



INITIATIVE FOR CLIMATE ACTION TRANSPARENCY
PROJECT: SET UP OF SECTORAL MRV SYSTEMS FOR THE
AGRICULTURE SECTOR

Fiji Agriculture Rice Cultivation Emissions
Inventory Manual

September 2021

Initiative for Climate Action Transparency - ICAT SET UP OF SECTORAL MRV SYSTEMS FOR THE AGRICULTURE SECTOR

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Acronyms

BY	Base year
C	Carbon
CH ₄	Methane
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalent
COP	Conference of Parties to the United Nations Framework Convention on Climate Change
EF(s)	Emission Factors
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FBoS	Fiji Bureau of Statistics
GWP	Global Warming potential
kg	Kilogram
kt	Kilotonnes
MOA	Ministry of Agriculture
MRV	Measurement, reporting and verification
N O	Nitrous oxide

Preface

This manual is derived from the cumulative experience from work during Initiative for Climate Action Transparency project: Set up of sectoral MRV systems for the agriculture sector. It takes off from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Good Practice and Uncertainty Management in National Greenhouse Gas Inventories 2000. It is also informed by scientific literature specific to the Fiji case, where available.

The manual is organized by sub sectors of Rice cultivation under Agriculture, Land-Use Change and Forestry. It is intended for use by personnel who will be involved in generating GHG emissions data to be used for the inventory, from government such as the Ministry of Agriculture, the Fiji Bureau of Agricultural Statistics or among others. The Manual focuses on providing a guide to the process for emissions under rice cultivation.

Introduction

Rice (*Oryza sativa*) is one of the world's most important food crops. It forms the staple diet of very large proportion of the world's population. Currently in Fiji, rice is an important staple food substituted with root crops. Rice contributed to the improvement of livelihood of many farmers and their family members who rely on rice as the main source of income. Therefore, in Fiji, rice has multi-dimensional roles for food security and economic growth. Rice has been a major source of food for all ethnic groups in Fiji, with per capita consumption reaching 75 kg per year, an increase of up to 29 percent over the level in 2000 (Bong,2017). Further, rice has contributed to the improvement of the livelihoods of thousands of farmers and their family members who rely on rice as a main source of income. Therefore, in Fiji, rice has a multi-dimensional role as the foundation of food security, economic growth, as well as social and political stability.

Unfortunately, the Fiji rice industry has been increasingly weakened over the years as the rice area and production declined while the rice yield growth has been stagnant or marginal. Consequently, Fiji, which attained nearly 70 percent of self-sufficiency in rice in 1980s has had to import more than 80 percent of the total rice demanded annually. This is a dilemma because the agro-climatic conditions in Fiji are exceptionally favourable for rice cultivation. In 2019, Fiji imported \$42 million worth of rice from different countries whereby most of the rice imported was supplied by Vietnam. It is anticipated that this trend will continue to increase considering the increase in population and preference for rice.

Government of Fiji is highly determined to revitalize its rice industry with the establishment the National Rice Taskforce in September 2004 to steer and coordinate the country's rice revitalization program efforts to strengthen rice production toward reducing rice imports and achieving self-sufficiency in rice. Since then, the Government has given supportive policies and incentives along with increased investment from public and private sector to promote the rice industry development.

Rice production systems contribute to global climate change through emissions of carbon dioxide (CO₂), methane (CH₄), and nitrous oxides (N₂O) gases to the atmosphere and simultaneously are affected by the changed climatic variables. Rice paddy fields act as a source of greenhouse gases such as methane (CH₄) and nitrous oxides (N₂O) depending on soil organic matter status, land use and cropping intensity, irrigation water and drainage management practices, soil microbial populations and their activities, soil properties, and climatic variables. The management practices such as tillage operations, leveling, plant residue incorporation, irrigation frequency and standing water levels, drainage system, and organic and inorganic soil amendments followed in rice farming influence the amount of CH₄ and N₂O emitted to the atmosphere. Generally, CH₄ gas is produced under flooded or anoxic soil conditions while N₂O gas is produced through nitrification and denitrification processes depending on soil aerobic (oxygenated) and anaerobic conditions. Rice cultivation, for instance, also emits methane (CH₄) depending on where the rice cultivation occurs, and the CO₂ emissions contribute to global warming which will eventually further exacerbate the existential crisis caused by rising sea levels that confronts so many island communities. This document is a review of the current emissions from the Fiji rice industry and elaborates feasible options for mitigation in the future.

1. Rice production in Fiji

Rice has been grown in Fiji for a little over a century. It was cultivated in Fiji before the arrival in Fiji of Indians in 1879. The Indian laborers on sugar cane plantations expanded rice cultivation for family subsistence. The colonial government in 1930s and 1940s started Fiji's first official rice development programs in response to the low sugar prices and high imports of rice. Since 1960, rice area was expanded to the non-sugar land and the specialized areas to grow rice were formed in Northern, Central and Western Divisions. After Independence in 1970, there was another drive for self-sufficiency and this led to the establishment of large-scale (by Fijian standards) irrigation schemes for rice first at Lakena (Central Division) and later at Dreketi (Central Division) and Navua (Central Division). In 1970s, a total of 11 irrigation schemes in the Central and Northern Divisions were established. Along with the construction of irrigation schemes, several rice development projects were implemented, including the Northern Rice Development

Project under Australian Aid in the North, Agricultural Development Project (ADP) in the Central Division and Improvement of Rice Cultivation Technology Project (IRCTP) under Japanese Aid (JICA) at Koronivia Research Station. During 1980s the Government continued applying several policy measures to encourage rice production, which led to a steep increase of rice production since mid-1980s and Fiji attained 75percent of self-sufficiency in rice. Peak production was achieved in 1989 and 1989 at around 30 000 tonnes of paddy rice per year. In the late 1980s, the Government changed the policy in rice development by applying deregulation, removal of input subsidies (agro inputs, machine, water etc.), neglected investment for infrastructure maintenance and at the same time facilitation of rice imports. These adverse policies immediately resulted in negative impacts to the rice industry as the rice area and production started declining and simultaneously rice imports increased.

The major rice growing areas in Fiji are in the Northern, Western and Central Division, of which the Northern Division is the rice bowl of the country. Data from Fiji National Agricultural Census (2020) showed rice production was predominated by the Northern Division, while in Central Division rice production was almost negligible (Table 1). In 2010, the distribution of rice production was as follows: 80 percent of the production was from the North, 15 percent from the West and 5 percent, in the Central Division. The decrease in rice production in the Central Division was due to the damage to irrigation scheme so farmers have converted rice to other dry land crops. In the Northern Division, rice is mainly grown in rural areas of western Macuata and Bua Province. The main production areas are in the Dreketi Irrigation Project areas, sugar cane belt areas of Macuata, Nasarawaqa, Korokadi Irrigation Projects areas and in the Bua flats. In the Central Division, rice is mainly concentrated within Navua areas which are managed by Grace Road Food Company Ltd including small scale farmers scattered within the division. For the Western Division, rice production areas depend on rain fed conditions. Generally, the main areas in the West are, Ra Province, Northern, and Western region of Ba Province and portions of the Nadroga/Navosa Province. There are a total of 1,740 rice farmers throughout the province of Bua, Cakaudrove, Macuata, Serua/Namosi, Tailevu, Rewa, Ra and Ba.

Table 1: Fiji Rice Production trend table

Commodity	Division	Production (Mt)										
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019[p]
Rice	Central	66	65	53	249	99	177	115	399	605	2,073	615
	Northern	11,507	7,283	7,517	4,051	6,426	5,871	5,922	7,857	8,342	4,966	5,058
	Western	64	315	343	353	348	795	292	393	135	13	75
	Total	11,637	7,664	7,914	4,653	6,873	6,843	6,329	8,649	9,081	7,051	5,748

(Data source: Fiji Ministry of Agriculture)

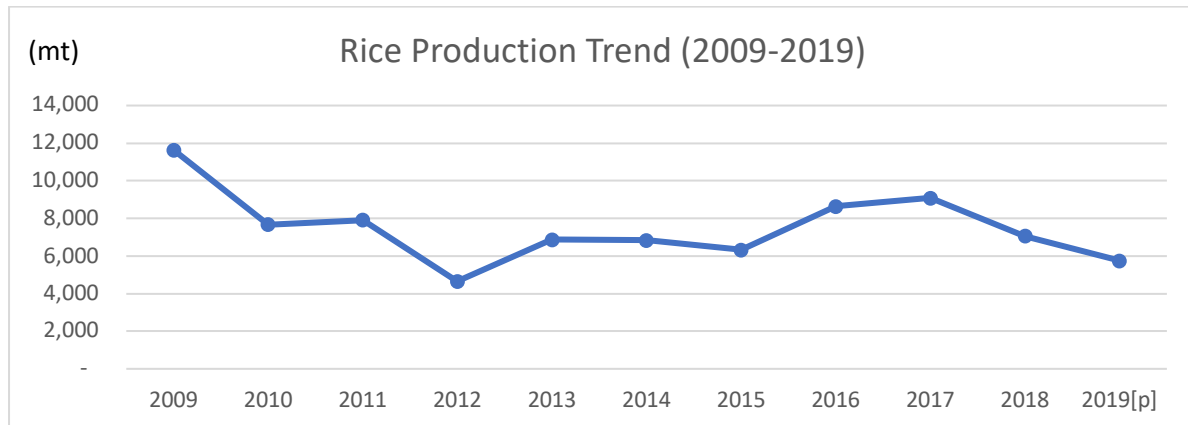
1.1 Rice seasons and ecosystems

The two climatic seasons in a year of Fiji intrinsically have formed the two rice seasons, main season and offseason. The main rice season is in the wet season with transplanting in October - November and harvesting in Feb - May. The second rice season or offseason is in the dry season with planting in June - July and harvesting in September - October. Within the season, rice is grown in the three major ecosystems, namely irrigated, rainfed wet land and rainfed dry land. For 1994 to 2010 the irrigated ecosystem was formed with the construction of irrigation schemes in 1970s in the Central Division and the North Division, which accounted for 20 percent of the total rice area. In this ecosystem, two rice crops were produced per year. Rainfed wet land ecosystem is the dominant system of rice production in Fiji, comprising 44 percent of total rice area. Fields are normally submerged with water. In some parts of this ecosystem, two rice crops can be grown annually. Rainfed dry land ecosystem located in higher elevation where rice is grown only in the wet season with high rainfall or intercropped with other dry land crops like sugar cane. This ecosystem comprised of 36 percent of the total rice area

1.2 Long-term trends in rice production in Fiji

Data on rice area, production, and yield in Fiji in the last ten years (2009-2019) were present in Figure 1 and Table 2 (Data source: Fiji Ministry of Agriculture). The rice area and production in Fiji in the period of 2009-2019 decreased as compared to those in 2000s. In this period, the rice area fluctuated from 1,803 ha in 2012 to 3,355 ha in 2011, the production varied from 4,658 tonnes in 2012 to 7,914 tonnes in 2011, and the yield fluctuated from 2.00 tonnes/ha in 2015 to 3.19 tonnes/ha in 2013. Total rice production in 2018 was 7,015 tonnes (17.5% self-sufficient) from 2,350 ha. Currently

70% of farmers have average land size of 0.8 ha with minimum land size of 0.4ha. There are about 20% farmers with rice land between 2 – 4ha and 10 % with more than 4ha. (Draft Rice policy 2021)



(Source: Fiji Agriculture Rural Statistics Unit/Fiji Bureau of Statistics)

Figure 1: Fiji Rice Production from 2009 to 2019

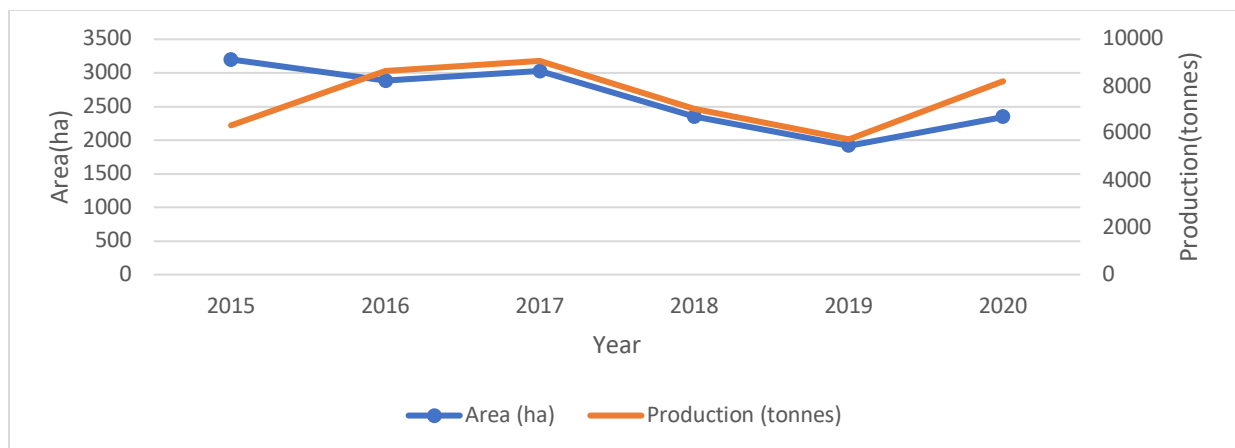


Figure 2: Fiji Rice Production from 2009 to 2019(Data source: FAO STAT and Ministry of Agriculture)

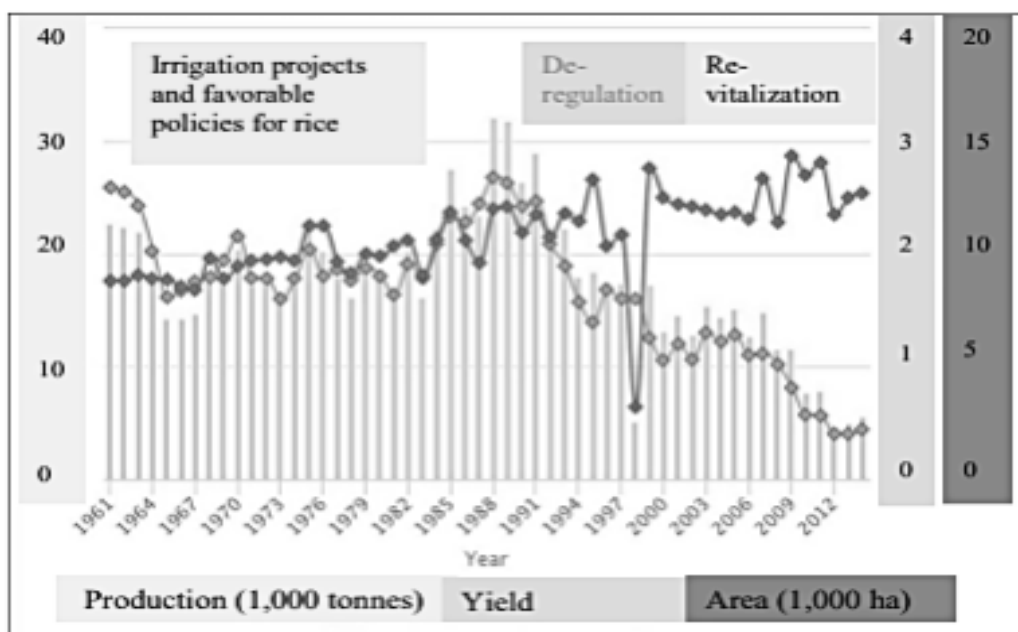


Figure 3. Trends of rice production, area and yield in Fiji (1961-2014)
Source: Ricepeidia(CGIAR/IRRI) and Bong ,2017 FAO (Based on FAO data)

Data on rice area, production and yield in Fiji in the last six years (2010-2020) were present in Table 2 and Figure 3 on Trends of rice production, area and yield in Fiji (1961-2014). The rice area, production and yield in Fiji in the period of 2010-2015 decreased as compared to those in 2000s. In this period, the rice area fluctuated from 2156 ha in 2013 to 1916 ha in 2019, the production varied from 6873 tonnes in 2013 to 5748 tonnes in 2019, and the yield fluctuated from 2.00 tonnes/ha in 2019 to 3.19 tonnes/ha in 2013. In 2016, it is recorded that the rice area increased as compared to the previous years, but in 2013-2019, the lowest yield was recorded in 2015. In fact, the low yield levels, as 2.0-2.5 tonnes/ha in four of six recent years are a matter of concern in the revitalization of Fiji rice industry.

Fiji used the Tier 1 approach because methane emissions from rice cultivation aren't a significant source and country-specific emission factors aren't available. The methane emissions from rice production were calculated using equations 5.1 and 5.3 from chapter 5.5 of volume 4 of 2006 IPCC Guidelines.

Table 2: Fiji Rice Area, Production and Yield trend for the past 10 years

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Area (ha)	2507	3355	1803	2156	3156	3200	2883	3027	2350	1916	2345
Production (tonnes)	7663	7914	4653	6873	6843	6329	8649	9081	7051	5748	8209
Yield (tonnes/ha)	3.01	2.36	2.58	3.19	2.20	2.0	3	3	3	3	3.5

Source: Fiji Low Emission Development Strategy, 2018 and Bong, 2017 FAO

2.0 Calculating Greenhouse Gas Emissions in Fiji

Four worksheets are used for calculating greenhouse gas emissions from this sector. Each worksheet has several component sheets needed to complete the calculations. These are listed in below.

Activities under 3C are subdivided into:

- Biomass Burning (3C.1)
- Liming (3C.2)
- Urea application (3C.3)
- Direct N₂O emissions from managed soil (3C.4)
- Indirect N₂O emissions from managed soil (3C.5)
- Rice cultivations (3C.7)

*There is no biomass burning and lime application in rice cultivation in Fiji.

Rice cultivation, for instance, also emits methane (CH₄) depending on where the rice cultivation occurs (ecosystem – upland rice, irrigated rice, and rainfed rice). The three types of rice farming systems practiced in Fiji depend on the availability of water resources and topography. These three systems are irrigated, rainfed wetland and rainfed dryland which are planted with recommended varieties such as *Sitara*, *Cagivou*, *Star*, *Boldgrain* and *NuiNui*. Most of the CH₄ emissions are from rainfed and irrigated rice cultivation based on the rice flooding regime.

3.0 Methane emission from rice fields

One of the most significant causes of CH₄ emission is anaerobic conditions in wetland rice fields caused by soil submergence. In flooded rice fields, decomposition of organic material releases methane (CH₄), which escapes to the atmosphere mostly through vascular transport through the rice plants. Crop duration, water regimes, and organic soil amendments all contribute to the amount of CH₄ emitted annually from a given area of rice. By multiplying the seasonal emission factors by the annual harvested areas, the CH₄ emissions are calculated. For each sub-unit (state), the harvested area will be

multiplied by the emission factor that represents the conditions that define the sub-unit (state). The total annual emissions are equal to the sum of emissions from each sub-unit of harvested area using the following equation

$$\text{CH}_4 \text{ Rice} = \sum_{i,j,k} (\text{EF}_{i,j,k} \cdot \text{A}_{i,j,k} \cdot 10^{-6}) \quad (1)$$

Where $\text{CH}_4 \text{ Rice}$ = annual methane emissions from rice cultivation, $\text{Gg CH}_4 \text{ yr}^{-1}$; EF_{ijk} = a seasonal integrated emission factor for i , j , and k conditions, $\text{kg CH}_4 \text{ ha}^{-1}$; A_{ijk} = annual harvested area of rice for i , j and k conditions, ha yr^{-1} ; i , j and k = represent different ecosystems, water regimes, type and amount of organic amendments, under which CH_4 emissions from rice may vary. Separate calculations were undertaken for each rice ecosystems (i.e., irrigated, rainfed and deep water rice production).

The baseline emission factor is scaled for organic amendments and water regime in rice ecosystems according to the equation (2) given below

$$\text{EF}_i = \text{EF}_c \cdot \text{SF}_w \cdot \text{SF}_p \cdot \text{SF}_o \quad (2)$$

EF_i = adjusted seasonal emission factor for a particular harvested area (state) EF_c = baseline emission factor for continuously flooded fields without organic amendments. A baseline emission factor for no flooded fields for less than 180 days prior to rice cultivation and continuously flooded during the rice cultivation period without organic amendments (EF_c) is used as a starting point. The IPCC 2006 default for EF_c is $1.30 \text{ kg CH}_4 \text{ ha}^{-1} \text{ day}^{-1}$ (with error range of 0.80 - 2.20). SF_w = scaling factor to account for the differences in water regime during the cultivation period. SF_p = scaling factor to account for the differences in water regime in the pre-season before the cultivation period SF_o = scaling factor for both type and amount of organic amendment applied. (More CH_4 is emitted from amendments containing higher amounts of easily decomposable carbon and emissions also increase as more of each organic amendment is applied. The scaling factor should be based on the application rate of organic amendment and also its conversion factor.

Uncertainties in methane emission

The uncertainties associated with estimating CH₄ emissions are considerable. Various components, including as climate, agronomic techniques, and soil qualities, all contribute to uncertainty. The generation of CH₄ in soil is influenced by a variety of physical, chemical, and biological features of the soil. Different soil types, rice cultivars utilized, and agronomic procedures of water, fertilizer, and manure management all contribute to uncertainty in emission variables. The duration of different rice types utilized in a state is a source of uncertainty. The most popular cultivar in a given region must be determined based on the area under cultivation as well as expert opinion. This factor will be connected with the greatest amount of uncertainty. The application of organic amendments, particularly rice straw incorporation, might be unpredictable. Uncertainties develop as a result of the non-availability of harvested area in each rice ecosystem under each water regime and type of organic amendment. When compared to the accuracy of emission factors, activity data is likely to be more reliable.

Assumptions used in calculations

As methane emissions from rice cultivation is not a significant source and country-specific emission factors were also not available, for Fiji currently the Tier 1 approach is applied. Equations 5.1. and 5.3 in chapter 5.5, volume 4 of IPCC1 2006 were applied to determine the methane emissions from rice production. Area and production data were taken over from a review of rice production, FAOSTAT and Ministry of Agriculture. These data are based on national reports and adjustments made by FAO. FAOSTAT covers the areas of rice cultivation, synthetic fertilizers, enteric fermentation, manure applied to soils, manure left on pasture, manure management, burning – crop residuals, burning – savanna, crop residues, and cultivation of organic soils. These data are also subject to an error frame of 30-50%.

According to IPCC,2006 guidelines the increase in biomass stocks of annual crops in a single year is assumed equal to biomass losses from harvest and mortality in that same year, thus, there is no net accumulation of biomass carbon stocks. Data on the use of nitrogen fertilizers and urea application were taken from the FAO database 2020.

Figure 4 shows the map of Fiji showing rice cultivation in Fiji, it is assumed that 44% of the total area planted is under continuous flooding, 52% is rain fed and 4.2 % s in

upland (Chand, D. 2018). A total of 90 -130 days cultivation was taken into consideration according to the variety taken. Based on the production data, a rice-straw ratio of 1:2 is assumed to calculate the amount of straw produced. The amount of straw absorbed into the soil is determined on the basis of an equal mass basis equal to the dry weight of the straw.

In Fiji, 60 percent of farmers are planting traditional varieties due to reduced costs particularly in the use of fertilizer. However, it has low yields and lodges easily due to heavy rain and strong winds.

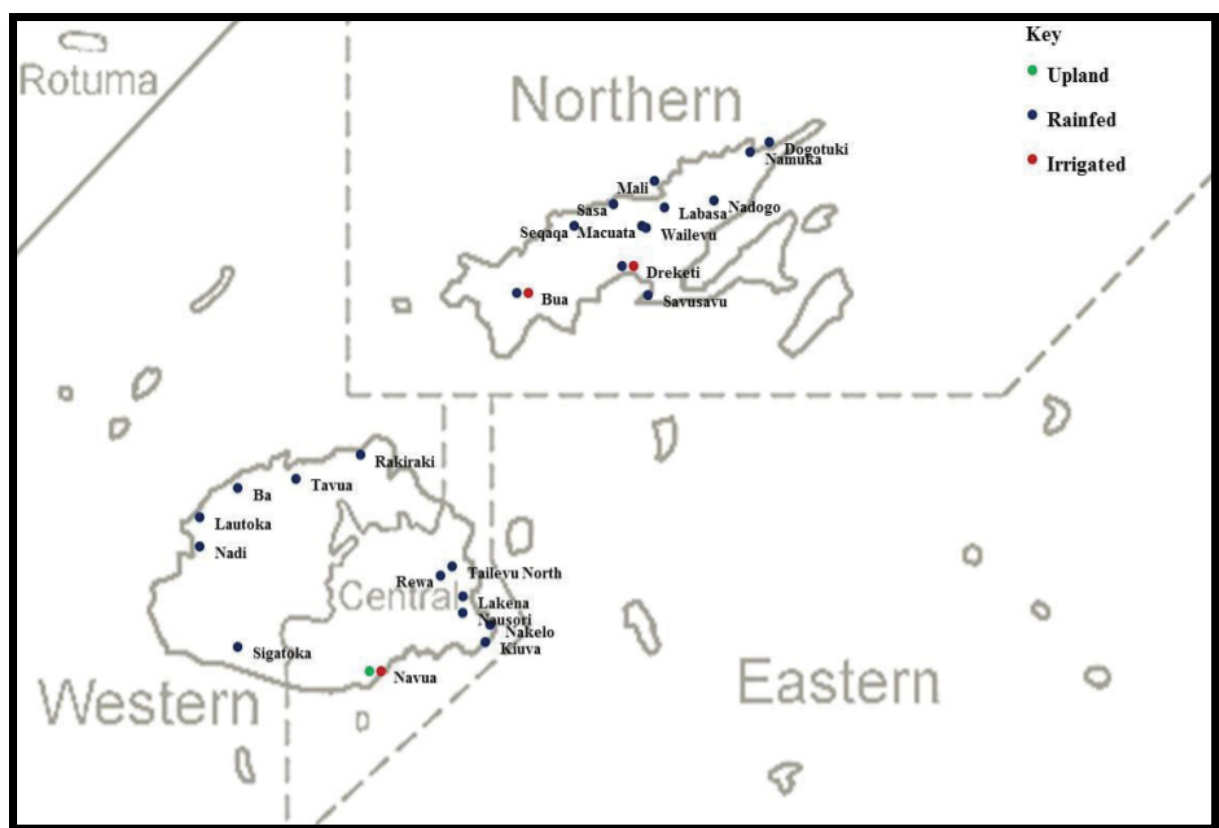


Figure 4: Classification of rice cultivation in Fiji

Rice cultivations and methane emission (3C.7)

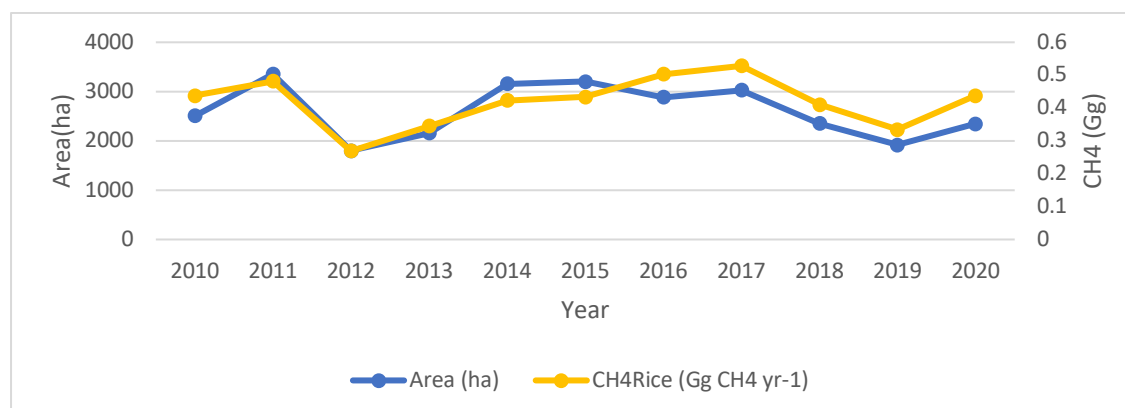


Figure 5: Fiji Rice Methane and Area trend for the past 10 years

Figure 5 shows that the total area of rice planted in Fiji in 2010 to 2020 were 2507 to 2345 ha. The CH₄ emission is positively correlated with the area of cultivation of rice. The lowest was recorded for year 2012. Lower emission has been attributed to the decrease in production of rice as a result of crop failure due to crop damage from natural disaster or land issues between farmers and land owner. Secondly due to cost of production the farmers are unable to make profits from cultivation of rice and thus prefer other cash crops that bring more income. Most of the rice is grown for household consumption in Fiji.

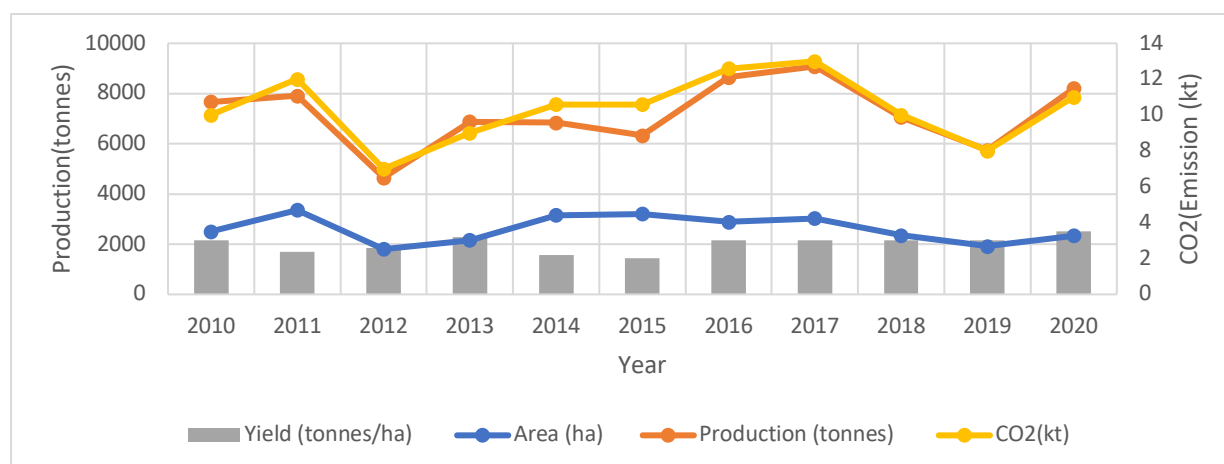


Figure 6: Fiji Rice Production trend for the past 10 years

Data on rice area, production, yield and CO₂ emission in kiloton in Fiji in the last ten years (2010-2019) were present in Figure 6. In this period, the rice area fluctuated from 1,803 ha in 2012 to 3,355 ha in 2011, the production varied from 4,658 tonnes in 2012

to 7,914 tonnes in 2011, and the yield fluctuated from 2.00 tonnes/ha in 2015 to 3.19 tonnes/ha in 2013. Total rice production in 2018 was 7,015 tonnes (17.5% self-sufficient) from 2,350 ha. CO₂ emission was positively correlated with the production and area, the fluctuation in production were due to crop failure or crop damage due to climatic disasters like flooding, cyclones, drought etc. Irrigated rice fields are the major source of methane from rice fields. Methane production is favored by the assured water supply and control, intensive soil preparation and fertilization, and resultant improved growth of the rice.

Methane emissions are much lower and more variable in rain-fed rice because of drought periods during the growing season and poorer growth of rice. Upland rice is not a source of methane emission because it is not flooded for any significant period of time. Methane production is positively correlated with production and area. Sound and feasible management practices that reduces methane emissions, without enhancing nitrogen losses and increasing rice yields, must be developed.

4.0 Urea application (3C.3)

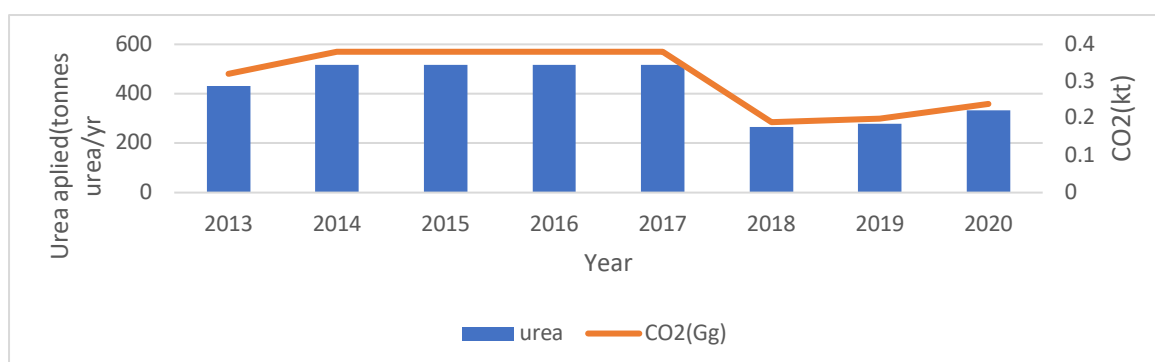


Figure 7: Urea application and emission CO₂ for the past 10 years

Default values Equation 11.9 from the 2006 IPCC's AFOLU Guidelines is used to estimate the emissions from the use of synthetic fertilisers. Default values (Table 11.3 from the IPCC Guidelines) are used for the emission factors and the volatilization from synthetic fertilisers. The annual amount of synthetic fertilisers applied to soil is taken from FAOSTAT (Figure 7). Urea application is positively correlated with the CO₂ emission, the more application of nitrogenous fertilizer more is the emission.

Since FAOSTAT only provides values until 2013, the average consumption of the years 2006 to 2013 is used to estimate the consumption in the years 2014 and 2015, the average consumption of the years 2002 to 2015 is used to estimate the consumption in the years 2016 and 2017. Expert opinion from Ministry of agriculture –Extension officers explained that the urea was not applied from 2001-1994 so the urea consumption data is not available. Ammonium sulphate was applied to rice during that period as reported.

The direct impact of chemical fertilizer applications (table 3) on methane emission is not clear. Because most methane is emitted through the rice plant, improved rice growth (more tiller and roots) in response to fertilizer application increases emission. But source and mode of application may also have direct effects. Sulfate-containing fertilizer reduces methane emission. Sulfate-reducing bacteria compete with methanogens for the limited hydrogen, but the amount of sulfate normally added as fertilizer seems to be insufficient to have significant effects.

Table 3. N-fertiliser and urea application.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
N-fertiliser application (tonnes)	4,220	4,025	6,758	2,747	2,435	4,101	4,020	3,662	3,996	3,996
Urea (tonnes)	453	458	632	948	453	151	605	432	516	516
Source: Fiji Low Emission Development Strategy, 2018										

5.0 Inventory of nitrous oxide emissions from managed soils

Nitrous oxide is produced naturally in soils through the processes of nitrification and denitrification. Nitrification is the aerobic microbial oxidation of ammonium to nitrate, and denitrification is the anaerobic microbial reduction of nitrate to nitrogen gas (N₂). Nitrous oxide is a gaseous intermediate in the reaction sequence of denitrification and a by-product of nitrification that leaks from microbial cells into the soil and ultimately into the atmosphere.

One of the main controlling factors in this reaction is the availability of inorganic N in the soil. This methodology, therefore, estimates N₂O emissions using human-induced net N additions to soils (e.g., synthetic or organic fertilizers, deposited manure, crop residues, sewage sludge), or of mineralization of N in soil organic matter following drainage/management of organic soils, or cultivation/land-use change on mineral soils.

The emissions of N₂O that result from anthropogenic N inputs or N mineralization occur through both a direct pathway (i.e., directly from the soils to which the N is added/released), and through two indirect pathways: (i) following volatilization of NH₃ and NO_x from managed soils and from fossil fuel combustion and biomass burning, and the subsequent re deposition of these gases and their products NH₄⁺ and NO₃ to soils and waters; and (ii) after leaching and runoff of N, mainly as NO₃, from managed soils. Total emissions of N₂O from managed soils are estimated using equation (3)

Total N₂O- N emission:

$$\text{N}_2\text{O-N TOTAL} = \text{N}_2\text{O-N DIRECT} + \text{N}_2\text{O-N INDIRECT} \quad (3)$$

Direct emissions of N₂O from managed soils are estimated separately from indirect emissions, though using a common set of activity data. In most soils, an increase in available N enhances nitrification and denitrification rates which then increase the production of N₂O. Increases in available N can occur through human-induced N additions or change of land-use and/or management practices that mineralize soil organic N

The following N sources will be included in the methodology for estimating direct and indirect N₂O emissions from managed soils:

- Synthetic N fertilizers (FSN)
- Organic N applied as fertilizer (e.g., animal manure, compost, sewage sludge) (FON)
- Urine and dung N deposited as manure (FPRP)
 - N in crop residues (above-ground and below-ground), including from N-fixing (FCR)
- N mineralization associated with loss of soil organic matter resulting from management of mineral soils (FSOM)
- Drainage/management of organic soils (i.e., Histosols) (FOS).

Direct N₂O emissions from managed soil (3C.4)

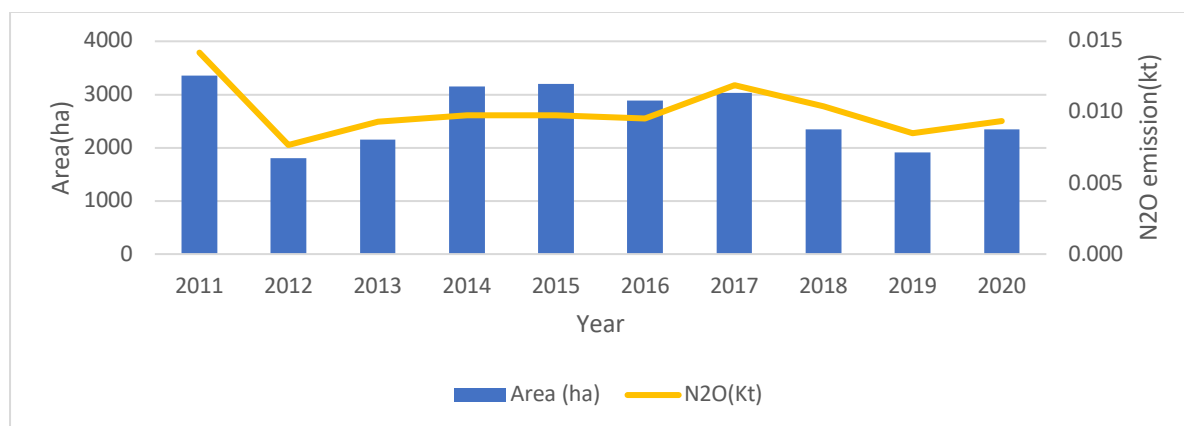


Figure 7: Direct N₂O emissions and area of rice for the past 10 years

Indirect N₂O emissions from managed soil (3C.5)

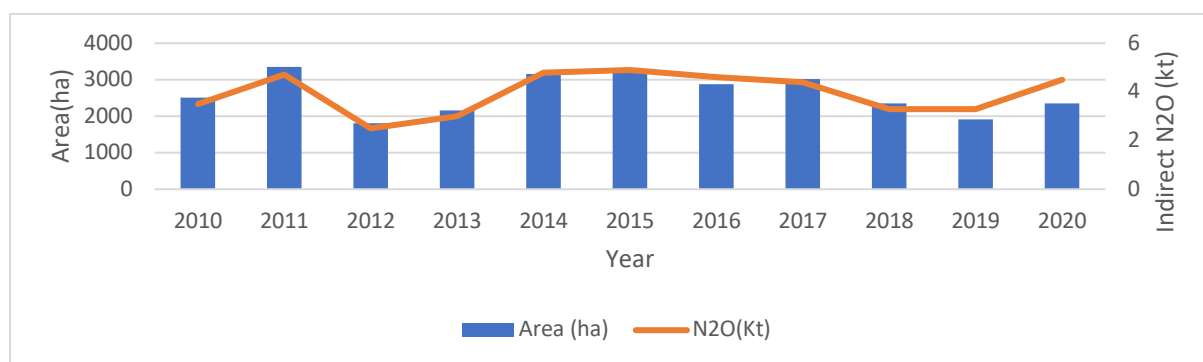


Figure 8: Indirect N₂O emissions and area of rice for the past 10 years

The direct and indirect N₂O emission is positively correlated with the area of cultivation of rice. The lowest was recorded for year 2012. Lower emission has been attributed to the decrease in production of rice as a result of crop failure due to crop damage from natural disaster or land issues between farmers and land owner. Secondly due to cost of production the farmers are unable to make profits from cultivation of rice and thus prefer other cash crops that bring more income. Most of the rice is grown for household consumption in Fiji.

7.0 Recommendations

Methane (CH₄) and nitrous oxide (N₂O) are the foremost critical greenhouse gases due to their radiative impacts as well as global warming possibilities (GWPs). CH₄ and N₂O gasses are at the same time transmitted from rice areas to the air due to their favorable generation, utilization, and transport frameworks. The intensive rice cultivating framework may make over the top weight on rice areas to deliver more rice for the extending populace, subsequently falling apart soil ripeness status and rice paddy biological system adjust by stimulating more CO₂, CH₄, and N₂O fluxes to the environment. The extraordinary climatic factors such as tall light concentrated, tall water vapor or relative stickiness, tall temperature, and dry spell stretch may severely stifle advantageous microbial movement, soil supplements, and water accessibility to rice plant; inevitably, rice surrender may be diminished radically, and at the same time, greenhouse gas emissions can be expanded essentially. In this circumstance, conservation tillage, water saving water system procedures such as alternate wetting and drying, soil revisions with biochar, vermicompost, with minimum fertilizer ought to be presented to the field level agriculturists for maintainable rice generation and mitigating greenhouse gas emissions. Tillage operations, leveling, plant residue incorporation, irrigation frequency and standing water levels, drainage system, and organic and inorganic soil amendments used in rice farming all have an impact on the amount of CH₄ and N₂O released into the atmosphere. This should not, however, exclude the inclusion of low-cost alternatives that reflect a return to traditional agricultural practices that encourage varied incomes and soil resilience (e.g. agroforestry and intercropping).

Table 4. Checklist and detail for data collection for Extension Officer in Rice Division

Checklist(ecosystem)	Data type	Collection of data in Rice field
Irrigated Rice	Aggregated data	<ul style="list-style-type: none">• Number of crops in a year• Duration of crops grown(days)• Soil type• Air temperature• Rice cultivar• Area• Fertilizer applied• production• Yield (straw yield)• Above ground biomass

	Disaggregated data	<ul style="list-style-type: none"> • Water regimes before the cultivation period three ecosystem • Water regime during the cultivation period' • Organic and inorganic soil amendments • Type of drainage for each area • Soil temperature • flooding pattern before and during the cultivation period • Soil pH • Soil Eh (Redox potential)
Rainfed wet land		<ul style="list-style-type: none"> • Number of crops in a year • Duration of crops grown(days) • Soil type • Air temperature • Rice cultivar • Area • Fertilizer applied • production • Yield (straw yield) • Above ground biomass
		<ul style="list-style-type: none"> • Water regimes before the cultivation period three ecosystem • Water regime during the cultivation period' • Organic and inorganic soil amendments • Type of drainage for each area • Soil temperature • flooding pattern before and during the cultivation period • Soil pH • Soil Eh (Redox potential)
Rain fed Dryland Rice		<ul style="list-style-type: none"> • Number of crops in a year • Duration of crops grown(days) • Soil type • Air temperature • Rice cultivar • Area • Fertilizer applied • production • Yield (straw yield) • Above ground biomass
		<ul style="list-style-type: none"> • Water regimes before the cultivation period three ecosystem • Water regime during the cultivation period' • Organic and inorganic soil amendments • Type of drainage for each area • Soil temperature • flooding pattern before and during the cultivation period • Soil pH • Soil Eh (Redox potential)

Conclusion

This manual outlines which data, emission factors, and computation processes are required and sufficient to generate a simple yet reliable GHG national Inventory for rice farming at Tier 1. Fiji used the Tier 1 strategy since methane emissions from rice agriculture aren't a significant source and country-specific emission factors aren't available. However, if the rice-growing area is large, both irrigated and rainfed, there may be more GHG emissions than in years with smaller rice farm areas. There is a requirement for gathering disaggregated data from rice fields that can be used to calculate Tier 2 or 3 methane emissions from rice productions. More participatory, action-oriented study with farmers is also needed to better understand the situation.

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ANNEXURE

Details for Sources for Activity Data in Fiji

Data Sources	Website
Fiji Bureau of Statistics (FBoS)	https://www.statsfiji.gov.fj/index.php
FAO STAT	http://www.fao.org/faostat/en/#home
Fiji Data source 2020 Census	

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