATION OF ABBREVIATIONS

The following abbreviations have regularly been used in the text.

Notation key for tables:

IE:	Estimated but included elsewhere
NA:	Not applicable
NE:	Not estimated
NO:	Not occurring
UK:	Unknown

Chemicals

CO <sub>2</sub> :	Carbon Dioxide
CH <sub>4</sub> :	Methane
N <sub>2</sub> O:	Nitrous Oxide
NO <sub>x</sub> :	Nitrogen Oxides
CO:	Carbon Monoxide
NM VOC:	Non-Methane Volatile Organic Compound
HFCs:	Hydrofluorocarbons
PFCs:	Perfluorocarbons
SFs:	Sulphur Hexafluoride
CFCs:	Chlorofluorocarbons
CF <sub>4</sub> :	Sulphur Hexafluoride
C <sub>2</sub> F <sub>6</sub> :	Hexafluoroethane

Others:

IPCC:	The Intergovernmental Panel on Climate Change
GWP:	Global Warming Potential

## **1. Energy**

### **1.1 CO<sub>2</sub> From Energy: Reference Approach**

Differences from IPCC source/sink category structure:

None.

Differences from IPCC default methods for the estimation of greenhouse gases:

None.

Estimation methods, major assumptions and verification:

*Worksheet 1-1 CO<sub>2</sub> From Energy: Reference Approach*

Production, Imports, Exports, International Bunkers and Stock Change were derived from Table 53 and Table 1, 2 and 3 of the Energy Statistics Yearbook 1992.

The results are shown in Worksheet 1-1, sheet 1 of 5. All the relevant pages from the Energy Statistics Yearbook 1992 are provided in the appendices (source documents).

In general data from Table 53 were used. The data in Table 53 are not provided in kg or litres but in Terajoules and therefore the data in Worksheet 1-1, sheet 1 of 5 (column A, B,

C, D, E and F) are provided most of the time in Terajoules. The same is applicable for Worksheet 1-1, sheet 4 of 5 (column A).

The conversion factors that were used in the Energy Statistics Yearbook are mentioned on page 51 of this Yearbook. These are not the same as the proposed IPCC default values but we believe that the conversion factors from the Energy Statistics Yearbook 1992 are more appropriate.

The data from Table 53 were verified with Table 1, and 3 and Table 52. In general the information is consistent. It appears that Re-export in Table 2 equals Re-export plus Bunkers in Table 52. It appears in general that Retained Imports (Table 3) equals Domestic Requirements (Table 52).

However it appears that Retained Imports for Aviation Spirit in Table 3 (1,176,754 l) doesn't equal Domestic Requirements for Avgas in Table 52 (1,082,000 l). There is a difference of 94,754 l between these two figures (which is about 9 %).

The same is found for Automotive Distillate. Automotive Distillate in Table 3 (120,600,801 l) doesn't equal the figure in Table 52 (122,231,000 l). There is a difference of 1,630,199 l (which is about 1 %).

It is not clear which table (Table 3 or Table 52) gives the right values. However, because of these differences the uncertainty of the data is higher. Table 52 is used to provide data for the inventory.

If Table 3 had been used than the estimate of the Total Actual CO<sub>2</sub> Emission for Liquid Fossil Fuels would have been 0.03% larger because of the error in relation to Avgas and would have been 0.4% smaller because of the error in relation to the Automotive Distillate. These changes are negligible in relation to the estimated uncertainty.

Attempts have been made to check this information from source data. These attempts have been unfruitful so far. The Customs Department have lost the 1991 data from their computer database. They are still trying to resolve this problem. If in the future this data would become available, then the inventory will be updated.

Page 51 of the Energy Statistics Yearbook 1992, shows the Conversion Factor used to calculate the units of Table 52 (t or kl) into the units of Table 53 (Terajoules). The Conversion Factor is given in Terajoules per 1000 metric tons. One metric tons is assumed to be one megagram. This assumption appears to be correct for Coal and for Greases and is therefore used. The other fuels are in kilo litres. The relative density (kilogram per litre) estimates of these fuels are not specifically mentioned in the Energy Statistics Yearbook 1992. The National and Regional Energy Supply/Demand Database (see appendices) provides these relative density data but apparently these values have not been used for the Energy Statistics Yearbook 1992. It is the assumption of the authors that the relative density data used for the Energy Statistics Yearbook 1992 are the most appropriate.

The Conversion Factors (Terajoules / 1000 metric tons) that are used for the Energy Statistics Yearbook 1992 (page 51) are shown below. According to Ravindra Deo of the Energy Department these Conversion Factors are Net Caloric Values.

The following conversion factors were used in the Energy Statistics Yearbook 1992:

FUEL TYPE	Conversion Factor (TJ/1000tonnes)
Gasoline	43.95
Jet Kerosene	43.20
Other Kerosene	43.20
Gas/Diesel Oil	42.49
Residual Fuel Oil	41.48
LPG	45.40
Bitumen	40.19
Lubricants	41.44
Other Oil	43.95
Other Bituminous Coal	29.73
Fuel Wood	17.70
Bagasse	9.70

Because of the difficulties with the Customs database it is unclear what kind of solid fossil fuels have been imported in 1991. However we have these kind of data from Customs for the year 1996. This information mentions that two kinds of solid fossil fuels were imported in 1996: “coal; briquettes, ovoids and similar solid fuels manufactured from coal” (item number 2701.00.00 Customs tariff classification system) and “Peat (including peat litter), whether or not agglomerated” (item number 2703.00.0000 Customs tariff classification system).

The authors assume that no other solid fossil fuels were imported into Fiji in 1991 than these two. The total “coal” import is known from the Energy Statistics Yearbook 1992. How much of this total is “coal; briquettes, ovoids and similar solid fuels manufactured from coal” and how much is “Peat (including peat litter), whether or not agglomerated” is unknown.

It has been assumed that “Coal; briquettes, ovoids and similar solid fuels manufactured from coal” can be classified as “Other Bituminous Coal” from the IPCC guidelines. The letter from Fiji Industries (the cement factory) dated April 9, 1996 contains an estimation of the amount of CO<sub>2</sub> produced because of combustion of the type of coal that is used by the cement factory. This estimation suggest that this type of coal has a carbon emission factor of 23.9 tonnes C/TJ. Because of the low carbon emission factor we assume that this type of coal can be classified under “Other Bituminous Coal”.

It is not known whether the information provided by the cement factory is reliable and takes into account issues like “Fraction of Carbon Oxidised”. Volume 3 of the IPCC Guidelines doesn't mention carbon emission factors for coal which comes near to 23.9 tonnes C/TJ. For

that reason the default value for the Fraction of Carbon Oxidised provided by the IPCC Guidelines of 25.8 tonnes C/TJ has been used in the calculations.

“Coal; briquettes, ovoids and similar solid fuels manufactured from coal” is used in Fiji by the Cement Factory which uses significantly more solid fossil fuels than any other importer in Fiji (about 97% of the volume in 1996). The amount of “Peat (including peat litter), whether or not agglomerated” is insignificant compared to the amount of “Coal; briquettes, ovoids and similar solid fuels manufactured from coal” imported in 1996. Therefore the authors have included “Peat (including peat litter), whether or not agglomerated” under Other Bituminous Coal because these amounts were likely insignificant in 1991 as well and would only cause a small bias in the outcome (because of a small difference in the default figures for the Carbon Emission Factors).

According to the Energy Statistics Yearbook 1992, the retained imports for coal were 6,009 tonnes. According to the information we received by Fiji Industries Ltd. they used 17,579 tonnes of coal. This figure seems realistic looking at the figures of coal imported in other years than 1991. The authors assume that the information provided from this industry is more accurate. The figure from Fiji Industries Ltd. is in accordance with Table 52 which shows that Final Consumption is estimated as 19,212 tonnes. According to the same table the Stock Change would account for 3,189 tonnes. The authors assume that the stock change has been estimated wrongly and that the real Apparent Consumption was 19,212 tonnes of coal which would be 571 Terajoules.

The authors assume that import or production of Crude Oil, Natural Gas Liquids, Ethane, Naphtha, Petroleum Coke, Refinery Feedstocks, Natural Gas does not occur in Fiji. This assumption is based on the Energy Statistics Yearbook 1992.

The data from Energy Statistics Yearbook 1992 were gathered from the Bureau of Statistics which was supplied by Fiji Customs. Fiji Customs Department gathered these data from three existing Oil Companies in Fiji (Shell, BP and Mobil Oil). Because of the many links involved in this chain, errors might have occurred. However it was not possible to verify these data because of the difficulties with the Customs database.

It was verified with Mr. Ravindra Deo of the Energy Department that Re-export (Table 52, Energy Statistics Yearbook 1992) is Export (as defined under the IPCC Guidelines) and Bunkers (Table 52, Energy Statistics Yearbook 1992) is International Bunkers (IPCC Guidelines).

It is assumed that the Stock Change of all fuels except for Coal is zero. Mr. Ravindra Deo of the Energy Department agreed with this assumption. The Final Consumption compared to the Domestic Requirements in Table 52 varies great for certain fuels. This could have been caused by the relatively high uncertainty of the estimate of the Final Consumption or by a Stock Change of these fuels.

The uncertainty on the occurrence of “Stock Change” makes the estimate of the CO<sub>2</sub> Emission by combustion of fuels more uncertain. This is further described under “uncertainty estimates”.

Bitumen are not mentioned in Table 52 and 53. Therefore these figures were derived from Table 1, 2 and 3. The default value for the Conversion Factor from the IPCC Guidelines (40.19 TJ/1000 tonnes) was used.

Table 28 of the Yearbook provides an estimate for International Bunkers and Apparent Consumption for Aviation Turbine Fuel and Aviation Gasoline. This estimate however seems to be highly uncertain. The use of Regional Aviation Turbine Fuel according to this Table is 137,573,000 litre and the Domestic use is 3,551,000 litre. The Import of this fuel in 1991 however was only 56,237,000 litre. It seems highly uncertain that this fuel use was caused by a Stock Change. It seems more likely that this figure describes the fuel use for other parts of the Pacific region. For that reason figures from Table 28 were not used.

The data provided in the Energy Statistics Yearbook 1992 were categorised in other definitions than mentioned in the IPCC Guidelines. The definitions were partly explained by Mr. Ravindra Deo of the Department of Energy. The classification of fuels that have been used by the authors is described below.

<u>Energy Statistics Yearbook 1992, Table 1, 2, 3</u>	<u>IPCC Guidelines</u>
Coal, Coke, Briquettes	Other Bituminous Coal and Peat
Motor Spirit + Aviation Spirit	Gasoline
Other Petroleum Spirit + Mineral Turpentine	Other Oil
Kerosene	Other Kerosene
Aviation Turbine Fuel	Jet Kerosene
Automotive Distillate + Industrial Distillate	Gas/Diesel Oil
Residual Fuel Oil	Residual Fuel Oil
Lubricating Oil + Greases	Lubricants
Mineral Jelly + Other Bituminous Mixtures	Bitumen
Gas, Natural and Manufactured	LPG
<u>Energy Statistics Yearbook 1992, Table 52, 53</u>	<u>IPCC Guidelines</u>

Coal	Other Bituminous Coal and Peat
Motor Spirit + Avgas	Gasoline
Solvents	Other Oil
Kerosene	Other Kerosene
A.T.F. (Aviation Turbine Fuel)	Jet Kerosene
Diesel	Gas/Diesel Oil
Residual Fuel Oil	Residual Fuel Oil
Lubricants + Greases	Lubricants
L.P.G.	LPG

It was agreed with Mr. Ravindra Deo of the Department of Energy that the Domestic Requirement for solvents is wrongly presented in Table 53. It should be 111 Terajoules.

For determining the figures in column I, J, K, L, M, N, O, P of Worksheet 1-1 the default values from the IPCC Guidelines were used.

According to Mr. Ravindra Deo of the Department of Energy there is no domestic production of bitumen and lubricants.

The default value for the Fraction of Carbon Oxidised for LPG has been derived from the IPCC Guidelines (Volume 2, Table 1-4, page 1.8). This table mentions for gas a value of 0.995.

*Auxiliary Worksheet 1-1: Estimating Carbon Stored in Products*

The data in Table 53 are not provided in kg or litres but in Terajoules and therefore the data in Auxiliary Worksheet 1-1 Estimating Carbon Stored in Products (column A) are provided in Terajoules.

LPG and Gas/Diesel Oil is assumed not to be used as feedstock for non-energy purposes. This assumption was confirmed by the Department of Energy. There is no ammonia production out of natural gas, no use of LPG to produce solvents and synthetic rubber and no production of plastics, rubber, bitumen, formaldehyde, silicon carbide, tires and fabrics. Plastics are only produced in Fiji by melting plastic granules. There is also no production of coke out of coking coal.

Solid biomass apparent consumption was derived from Worksheet 1-2 Optional Fuelwood Consumption Accounting. Total Wood Consumption is 296.909 kt dm (which includes copra use but excludes bagasse). Total Bagasse Consumption is 883.853 kt dm. Conversion Factors were derived from the Energy Statistics Yearbook 1992 page 51. The default values from the IPCC Guidelines were used to calculate the Actual CO<sub>2</sub> Emission.

#### Uncertainty estimates

Table 53 of the Energy Statistics Yearbook 1992 shows that the Total Domestic Requirement (Production + Imports - Re-exports - Bunkers + Stock change) is 24963 Terajoules while the Statistical Difference (Domestic requirement - Electricity Input - Final consumption) is 1330 (about 5 % of the Total Domestic Requirement).

The Statistical Difference could have been caused by the relatively high uncertainty of the estimate of the Final Consumption or by a Stock Change of these fuels. A pessimistic assumption would be that the Statistical Difference would have been caused for 100% by Stock Changes. In such a case the estimated extra uncertainty of the total fossil fuel use would be 5 %.

A pessimistic estimation of the uncertainty of the actual CO<sub>2</sub> emission because of fossil fuel combustion would be 20%.

## **1.2 Greenhouse Gas Emissions from Burning Traditional Biomass Fuels**

#### Differences from IPCC source/sink category structure:

None.

#### Differences from IPCC default methods for the estimation of greenhouse gases:

None.

#### Estimation methods, major assumptions and verification:

##### *Worksheet 1-2 Optional Fuelwood Consumption Accounting*

Figures to enter in Worksheet 1-2 Optional Fuelwood Consumption Accounting were most of the time derived from Table 16 and 26 from the Energy Statistics Yearbook 1992.

Not only fuelwood was used as “Traditional Biomass Burned for Energy” but also Copra (for rural cooking purposes) and Bagasse in the Sugar Industry. Copra has been included under this table because the authors believe that it is a woody substance. Bagasse has not been included under this table but has been included under Worksheet 1-3 Traditional Biomass Burned for Energy.

Fuelwood is also used in tropic wood pine processing (Tropic Woods, Lautoka). Data are available from the publication "Department of Energy audit of Tropic Wood Industries Limited". According to this publication the current fuelwood consumption is 40,000 T/yr. This has not been mentioned in the Energy Statistics Yearbook 1992 but should have been

mentioned in this Yearbook as was verified with Mr. Ravindra Deo. According to Ravindra Deo, other industries in Fiji don't use fuelwood.

Fuelwood is also used by the Fiji Sugar Cooperation (FSC). The Fiji Sugar Corporation uses (apart from bagasse, 883,853 t) 1,017 tonnes of fuelwood as mentioned in Table 26 (Energy Statistics Yearbook 1992).

In former reports from the authors it was mentioned that calculation errors occurred in Table 16 of the Energy Statistics Yearbook 1992. This interpretation was wrong. The data in Table 16 are actually correct.

No Charcoal made out of wood is produced in Fiji according to Ravindra Deo, Department of Energy. Furthermore charcoal consumption is not mentioned in the Energy Statistics Yearbook 1992. However the Annual Report for the Year 1991 of the Forestry Department mentions that charcoal is produced in Fiji (1,800 kg in 1991). This amount is insignificant compared to other wood consumption and is therefore ignored.

There are no local data on the Fraction Carbon Oxidized, Carbon Content and other ratio's available in Fiji. Therefore the average default values are used.

It is assumed that the default values for Copra equal the default values for Fuelwood.

In former reports made by the authors the aspect of moisture content of the biomass was not taken into account. The information on this issue is presented in the following table.

Table 4: Available data on wood consumption

Type of fuel	Per Capita Annual Consumption (kt/1000 persons)	Total Annual Consumption (kt)	Moisture content	Total Annual Consumption (kt dm) (assumption wet basis)	Caloric value (Tjoules/kt)
Fuelwood urban	<b>0.087</b>	<b>25.414</b>	<b>10%</b>	<b>22.8726</b>	<b>17.70 (10%)</b>
Fuelwood rural	<b>0.35337</b>	<b>161.451</b>	<b>10%</b>	<b>145.3059</b>	<b>17.70 (10%)</b>
Copra rural	<b>0.15098</b>	<b>68.998</b>	<b>10%</b>	<b>62.0982</b>	<b>17.70 (10%)</b>
FSC	<b>NA</b>	<b>1.017</b>	<b>55%</b>	<b>0.45765</b>	<b>17.70 (10%)</b>
Tropic Woods	<b>NA</b>	<b>40</b>	<b>55-60% (wet basis)</b>	<b>16 - 18</b>	<b>bark: 21 sawdust: ?</b>
Bagasse	<b>NA</b>	<b>883.853</b>	<b>48%</b>	<b>459.60356</b>	<b>9.70</b>

The following remarks need to be made:

- the authors assume that the information on urban and rural fuelwood and copra use involves this moisture content because this is mentioned on page 51 of the Energy Statistics Yearbook 1992;
- the authors assume that the information on FSC fuelwood use involves this moisture content (of 55%) because this is mentioned in table 26 on page 44 of the Energy Statistics Yearbook 1992; looking at the figures from table 26 (according to source moisture content of 55%) in relation to the figures of tables 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52 and 54 (which should also be wood with a moisture content of 10%), than it seems that a actually moisture content of 57.3625% has been used. It is unclear to the authors why 57.3625% has been used and not 55%. The authors assume that 55% is more correct.
- the authors assume that the information on Tropic Woods fuelwood use involves these moisture contents because this is mentioned under paragraph 3.8 of the literature on Tropic Woods;
- in the literature on Tropic Woods it is mentioned that the moisture content is on a wet basis (moisture content on a wet basis = wet content / (wet content + dry content)), for the other sources it is unknown whether the moisture content is on a wet or dry basis (moisture content on a dry basis = wet content / dry content); it has been assumed that all information on moisture contents are on a wet basis because this is the most common practice used internationally as far as the authors know;
- the authors assume that the information on urban, rural and FSC fuelwood, copra and bagasse use involves these caloric values because this is mentioned on page 51 of the Energy Statistics Yearbook 1992;
- the literature on Tropic Woods mentions under paragraph 3.8 that the caloric value of bark is 21 KJ/g (which is 21 Tjoules/kt); however the caloric value of sawdust is not provided; 87% of the wood waste Tropic Woods is bark and 13% is sawdust; the authors have assumed that the sawdust would have the same caloric value of 21 Tjoules/kt); the caloric value of 21 KJ/g is unlikely for the volume with a moisture content of 57.5 %, but likely refers to the volume of dry matter.

With the use of the above mentioned assumptions the following data have been developed which is the basis for the information used in the worksheets.

Table 5: Data on wood consumption used for the inventory

Type of fuel	Per Capita Annual Consumption (kt/1000 persons)	Total Annual Consumption (kt)	Caloric value (Tjoules/kt)	Total Annual Consumption (Tera-joules)	Moisture content (wet basis)	Per Capita Annual Consumption (kt <b>dm</b> /1000)	Total Annual Consumption (kt <b>dm</b> )

						persons)	
Fuel-wood urban	0.087	25.414	17.70	449.8278	10%	0.0783	22.8726
Fuel-wood rural	0.35337	161.451	17.70	2857.6827	10%	0.318033	145.3059
Copra rural	0.15098	68.998	17.70	1221.2646	10%	0.135882	62.0982
FSC	NA	1.017	17.70	18.0009	55%	NA	0.45765
Tropic Woods	NA	40	21	357	57.5%	NA	17
Total wood	NA	<b>296.88</b>	<b>NE</b>	<b>4903.776</b>	<b>NE</b>	<b>NA</b>	<b>247.73435</b>
Bagasse	NA	883.853	9.7	8573.3741	48%	NA	459.60356

*Worksheet 1-3 Traditional Biomass Burned for Energy*

Use of dung as a fuel does not occur or is insignificant in Fiji.

Uncertainty estimates

It is unknown to the authors how figures have been estimated (like the wood consumption per person) and uncertainty is therefore difficult to estimate. A pessimistic estimation of the uncertainty is 150%.

### 1.3 Methane Emissions from Coal Mining and Handling Activities

This activity doesn't occur in Fiji according to the Energy Statistics Yearbook 1992, Department of Energy and Mr. Ravindra Deo Department of Energy.

### 1.4 Fugitive Methane Emissions from Oil and Natural Gas Activities

Differences from IPCC source/sink category structure:

None.

Differences from IPCC default methods for the estimation of greenhouse gases:

None.

Estimation methods, major assumptions and verification:

*Worksheet 1-5 Fugitive Methane Emissions from Oil and Gas Activities (tier 1 approach)*

Only "Other Leakage of Gas" occurs in Fiji according to the Energy Statistics Yearbook 1992, Department of Energy and Mr. Ravindra Deo Department of Energy.

According to Table 53, 365 Terajoules per year is consumed by Industries and households. According to the same table 21.14% is used by industries and 78.86% is used by

households. Therefore 0.0772 PJ is non-residential gas consumption and 0.2878 PJ is residential gas consumption.

It is assumed that the Emission Factors For Methane From Oil And Gas Activities Systems are currently maximum.

#### Uncertainty estimates

A pessimistic estimation of the uncertainty is 100%.

## **2 Industrial Processes**

### **2.1 CO<sub>2</sub> from other Industrial processes**

Production of coke, iron, steel, aluminium, ferro-alloys, fertilizers, limestone, lime, dolomite, bricks, glass, pulp and print, soda ash and CO<sub>2</sub> manufacture unlikely occurs in Fiji.

It is unknown if limestone is consumed in Fiji.

Soda ash is consumed by the Emperor Goldmine in Fiji. The Emperor Goldmining Company Ltd operates a 600,000 t/yr ore treatment plant at Vatukoula, Fiji. The Soda ash consumption is 2.70 kg/t ore which is 1620 t/yr. The emission factor is unknown, but it shows that the contribution of industrial processes to greenhouse gas production can be significant and should be estimated in future inventories. Since 1995 a new mine was opened in Vanua Levu (the Mount Kasi Mine). In the future another mine will be opened in Tuvatu. These activities could result in increasing CO<sub>2</sub> production in Fiji because of lime, limestone and soda ash use.

### **2.2 CO<sub>2</sub> from Cement Production**

#### Differences from IPCC source/sink category structure:

None.

#### Differences from IPCC default methods for the estimation of greenhouse gases:

None.

#### Estimation methods, major assumptions and verification:

##### *Worksheet 2-1 CO<sub>2</sub> From Cement Production*

According to the reference all clinker was used to produce Portland Cement. It is still unknown to us how Fiji Industries Limited collected these data. Estimates of uncertainty are therefore difficult to make.

In the letter from Fiji Industries Limited, date August 8, 1995, it is mentioned that in 1991, 69,144 tonnes of clinker and 78,878 tonnes of cement were produced.

In the letter from Fiji Industries Limited, date April 9, 1995, it is mentioned that in 1991, 95,295 tonnes of coral sand was used to produce cement and that this resulted in a CO<sub>2</sub> emission of 42,500 tonnes. The estimation of Fiji Industries is not according to the IPCC Guidelines.

We have therefore the following estimations available on CO<sub>2</sub> production:

- a) Clinker produced 69,144 tonnes x 0.5071 = 35,062.9224 tonnes CO<sub>2</sub> (IPCC Guidelines);
- b) Cement produced 78,878 tonnes x 0.4985 = 39,320.683 tonnes CO<sub>2</sub> (IPCC Guidelines);
- c) Coral sand used: 95,295 tonnes which would be 42,500 tonnes of CO<sub>2</sub> (estimated not according to IPCC Guidelines).

According to the IPCC Guidelines preferably the clinker data should be used to estimate the CO<sub>2</sub> production.

#### Uncertainty Estimates

A pessimistic estimate of uncertainty would be 20%.

### **3 Solvent and Other Product Use**

No method for calculation is provided by IPCC and therefore no estimations of emissions for this section have been provided.

### **4 Agriculture**

#### **4.1 Domestic Livestock**

##### Differences from IPCC source/sink category structure:

None.

##### Differences from IPCC default methods for the estimation of greenhouse gases:

None.

##### Estimation methods, major assumptions and verification:

We have used default values on emission factors from Asia instead of Oceania for enteric emissions from livestock because we believe that Fiji is more comparable to Asia than to countries like Australia and New Zealand (we assume that these countries determine to a large extent the default values for Oceania). 90% of livestock in Fiji do not have supplementary feed like in Australia but like Asia, substantial numbers are working beasts.

##### *Worksheet 4-1 Methane Emissions From Domestic Enteric Fermentation and Manure Management*

Camels, Lamas, Buffalos, Mules and Asses are not kept in Fiji.

*Enteric Fermentation:*

It is recommended that three-year averages for activity data are used. We don't have the three year data and therefore we only used the 1991 data.

Emission factors depend on feed intake and feed characteristics. Animal size and milk production are important determinants of emission rates for dairy cows. The authors assumed that the default figures on enteric fermentation provided for Asia were more suitable to be used in Fiji than the figures provided for Oceania.

No default values on emission factors for enteric fermentation on poultry are provided. The contribution of this emission from poultry is likely to be minor and therefore we assume that this contribution is nil.

*Manure Management:*

The principal factors affecting methane emission from animal manure are the amount of manure produced and the portion of the manure that decomposes anaerobically. The amount of manure that is produced is dependent on the amount produced per animal and the number of animals. The portion of the manure that decomposes anaerobically depends on how the manure is managed.

In Fiji most manure from livestock is handled as a solid. When manure is handled as a solid (e.g. in stacks or pits) or when it is deposited on pastures and rangelands, it tends to decompose aerobically and little or no methane is produced.

Some manure from cattle however is stored or treated as a liquid (e.g. in lagoons, ponds, tanks or pits). This manure tends to decompose anaerobically and produce a significant quantity of methane.

The livestock kept in farms where manure from that livestock was stored or treated as a liquid (e.g. in lagoons, ponds, tanks or pits) in 1991 was estimated.

Uncertainty Estimates

A pessimistic estimate of the uncertainty is 50%.

## **4.2 Rice Cultivation**

Differences from IPCC source/sink category structure:

None.

Differences from IPCC default methods for the estimation of greenhouse gases:

None.

Estimation methods, major assumptions and verification:

#### *Worksheet 4-2 Methane Emissions From Flooded Rice Fields*

The Workbook mentions that rice is cultivated in three different ways:

- continuously flooded
- dry area
- intermittently flooded

The data we have, covers only dry and continuously flooded. While intermittent flooding occurs on a small scale and the contribution is therefore negligible compared to the other rice growing activities. No data are available on the occurrence of this activity. Appropriate technology for farmers undertaking rice production on their appeared to be too costly. A few schemes were controlled and managed with subsidies by government.

Low rice yields are due to the farmers' unwillingness to spend money for fertilizers and pesticides and the uncertainty about the occurrence of rainfall. Therefore, most farmers prefer to plant traditional varieties which can be cultivated without fertilizer especially in the Central and Northern Division.

Fiji rice production has been unable to keep up with consumption and about half of the total domestic consumption has to be imported. In 1940 a public concern was raised regarding self-sufficiency in food production. The Colonial Sugar Refining Company allowed rice planting on land which was under their control. Most rice cultivation remained subsistence cropping and short term varieties were planted in rotation with sugar cane.

In the 1950s, cane farmers moved away from rice and increased their sugar acreage. Rice is mainly grown rain-fed without irrigation (dry-land) and on wetlands with the use of irrigation. In the irrigation areas the government recommended improving the rice varieties such as Utaam, Maleka, Deepak which are still grown and planted in Fiji today in about 85% of the rice growing areas.

The traditional rice varieties are grown widely and are cultivated without fertilizer. Many traditional varieties possess considerable drought tolerance and resistance against insect attacks. In spite of the low yields, farmers in upland and rainfed areas prefer to plant traditional varieties because of agronomic and economic conditions. An explanation could well be that because of the Lome Convention and the higher than world market prices for sugarcane, the farmers prefer to grow sugarcane instead of rice.

Low prices of rice on the world market made imported rice more popular and hence the imported quantities (Fiji Development Plan 8, 1980).

There are two rice planting seasons. The main season is from October to February when adequately rainfall is obtained to plant rice. During the same period there is an increased risk for cyclone attacks involving heavy rains and strong winds. Planting and harvesting dates can be affected by floods.

The rice yield potential is higher in the dry parts of Fiji, but only limited land is available there, especially in Viti Levu due to the planting of sugar cane.

Most farmers are applying low levels of technology and input because of lack of knowledge and economic reasons.

According to "Ministry of Agriculture, Fisheries & Forests, Annual report 1992" the land under cultivation for irrigated rice is 2,238 ha. According to "Ministry of Primary Industries" there are two seasons for rice cultivation in Fiji, from October to February and from June to September. So the Harvested area is 4,476 ha.

According to the IPCC guidelines however the harvested area for 1990 should be 13,000 ha x 50% = 6,500 ha.

The figures from "Ministry of Agriculture, Fisheries & Forests, Annual report 1992" are used because these are 1991 data and they are locally produced.

According to the IPCC-guidelines the default values for the Season Length for Fiji is 81 days. According to "Ministry of Primary Industries" however maturity period for improved varieties is 120 - 130 days and for traditional varieties it should be 4 - 6 months. It is assumed that the IPCC-guideline default values are more accurate because the estimates from "Ministry of Primary Industries" probably account for the full growing season, including staggered crops. The IPCC-guideline default Season Length is therefore used.

We have no local available measurements to estimate the emission factor. We therefore use the default values from the IPCC-guidelines. According to the Fiji Meteorological Service the average temperature in Fiji in 1991 was 26.8°C. The Emission Factor is therefore 5.90 kg methane/ha-days.

Rice cultivation is not a major contributor to methane production in Fiji and for that reason it doesn't seem necessary to produce a more accurate estimate. See the summary reports.

#### Uncertainty Estimates

A pessimistic estimate of the uncertainty is 200%.

### **4.3 Prescribed Burning of Savannahs**

Burning of wild grassland occurs in Fiji. The wild grassland is burned by man-made and by natural fires called bush fire. Bush fires in the Western Division of Viti Levu occur due to drought and because the dry climate. Crops aren't flourishing on the hillsides. The future of the Western Division and the dry outer islands could be one of poverty and desolation turning the western provinces into a wasteland. Hillsides have no soil left as a result from burning and exposure of the soil, which is easily dislodged, to heavy rain and wind. No detailed data were available from the National Fire Authority on the causes of the fires. It seems however that these fires are sometimes caused by land disputes, arson and uncontrolled sugar cane farm fires spreading outside the cane belt. According to Mr. Vilitati

Seru burning of grass land occurs in the west sometimes to harvest wild yam. This practice is used because it is easier to find the yam after burning the grass land.

There are no data available on this activity. It is questionable if this can be described as prescribed savannah burning. According to the IPCC-guidelines volume 3 page 4.67 savannahs exist in Africa, Latin America, Asia and Australia. However the activity causes emissions of CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>x</sub> and CO. Because of the lack of data it was not possible to make any estimations for this activity. Emissions of methane, carbon monoxide, nitrous oxide and nitrogen oxides from burning wild grassland could be significant. This was confirmed by Mr. Osea Tuinivanua and Mr. Vilitati Seru. Future inventories should try to cover this issue.

#### **4.4 Field Burning of Agricultural Residues**

Differences from IPCC source/sink category structure:

None.

Differences from IPCC default methods for the estimation of greenhouse gases:

None.

Estimation methods, major assumptions and verification:

*Worksheet 4-4 Field Burning of Agricultural Residues, Sheet 1, 2 and 3*

Data on annual production for 1991 were available for the crops rice, maize, peanuts and sugarcane. The most important crop in Fiji is sugarcane and the contribution of field burning of residues from any other crop is likely negligible. However the crop data for rice, maize and peanuts were also provided.

Annual production data were derived from the Annual Report 1991 and the Annual Report 1992 of the Ministry of Primary Industries.

Residue to Crop Ratio and Dry Matter Fractions were derived from the IPCC Guidelines. For the most important crop in Fiji, sugarcane, no data were available on the Residue / Crop Ratio or on the Dry Matter Fraction. The authors assume that sugarcane, looking at the ratio of residues produced, is mostly comparable to maize.

No data for the Dry Matter Fraction of peanuts was provided by the IPCC Guidelines. The authors believe that the dry matter fraction of maize would be most appropriate to use for peanuts.

The Fraction Burned in the Fields for rice, maize and peanuts were unknown. These crops contribute little to field burning of agricultural residues. Therefore the suggested maximum likely Fraction Burned in the Fields (0.4) provided in Volume 3 of the IPCC Guidelines was used.

The Fiji Sugar Cooperation provided information on the fraction of crop residues burned in the field for sugarcane. According to them 72,710 ha of sugarcane were harvested in 1991.

Subsequently 35,625 ha was burned to facilitate harvest activities. Of the green cane harvested (37,085 ha), only 18,319 ha were not burned. Therefore  $(100 - 18,319/72,710 \times 100 =) 74,81\%$  of the sugarcane residues were burned in 1991.

For the other default values the IPCC Guideline recommendations were used

#### Uncertainty Estimates

A rough estimate of the uncertainty is 100%.

## **5. Land Use Change and Forestry**

### **5.1 Changes in Forest and other Woody Biomass Stocks**

#### Differences from IPCC source/sink category structure:

None.

#### Differences from IPCC default methods for the estimation of greenhouse gases:

None.

#### Estimation methods, major assumptions and verification:

The following information sources were provided by the Department of Forestry and are included in the appendices in the source documents on Land Use Change and Forestry:

- a) Letter from Conservator of Forests, date 17.07.95;
- b) Letter from Conservator of Forests, date 26.07.95;
- c) Annual Report for the year 1990, Forestry Department;
- d) Annual Report for the year 1991, Forestry Department;
- e) Annual Report for the year 1992, Forestry Department;
- f) Fiji Forest Inventory, Volume 1, The Environment and Forest Types, by M.J. Berry and WJ Howard Land Resource Study No. 12, Land Resources Division, Tolworth Tower, Surbiton, Surrey, England, 1973;
- g) Fiji Country Statement presented to the United Nations 19th Special Session of the General Assembly on Sustainable Development (New York, 25 th June, 1997);
- h) Forestry Department, Mr. Osea Tuinivanua.

The forest cover data in the annual reports on Indigenous Forest Management is estimated by recording timber removals and logging licences: "Logging progress in indigenous forests continued to be monitored through the updating of licence area records. This involves recording timber removals and mapping the logged areas for individual licences and transferring this information onto a master plan". The accuracy of this approach is likely low.

It is known by the authors that another forest inventory has been developed (Forest Area Estimation for Fiji Forests by GTZ). However this information was not made available to the Department of Environment until this day. Mr. Osea Tuinivanua has recently promised to provide this information to the Department of Environment. The inventory will be updated in case this information is received in the future. The last letter send to forestry to

ask for this information is attached under the source documents on land use change and forestry.

*Worksheet 5-1 Changes in Forest and Other Woody Biomass Stocks, Sheet 1 of 3*

The data for column A are derived from source d) and source a) under “(4) Plantation Forest Areas by Softwoods and Hardwoods”. There are small differences between these two sources. According to Mr. Tuinivania the annual report is more accurate and therefore the data from the annual report are used. He explained that:

- The area of Crown Land, Forest Reserves and Crown Lease are mainly hard wood plantations.
- The area of Fiji Pine Lease (*pinus caribaea*) and Private (extension) are mainly softwoods.

The columns in the annual report under “indigenous forest” are also classified under production forests and are subject to commercial logging. After logging replanting takes place in these areas. The logging doesn’t take place as frequent as with plantation forests. Some of these forests have even never been commercially logged and are undisturbed forests. The re-growth occurring on these areas also causes a carbon sink. However there are no data available on which areas have recently been logged and replanted and this sink can therefore not be estimated which was conformed by Mr. Tuinivania. The carbon sink because of changes in forest and other woody biomass stocks is therefore likely larger than estimated.

Mixed Fast Growing Hardwoods do occur in Fiji but are included under Mixed Hardwoods because no separate data are available.

*Worksheet 5-1 Changes in Forest and Other Woody Biomass Stocks, Sheet 2 of 3*

Commercial harvest data are derived from source d).

For column G the following assumptions have been made:

- All wood to be used for fire or fuel wood or charcoal from indigenous forest is assumed to be harvested from unproductive forests. The assumption is that people go individually to pick up some branches from the forest regularly without clear cutting a certain area.
- All wood to be used for fire or fuel wood or charcoal from plantation forest is assumed to be harvested from logged forests. The assumption is that this wood is used by industries as a by-product of commercial logging activities.
- All wood to be used for post and poles from indigenous forest is assumed to be harvested from unproductive forests. The assumption is that people go individually to pick up wood for this purpose.
- All wood to be used for post and poles from plantation forest is assumed to be harvested from logged forests. The assumption is that this wood is used for posts and poles after commercial harvesting.
- Logs and pulpwood are harvested commercially and are harvested from logged forests.

These assumptions were supported by Mr. Tuinivania. Sheet 2 of 3 shows that the estimation made by the Department of Forestry are very much different from the estimations

made by the Department of Energy. The data from Forestry are partly based on firewood licences. This is likely an inaccurate method. The data from the Department of Energy are based on a report developed specifically for that purpose by the University of the South Pacific (referred to as “Rural Energy in Fiji”, 1977, USP, Siwatibau, more information on the literature than this was not provided in this source document).

For that reason the Department of Energy data were assumed to provide for a better estimate than the Department of Forestry data. The data on “fuelwood” and “firewood licence” were therefore ignored in column K.

Column L represents the fuelwood retrieved from a reduction in forest area. This amount of fuelwood should be smaller than the total amount of fuelwood wood as shown in column K (or better column C of Worksheet 1-2, 247.734 kt dm). This shows that the initially estimated fraction of biomass burnt off site of 0.19 is overestimated for the year 1991. Assuming that fuelwood used by urban and rural populations are mostly derived from non-plantations a fraction of biomass burned off site of less than  $[247.734 / (910.6 + 1652.0) =]$  0.10 seems more appropriate. When it is assumed that the urban and rural population derive their fuelwood for 50% from clear cutting natural forests, than the fraction of biomass burned off site would be 0.05. Therefore a fraction of 0.05 has been chosen for column L, Worksheet 5-2, sheet 3 of 6.

Column Q results in a positive figure, which means that this is a CO<sub>2</sub> sink.

The Current Economic Statistics October 1995 (page 3) shows that the population in Fiji in 1881 counted 127,000 people which has grown to 773,000 in 1996 (last census). This must have resulted in a continuously increasing need for harvesting activities by people living in rural and urban areas. The increased traditional fuelwood consumption should have resulted in a net source of carbon dioxide.

It means that the carbon source because of harvesting activities from plantations and natural forest is smaller than the carbon sink because of the regrowth of plantations. An explanation could be that the commercial harvest of logs, post and poles and pulpwood is underestimated. Another explanation could be that the years before 1991 the area of plantation forest had been largely increased. Source document d) suggests that this is correct. This would result in a larger area of plantation forest but it would not yet have resulted in logs to be harvested. The last assumption was supported by Mr. Osea Tuinivanua.

## **5.2 CO<sub>2</sub> Emissions from Forest and Grassland Conversion**

Differences from IPCC source/sink category structure:

None.

Differences from IPCC default methods for the estimation of greenhouse gases:

None.

Estimation methods, major assumptions and verification:

*Worksheet 5-2 Forest and Grassland Conversion, sheet 1 of 6*

Fiji Country Statement presented to the United Nations 19th Special Session of the General Assembly on Sustainable Development (New York, 25th June, 1997) states that the total forest area was 899,100 ha in 1985, 890,480 ha in 1990 and 870,010 ha in 1996. This information seems to be in accordance with the sources a), c), d) and e).

Therefore from 1985 to 1996 the total forest area was reduced with an average of 2,645 ha forest per year (which is about 0.3% of the total forest area converted per year).

In 1969 the total forest area was estimated to be 668,027 ha but this only included Viti Levu, Vanua Levu and Kadavu.

As has been mentioned before it is known by the authors that another forest inventory (Forest Area Estimation for Fiji Forests by GTZ) has been developed since the inventory of 1969 but this information was not made available to the Department of Environment.

The following data on total forest area are therefore available:

1969:	668,027 ha
1985:	899,100 ha
1989:	895,940 ha
1990:	890,480 ha
1991:	875,540 ha
1992:	878,610 ha
1996:	870,010 ha

Fiji does not have any data on grassland or woody savants. It is therefore not possible to provide these data in this worksheet.

From 31.12.90 to 31.12.91 the total forest area was reduced by 14,940 ha (which is a lot higher than the 11 year average of 2,645 ha forest per year). Fiji Pine Limited is involved in converting grassland into forest plantations. However in 1991 the area under Fiji Pine Lease decreased.

The information asked for in this worksheet is the conversion of tropical forest into other land uses. Mr. Osea Tuinivanua explained that only Protection Forest would be mostly undisturbed and is therefore assumed to be primary forest.

The area of production forest and non-commercial forest decreased from 622.35 kha (end 1990) to 608.96 kha (end 1991) which is a net reduction of 13.39 kha. The area of protection forest decreased from 268.13 kha (end 1990) to 266.58 kha (end 1991) which is a net reduction of 1.55 kha.

There were small increases in the plantation areas under crown lease and private plantations (private). These increases are negligible.

The default values from Asia, moist forests from the IPCC Guidelines are used to determine the biomass before conversion.

It is assumed that the cleared forest will be used for agricultural purposes.

According to the source documents c), d) and e) the total mangrove area has not been reduced from 1990 to 1992. This is unlikely. In urban areas mangroves are many times cleared for reclamation. However no information on deforestation of mangrove areas because of reclamation is available.

*Worksheet 5-2 Forest and Grassland Conversion, sheet 2 of 6 and 3 of 6*

According to the authors burning of forest occurs mostly in the dry parts of Fiji (the west) the mangrove areas excluded. Clearing with less burning occurs in the wet parts of Fiji and all the mangrove areas because the rain or the sea water would disturb the burning.

It is assumed that only non-plantation non-mangrove forest area is subjected to deforestation. Therefore in 1991 the area of forest subjected to deforestation in the dry areas (the west) was 203.92 kha (26.90%) (excluding mangrove areas). The area of forest subjected to deforestation in the wet areas (the north and south) was 554.11 kha (73.10%) (excluding mangrove areas). The authors have no reason to believe that deforestation would occur more in the wet areas than in the dry areas and assume therefore that deforestation occurred for 26.9% in the dry areas and for 73.1% in the wet areas.

The authors have assumed that deforestation is caused for 60% of the area by commercial logging, 20% of the area because of the need to increase agricultural area by the Indo-Fijian population and 20% of the area because of the need to increase agricultural area by the indigenous people.

Commercial logging:

Because of commercial logging without replanting of forest 80% of the wood would be removed from the area and 20% would be left to decay.

Indigenous people, dry areas:

In the dry parts the wood is usually dry enough to be burnt completely. Many times the indigenous people would use the wood for firewood. The percentage of forest burnt on site is estimated to be 50%, 35% would be used as firewood, 5% would be other use (furniture, building material), and 10% would be left to decay. The roots would be taken out of the ground when they are dry to be used as firewood.

Indo Fijians, dry areas:

In the dry parts the wood is usually dry enough to be burnt completely. Many times Indo-Fijians would use the wood for firewood. The percentage of forest burnt on site is estimated to be 5%, 70% would be used as firewood, 20% would be other use (furniture, building material) and 5% would be left to decay. The roots would be taken out of the ground when they are dry to be used as firewood.

Indigenous people, wet areas:

In the wet parts, in case the forest is cleared for the land to be used for agricultural purposes, the forest is first cut down. Then the branches will be burnt separately or used as fuelwood. The trees which are cut are sometimes left to decay but are most of the time used for firewood when they are dry. In the wet part it is assumed therefore that 30% of the wood will be burnt on site, 50% will be used as firewood, 10% would be other use (furniture, building material) and 10% will be left to decay. The roots would not be removed.

Indo Fijians, wet areas:

In the wet parts, in case the forest is cleared for the land to be used for agricultural purposes, the forest is first cut down. Then the branches will be burnt separately or used as fuelwood. In the wet part it is assumed therefore that 30% of the wood will be burnt on site, 40% will be used as firewood, 20% would be other use (furniture, building material) and 10% will be left to decay. The roots would not be removed.

Indigenous people and Indo Fijians, mangroves:

Almost 90% is used for firewood. 5% is used for other purposes (furniture, building materials) and 5% would be left to decay. The roots would not be removed.

Table 6: Assumptions on the fate of biomass

Commercial logging	60%	80%			other use
		20%			left to decay
Indo Fijian	20%	73.1%	wet areas	40%	burnt on site
				40%	firewood
				20%	other use
				10%	left to decay
		26.9%	dry areas	5%	burnt on site
				70%	firewood
				20%	other use
				5%	left to decay
Indigenous people	20%	73.1%	wet areas	30%	burnt on site
				50%	firewood
				10%	other use
				10%	left to decay
		26.9%	dry areas	50%	burnt on site
				35%	firewood
				5%	other use
				10%	left to decay

On site burning is therefore:  $0.2 \times 0.731 \times 0.3$  +  
 $0.2 \times 0.269 \times 0.05 + 0.2 \times 0.731 \times 0.3$  +  
 $0.2 \times 0.269 \times 0.5 = 0.11731$

Left to decay is therefore:  $0.6 \times 0.2 + 0.2 \times 0.731 \times 0.1 + 0.2 \times 0.269 \times 0.05 +$   
 $0.2 \times 0.731 \times 0.1 + 0.2 \times 0.269 \times 0.1 = 0.15731$

Off site burning is therefore:  $0.2 \times 0.731 \times 0.4 + 0.2 \times 0.269 \times 0.7 +$   
 $0.2 \times 0.731 \times 0.5 + 0.2 \times 0.269 \times 0.35 = 0.18807$

Export and other use is therefore:  $0.6 \times 0.8 + 0.2 \times 0.731 \times 0.2 + 0.2 \times 0.269 \times 0.2 +$   
 $0.2 \times 0.731 \times 0.1 + 0.2 \times 0.269 \times 0.05 = 0.53731$

The estimation of the fraction of biomass burned off site (0.19) is likely incorrect and has been changed into 0.05 because of the reasons mentioned under Worksheet 5-1 Changes in Forest and Other Woody Biomass Stocks, Sheet 2 of 3.

*Worksheet 5-2 Forest and Grassland Conversion, sheet 4 of 6*

The same method is used as under Worksheet 5-2 Forest and Grassland Conversion, sheet 2 of 6 and 3 of 6. For the 11 year period from 1985 to 1990 it is unknown what part of the reduction in forest area was due to a reduction in primary forest and what part was due to a reduction in secondary forest. The assumption has been that 100% of the reduced forest area was primary forest.

*Worksheet 5-2 Forest and Grassland Conversion, sheet 5 of 6*

The same method is used as under Worksheet 5-2 Forest and Grassland Conversion, sheet 4 of 6. A 25 year average could not be made. Therefore the same data for the “Average Annual Forest/Grassland Converted” as under Worksheet 5-2 Forest and Grassland Conversion, sheet 4 of 6 has been used.

**5.3 On-site Burning of Forests: Emissions on non-CO<sub>2</sub> Trace Gases**

Differences from IPCC source/sink category structure:

None.

Differences from IPCC default methods for the estimation of greenhouse gases:

None.

Estimation methods, major assumptions and verification:

*Worksheet 5-3 On-site Burning of Forests, sheet 1 of 1*

No comment is needed. See section 5.2 (CO<sub>2</sub> Emissions from Forest and Grassland Conversion).

## 5.4 Abandonment of Managed Lands

No data are available on this issue. It is known that the dry areas in the west were already degraded to grassland before the first Europeans came. Whether these grassland areas have grown or whether forests are re-growing is unknown.

## 5.5 Uncertainty Estimates

The uncertainty of all the figures produced under this chapter is likely very large, taking into account all the assumptions that had to be made. No uncertainty estimates have been made.

# 6 Waste

## 6.1 Land Disposal of Solid Waste

Differences from IPCC source/sink category structure:

None.

Differences from IPCC default methods for the estimation of greenhouse gases:

None.

Estimation methods, major assumptions and verification:

The National State of the Environment Report gives the following description of waste dumps in Fiji:

“A characteristic of all but two municipal dumps (Nausori and Ba) in Fiji, is their location in former mangrove habitats. This is not a result of being unable to secure other sites, rather that mangrove areas being state land, does not have to be negotiated neither does it involve the payment of lease rent. Their use is merely a financial and expedience measure. Mangrove areas are totally unsuitable for garbage dumps unless seepage of pollutants can be contained by lining and bunding the whole area with an impervious material. No municipal garbage dump in Fiji is managed to accepted international standards, (despite claims to the contrary) and none could be described as a 'sanitary landfill'. Open dumping and burning is the most fitting general description.

In other words landfills do not occur in Fiji, only open dumping occurs. Compaction however was used for the Suva and Lautoka waste dumps in 1991. Furthermore burning is used mainly at the larger waste dumps.

*Worksheet 6-1 Methane Emissions from Landfills (Supplemental)*

The urban population was derived from the National State of the Environment Report (table 17.2). The report was developed in 1992 and the authors assume that this table reflects the

1991 data. This assumption strokes with the 1986 data from the Current Economic Statistics taking into account a population growth since 1986.

The National State of the Environment Report provides the following figures:

<u>Place:</u>	<u>Population estimate:</u>
<u>Cities:</u>	
Lautoka	30,000
Suva (City)	75,000
<u>Towns:</u>	
Ba	8,000
Labasa	16,000
Lami	unknown
Levuka	8,200
Nadi	16,000
Nausori	5,000
Savusavu	4,000
<u>Rural areas:</u>	
Ba	60,000
Labasa	10,000
Lautoka	unknown
Nadi	60,000
Nausori	60,000
Navua	25,000
Rakiraki	5,000
Taveuni	7,000
Tavua	33,000
Suva	<u>70,000</u>
<b>Total</b>	<b><u>492,200</u></b>

In 1986 the urban population of Lami counted 8,597 people. The Draft Naboro Landfill EIS and Engineering Studies estimated, the serviced population in Lami to be 10,480 (for 1996). The 1991 population for Lami is therefore estimated to be 9,500 people (average).

The Lautoka rural area counted 10,329 people in 1986 (Current Economic Statistics). The Lautoka rural population for 1991 is estimated to be 11,000 people.

The total population disposing waste at waste dumps that would produce significant amounts of methane is therefore estimated to be  $(492,200+9,500+11,000=)$  512,700 people.

In 1996 the Solid Waste Generation Rate was estimated as 550 kg/person/yr (Draft Naboro Landfill EIS and Engineering Studies). In 1994 the Solid Waste Generation Rate was estimated as 374 kg/person/yr (Solid Waste Management in Fiji). This first estimate (1996) is assumed to be quite accurate. The second figure could have been derived from a report

developed in 1988 (Preliminary Study Report on Solid Waste Disposal Problems in Greater Suva area) being an estimate for 1988. For 1991 the Solid Waste Generation Rate was therefore estimated as 420 kg/person/yr, which is 420 Gg/10<sup>6</sup> persons/yr (uncertainty about 10%).

It was assumed that this estimate is representative for other areas as well.

The default fraction landfilled of 0.8 is likely realistic taking into account burning activities.

#### *Worksheet 6-1 Methane Emissions from Landfills*

According to the Draft Naboro Landfill EIS and Engineering Studies, 65% (by weight) of the waste from Suva was putrescible waste in 1996. However the carbon fraction of this waste fraction is unknown. For that reason it was not possible to estimate a country specific fraction for degradable organic carbon of municipal solid waste (DOC of MSW Fraction) and therefore the default figure was used.

Smell nuisance is a problem with most sites which suggests that methane production does occur. Volume 3 of the IPCC Guidelines says that “where open dumps are large and relatively undisturbed, they may emit CH<sub>4</sub> very much like a landfill. In other cases, small open dumps may be disturbed by animals, burning or other factors, and produce very little CH<sub>4</sub>.”

For that reason an estimate had been made for the urban waste dumps (which are also used for disposal of some waste from “rural areas”). Volume 3 of the IPCC Guidelines suggests that open dumps would produce 50% less methane than landfills. This seems a reasonable estimate taking into account the clear methane smell near those waste dumps.

The fraction C-CH<sub>4</sub> to C-Biogas was therefore estimated to be (50% of 0.5) which is 0.25

#### Uncertainty estimates

An uncertainty of 100% was roughly estimated.

## **6.2 Methane Emissions from Wastewater Treatment**

#### Differences from IPCC source/sink category structure:

None.

#### Differences from IPCC default methods for the estimation of greenhouse gases:

None.

#### Estimation methods, major assumptions and verification:

#### *Worksheet 6-2 Methane Emissions from Domestic and Commercial Wastewater Treatment*

Rural areas are most of the time not provided with septic tanks. The contribution of methane from this source is assumed to be nil.

Resorts and hotels in rural areas are usually provided with septic tanks. In 1991 259,350 visitors arrived in Fiji according to Current Economic Statistics. It has been assumed that the visitors classified “under business”, “official conference”, “visiting friends/relatives” and “education/training” stayed in hotels in urban areas (which are usually connected to the sewerage system). The visitors classified under holiday (209,146 in 1991) were assumed to stay in resorts for about two weeks (3.846% of the year) outside the urban areas. These resorts use most of the time septic tanks. Pacific Harbour, a tourist area was provided with a sewerage system for 2,000 people in 1994. It has been assumed that in 1991 the same amount of 2,000 people were provided with a sewerage system. To prevent double counting this figure has been subtracted from the tourist population, assuming that most people provided with a sewerage system in Pacific Harbour are tourists. The total population provided with septic tanks in 1991 was therefore estimated as  $(209,146 \times 0.03846 - 2,000) = 6,044$ .

Total population (provided with sewerage) were estimated by the Public Works Department. The letter from the Public Works Department, dated 10.11.95, is unfortunately not at all consistent with the 1994 Annual Report. The annual report for 1994 was assumed to provide the best estimate of the population connected to the sewerage system in 1994. In this report the total population connected to sewerage systems in Fiji, in 1994, was estimated as  $(109,224 + 3,800) = 113,024$ .

The population annual growth rate in Fiji is estimated as 1.1% (Draft Naboro Landfill EIS and Engineering Studies). The total population connected to sewerage systems in Fiji, in 1991, is therefore estimated as  $(113,024 / 1.011^3) = 109,375$ .

Total population provided with anaerobic sewage treatment is therefore estimated as  $(6,044 + 109,375) = 115,419$ .

Default Wastewater BOD values were derived from Volume 2 of the IPCC Guidelines. The figure provided for Asia, Middle East, Latin America was assumed to be the most appropriate for Fiji.

Public Works Department has estimated the Fraction of Wastewater Anaerobically Treated in the letter dated 10.11.95. This fraction is far higher than the default figures provided by the IPCC Guidelines.

The default figures provided by the IPCC Guidelines are likely more accurate. Therefore the default figure of 0.10 was used.

#### Uncertainty estimates

An uncertainty of 100% was roughly estimated.

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- e) Current Economic Statistics 1995, Bureau of Statistics, Suva, Fiji;
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### **Vulnerability and Adaptation Assessment of Suva Peninsular Area**

Under the umbrella of the US Country Program, the Department of Environment requested the South Pacific Applied Geoscience Commission( SOPAC ) to undertake surveys and assessments of coastal vulnerability in and around Suva the Political and Economic Capital of Fiji.

In the present VA study of the Suva area, water levels were predicted for a variety of storm conditions and base water levels, using a simple, one-dimensional, spreadsheet model for storm surge. Maps were produced to show the location of overtopping, based on the surveyed seawall and backshore elevations. The overtopping estimates were based on the surge level (Appendix III of Solomon & Kruger, 1996) and did not include wave runup. It was originally intended to produce maps of inundation extent, but there were insufficient topographic data to support this. In places where the 2-m contour had been

interpolated, it was possible to estimate the potential extent of flooding under some conditions, but mapping at a contour interval of 0.5 would be necessary for a comprehensive analysis of flooding.

Water levels were estimated at a range of sites for storms with return intervals of 2,5,10,25, and 50 years, and for all four ASLR scenarios (present water level +0.00, +0.25, +0.50, and +1.00 m). Table 1 presents the results in relation to mean, maximum and minimum shoreline elevations within each sector of the PSA shoreline. The GIS database of seawall and backshore elevations enables map outputs showing the extent of overtopping related to each of these scenarios

At present sea level, the area encompassing most of the downtown core is elevated sufficiently so flooding will not occur under most storm conditions. West of the primary study area (toward Lami), overtopping of seawalls and shorelines will occur during most storms. On the southern tip of Suva Peninsula (Nasease and Suva Point) flooding occurs along the lower elevation shoreline and protection structures during most storms, but does not overtop the higher portions of the sea wall.

On the east side of Suva Peninsula, the lower elevation shorelines are overtopped during all storms, and the mean and higher elevations are overtopped during the more severe (e.g. 10-year) events. Low terrain in this area includes squatter settlements, residential subdivisions, traditional village lands, extensive industrial and manufacturing development, educational facilities (including the University of the South Pacific) and public infrastructure (National Stadium, roads, bridges, sewage treatment).

As sea level rises, the storm-surge water levels rise on a virtually one-to-one basis. In the case of a 0.25-m rise in mean water level, overtopping of the shore protection in the downtown core of Suva will occur only during the more extreme events and, even then, the higher elevation structures will be above the surge level (though susceptible to runup and splash). Under the more extreme ASLR scenario of +1.00 m, the area of Suva Point and east will be flooded during most cyclone events, and even the downtown core will be susceptible to flooding during moderate cyclones.

As sea level rises, the frequency of overtopping from an event of a particular magnitude will increase. Essentially, the 25-year event at present sea level will become the 5-year event if sea level rises by 0.5 m (Solomon & Krüger, 1996).

An index of overtopping and flooding vulnerability was calculated, based on the storm severity required to raise water level over the mean elevation of the shoreline in a given sector. A low site subject to flooding in the least severe storm at present mean sea level will have an overtopping score of 20 (flooding at all 5 storm return intervals under all 4 ASLR scenarios), representing high vulnerability. Conversely, a site higher than the highest surge under the maximum ASLR scenario will have a score of zero overtopping. For simplicity, a mean index was derived by dividing the overtopping scores by the number of ASLR scenarios.

A second approach makes use of the GIS capabilities in the database. In this case, we map the average height of the shoreline and show the location of the overtopped shore protection structures for each sea-level scenario for the 5-year return-interval storm surge. We can also show, for example, the location of damaged shore-protection structures, major infrastructure, zoning, or other socio-economic data relevant to the VA. This method allows the identification of zones that are both vulnerable to overtopping and susceptible to additional damage. For example by examining the geographic locations of overtopping and damaged sea walls, managers can better allocate scarce resources to high-priority sites.

Another approach to flooding vulnerability using the GIS would be to assess the amount by which a given site is overtopped at a particular surge level. This can be done by mapping the difference between the surge height and the shore elevation, using linked data-base tables of survey points and storm surge return estimates for various locations. This allows a rapid point by point assessment of inundation potential for each scenario, and can be combined with a map of erosion indicators and status of protection. However, to map inundation zones effectively would require a high-resolution digital elevation model of the area below 5m elevation.

*The above study was scientific in nature, see attachment 2 for the detailed study.*

### **A Review of the types of Coastal Protection Structures Used in Fiji today with a Comment on their Effectiveness**

Mineral Resources Department of Fiji was contracted to carry out an assessment study to review all coastal structures in Fiji.

The objective of the study was two fold. First to provide an assessment of the effective of coastal structures and predict the impact the impact of any sea level rise and secondly to provide government with an overall view of the extent of foreshore reclamation. In the final analysis of the study it was shown that there was a predominant use of sea walls as a coastal protection structure in Fiji. It was also shown that there was a lack of monitoring which has led to massive losses of seawalls being incurred all over Fiji, especially in coastal villages where sea walls have fallen and rebuilt only to fall again. Another interesting outcome of the study have shown that for sometime most coastal communities in Fiji have been choosing retreat and abandon strategy, however recently the reclamation and retained strategy is becoming more common.

*See Attachment 3 for a more detailed analysis on the above study.*

### **Oral Literature Survey of Ovalau**

The Department of Environment together with the University of the South Pacific carried out a Literature survey on shoreline changes in Fiji and the first phase of this was carried out on the Island of Ovalau. The aim of the study was to collect information or changes

in coastal forms from knowledge of inhabitants in the absence of qualitative scientific long term data. Study was conducted on the whole island of Ovalau in an attempt to cover all of the villages as to ensure that data gathered would represent a more comprehensive picture of the Island as much as possible.

The analysis shows that in places where there is relatively higher population density, most of the mangroves has been extensively removed and significantly higher rate of shorelines erosion occurs. except in the village of Bureta where mangroves is a totemic symbol and have been left intact there is no shoreline erosion. The study also reveals that many sea walls up to 2 metres high are collapsing and are in a bad state of repair. Moreover out of the 19 villages where elderly informants were interviewed, 11 villages experienced coastal inundation while the remaining 8 did not. In 11 villages which had experienced coastal inundation the sea has gradually encroached laterally upon the land from a range of 5,10,15 to 50 metres, in a span of 50 and 70 years period. This has become particularly noticeable in the past 5 years. Most of the informants recalled in the last 50 to 70 years it was possible to walk the reef at low tide whereas today, it is virtually impossible. This would be seen as an indication of sea level rise and/or other natural phenomenon such as subduction or development of a channel by the changes in the movement of intertidal waves.

The study suggest that there should be replanting of mangrove because it would physically protects shoreline ( act as buffer zone ). It will also reduce nearshore sediment movement, allow built up of sediment along shores and boast supplies of seafood in the immediate area in terms of the importance of mangroves as nursery areas.

There should also be an appropriate designs of seawalls, it should shape at a similar angle to that which the beach would have in that particular situation and it should be permeable, preferably made of large boulder.

*See Attachment 4 for a more detailed analysis of the above study.*

## **Land Capability and Classification Study of Ovalau Island**

The Landuse capability classification is a systematic arrangement of different kinds of land according to those properties that determines their capacity for permanent sustained production. This capacity depends largely on the physical qualities of the soil and environment, this are often far from ideal and the difference between the ideal and the actual is regarded as limitations

The degree of limitation can be addressed from, susceptibility to erosion, steepness of slopes, liability to flooding, wetness or drought, salinity, depth of soil, soil texture, structure and fertility, stoniness and climate.

The land is classified according to the kind and degree of limitation to agricultural use and in this study it recognise 8 classes. Land Class1 contain no or only minor limitations

and the number and or severity of limitation increases from Class 1-VII and Sub Classes, like; e-eradicability, w-wetness, s-soil limitations and c-climate.

The main objective of the LUC of Ovalau is to i ) evaluate and classify its land resources according to its capacity for permanent sustained production and ii ) to assess the potential area for agriculture production and recommend crops to be grown on it. This is to ensure that Ovalau land resources are used in the best possible way to maximise production and the same time minimise land degradation ( sustainable land uses ) and iii ) to use the study as the Ministry of Forestry, Fisheries and Agriculture's [MAFF] contribution towards the Integrated Resources Management Study a very important technology.

Note: LU classification is the modified version of the USLUC.

The following methodology was adopted in the study

- i] Prefield Interpretation of Aerial photographs, research and collect information of study area
  
- ii] Field works      Assessment of land resources  
                            Soil surveying  
ground                Soil sampling  
thruthing            Present Land Use Survey  
                            Vegetation  
                            etc.
  
- iii] Postfield        Soil analysis at Chemistry Laboratory  
work                 Final aerial photo interpretation  
                          Finalization of mapping  
                          Mapping  
                          Report Writing

The report and the accompanying maps will discuss and indicate the land classes that exists in Ovalau, potential area for agriculture and for forestry and how it should be used to maximise production and minimise soil loss or degradation. The island has a total land area of 10468 hectares out of which 40% is suitable for some of agriculture and also needs conservation measures and 60% is unsuitable for agriculture but suitable for commercial forestry and protection forestry. The island is a great potential for agriculture development but the land should be used according to its capability for permanent sustained production.

Fiji has changed its policy in the agriculture sector of the economy with the refocus of emphasis mainly from import substitution and self sufficiency towards an export based economy. If Ovalau is properly managed and the land is properly used according to its capabilities, there would be an immense increase in crop production. Ovalau's close proximity to Suva and the daily ferry services that frequent the island could be used to

transport products to Suva as port of export. This could contribute to the savings of millions of dollars and source of foreign exchange in our foreign markets.

With the increase in number of unemployment youth in this country, a properly planned farming programme would serve as a panacea for the rural - urban drift syndrome that our country is experiencing. MAFFA always recommend that the land should be used according to its capacities for permanent sustained production.

*See Attachment 5 for a more detailed analysis of the above study*

### **The Coral Reef Survey of Ovalau Island**

Biological Consultant a private company was contracted to carry out a survey of the coral reefs around Ovalau Island. The objective of the study was to provide a general understanding of their nature and problems that maybe affecting them and a general assessment of the their present state. The survey involved several levels of scrutiny with the initial inspection through aerial photography providing an appreciation of the extent and nature of the varied reef complexes. Underwater inspection of reef detail provided a good understanding of the physiography and habitat variability. Sample sites were inspected around the island and on the fringing barrier reefs. The strategy employed was one of “rapid assessment” involving complimentary techniques which would yield a broad scale understanding of the system and highlight areas where problems exists and where more directed and detailed work should proceed. What is not is a fine scale survey. The use of line transect method has been useful as a compliment to general observation. In the analysis the survey revealed a gradation of reef development. This ranges from a reef reduced both in area and species compliment to one more typical of offshore environments with luxuriance of coral development. The reef structure grades from a sprawling assemblage on a silty bottom to a consolidated reef structure characterised by vertical reef.

In general the reefs around in Ovalau Island are thriving and diverse both in their species composition and habitat diversity. The reefs are generally healthy and the variability observes within the range is expected. Crown of thorns ( *Acanthester Plancii* ) infestations are extensive on the back reef areas and reefs affected by terrestrial activities are prominent in a few areas. The prominent linkages between land and sea is represented by sedimentation through runoffs which occurs due to extensive work and removal of plants around the watersheds through agricultural practices in villages or resorts development. Generally the state of the sediments in the deeper water off the reef has little effect. The reefs of the Southern and Western Areas, particularly near a village settlement have been conditioned by siltation both in form and composition. The study was basically a scientific analysis of the coral reefs of Ovalau, in relation to its vulnerability to sea level rise , little study has been focused on human activities on the whole island.

*See Attachment 6 for more detailed analysis on the above study.*

## **Ovalau Integrated Resource Management Plan**

In Fiji, the majority of the land ( 83% ) is owned by the indigenous people. Therefore any form of development initiated by government and private sectors in the future would impinge much on resources largely owned by the indigenous Fijians. Fiji's classical *Development model* is mostly based on a "*top - down approach*", whereby different government and private bodies have their own development *agendas* to implement. It was shown due to Fiji's intricate land tenure system, many problems have arise from this developmental approach in particular within and among the grassroot level, middle management and the top management ( decision making body ) of government and private sectors involved. This is where a clash of ideals, fabrication, overlapping and inconsistency in a lot of developmental processes occurs largely due to the lack of consultation, communication, integration and monitoring between the specific bodies involved.

From the above analysis our team carry out an Integrated Resource Management Plan (IRMP) of Ovalau, an island off the east coast of the main island ( Viti Levu ). Ovalau was chosen as a pilot project initiative of IRMP study because of its accessibility to Suva the Capital and Political Centre of Fiji and the availability of its political, socio and economic data that have been stored by previous and current development projects which have been undertaken and those that are still ongoing on the Island. With many rural community based workshops that our department has undertaken in Fiji, the Ovalau workshop was the first of its kind in terms of community-based "*bottom-up approach*" awareness. Our unit drafted and finalised an IRCM model, which specially focused on "*a bottom-up approach*". It is our aim that this approach would be a mechanism for a more integrated approach by all parties involved whether government, non government, private or rural community in facilitating any form of development process and its implementation.

The model integrates vertical and horizontal consultation It has been seen that in Fiji's case traditional system cannot cope with coastal management, it needs to promote integration at Multi-disciplinary, multi-sectorial and Multi-level ( wide involvement of community ) as to avoid the above and related problems associated with the *top-down approach* within the top and middle management, moreover and more importantly however among the indigenous who owned the land. In order that people concerned are properly advised and consulted before any development take place, specifically addressing the socio-economic, political and environmental impact assessment that would be encountered in any form of development that would take place on the their resources in the immediate future. ( *see attachment 7* )

## **A Description of Policies and Measures for Adapting to Climate Change**

The Department of Environment has endorsed to Parliament an Environmental Sustainable Development Bill for final submission and review before being passed as a Legislation. In the Bill the provision for a National Policy for the Reduction of Emission from GHG based on ecology, economic, social and cultural realities has been well addressed. In addressing the set up of a National GHG Inventory included are the issues on the evaluation of options and estimation of incremental costs concerning the reduction of emissions, the bill also focused on setting of realistic and achievable emission reduction goals for individual sources of greenhouse gases which will be undertaken in consultation with industries and other affected parties

This is where the establishment and enforcement of suitable emissions standards for motor vehicle with appropriate enforcement provisions ( a yearly check on motor vehicles ) will be implemented. Moreover establish targets to be archived and commencement dates for the reduction of emissions of greenhouse gases from all sources, with the objective of ensuring that by January 1, 2010 Fiji's production of such gases will not exceed the assimilative capacity of the country's carbon sink would be Fiji's Emission standard target. In the bill a provision for the establishment of an Action Plan containing mechanisms, programs and initiatives that are to be implemented to give effect to the National Policy for the Reduction of Emissions is also addressed. In particular development of guidelines and codes of practice, establishment of auditing programs to verify compliance, development and promotion of new and innovative technologies and specification of private and public sector roles and responsibilities in implementing the Action Plan.

In the drafting of this new and comprehensive Sustainable Bill the Department of Environment is trying to establish a power base forum called the National Council for Sustainable Development ( NCS D ), to be made up of government representatives of high powered officials and representatives of the private and public sector. This would be a policy-making organization where all policies will be approved by the council and would foresee implementation of the National Environmental Strategy ( NES ). The NCS D will ensure smooth co-ordination of the environmental management of both government and private sectors as well as to resolve conflict arising in the implementation of NES.

Special attention was also focused on Integrated Coastal Zone Management, an area which addresses vulnerability and adaptation assessment issues. Again we are trying to establish a Coastal Resource Management Committee ( CRMC ) to provide effective and co-ordinated decision making on coastal resource planning, development and management and to ensure that activities within the coastal zones are undertaken in such a manner so as not to affect the carrying capacity of coastal resources. Special functions of the CRMC will include co-ordinating the formulation of Coastal Resource Management Plan and shall be responsible for considering and approving Coastal Resource Development Permits.

The committee shall have the power to establish policies, procedures standards and codes of practice to protect and enhance the quality of coastal resources in an event that an environmental impact assessment ( EIA ) of an activity or undertaking within the coastal

zone is necessary pursuant to the requirements of the act. EIA screening is a requirement for any coastal development and if any requirements or condition contained on a permit is not strictly complied with, the chair may issue directions as maybe considered appropriate for the immediate cessation of activities, and where necessary, the rehabilitation of any coastal area or resource.

### **Activities Implemented Jointly ( AIJ )**

AIJ has not been undertaken formally within Fiji to date. However we are still developing an institutional framework in the sustainable bill which addresses the potential of setting up a Business Council for Sustainable Development with the Pacific Power Association ( PTA ) and the Sawmillers Association that would co-ordinate private sector awareness and involvement. In particular on projects that involve carbon sequestration and waste to energy. The Native Land Trust Board and the Forestry Department are seeking to finance a carbon sequestration project for the Sovi Basin ( Fiji's best tropical rainforest site, earmarked for world heritage status ) through AIJ. They have carried out initial discussions with USJI. Moreover we need more feasibility studies to be carried out before proceeding to AIJ projects therefore technical support for the preparation of AIJ projects is vitally needed. Again endogenous capacity building and technology transfer is a crucial element in the preparation and implementation of AIJ projects.

### **Conclusion**

Since the project life has come to its end, we see the work that has been carried out under the US Country Studies Program a crucial development in terms of implementing measures and strategies to mitigate anticipated sea level on Fiji's vulnerable shorelines. The studies carried out above also becomes the baseline information that the Government of Fiji could fall back to when making any future research and analysis on the impact of climate change to Fiji's environment in terms of economic and infrastructural development on her resources.

### **Acknowledgement**

On behalf of our Director, the Fiji Climate Change Team and the Government of Fiji, I Paulo Vanualailai would like to convey our sincere thanks and gratitude to the Government of the United States for the financial support of the Climate Change Program here in Fiji. Without the tremendous support we would not be able to carry out the above studies which forms a baseline information for which Fiji is obligated under the UNFCCC as a party member to and moreover the studies are also crucial to Fiji's response to global warming and sea level rise in our region as a member of Alliance of Small Island States [AOSIS].

I would also like to extend our sincere thanks to the various governments, non-governments, and private/public organisations that have made these studies possible and

in particular individuals from above organisations who have worked so hard to finalise draft reports on time.

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