Climate Mitigation Potential of Rice Value Chain

Carbon Balance of Rice Value Chain Strategic Scenarios in Madagascar towards 2020

Par

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SUMMARY

1. Introduction

Within the current evolution of rice value chain in Madagascar towards 2020, two scenarios have been compared, with a base year on 2002-2003 and a perspective of 17 years which roughly covers 2003-2020.

This scenario work is based on in-depth rice value chain scenario building work done in 2002 by UPDR , World Bank and French Cooperation (World Bank[1] , 2002). The political events which have occurred in Madagascar in 2002-2003 and later in 2009 have contributed to rescheduling or delayed strategy implementation at national level and gap of updated information on recent rice value chain development. In this perspective, 2015 initial objectives have been switched towards 2020 (4.3 millions tons of paddy and 2.8% of annual growth). This rice growth scenario has been compared to a business as usual (BAU) more pessimistic scenario (natural trend without massive public intervention).

Within this work, the attention is focused on carbon balance and on land use aspects of the two scenarios. The carbon balance result is an incremental carbon balance due to a wide set of pro-active public interventions.

The Carbon balance tool used is EX-ACT (EX-Ante Carbon-balance Tool); it provides ex-ante estimations of the impact of agricultural and forestry development projects policies and value chain scenarios on GHG emissions and sequestration, indicating its effects on a carbon balance. This tool has been developed by the FAO Policy Assistance Support Service, the Agricultural Development Economics Division, and the Investment Centre. EX-ACT is a land-based accounting system, measuring C stocks and stock changes per unit of land, expressed in t CO_2-equivalent/ha and year.

2. The rice value chain as main employer in Madagascar

With a Monetary Gross Product of 0.8 billion US$ and an economic weight of 1.1 Billion US$, the entire rice supply chain represented the single most important economic activity in Madagascar. The direct value added in 2000 contributed to 12% of the GDP in current terms and to 43% of agricultural GDP. Therefore, the performance of the rice sub sector determines to a large extent the overall performance of the agricultural sector in Madagascar.

A total of 1.721.000 farmers are involved in the production of rice in Madagascar. In addition, there are about 30,000 downstream operators, who perform multiple functions (collection, processing, wholesale, importers, retailers). Since the vast majority of them represent family businesses, there exist approximately 1.750.000 households that are involved in the production, processing and handling of rice. Based on the average family size of 5.7 persons per rural household, it could be calculated that there are about 10 million people in Madagascar, or almost 70% of its

[1] *Bockel, Review of rice value chain, Madagascar Rural/Environmental Sector Review ,World Bank, May 2002*

population, who derive at least part of their economic income from the rice sub-sector.

Increasing rice production through area expansion in last forty decades (1965-2005) has not prevented the rural population falling deeper into poverty. It has led to widespread deforestation, thereby foregoing income-generating opportunities associated with standing forests. And it has caused massive soil degradation with significant off-site erosion effects severely reducing the production potential of irrigation schemes in the Lac Alaotra, Eastern and Northern Regions. The actual environmental costs associated with a strategy based on area expansion implies that a shift towards a strategy based on systems intensification would potentially generate positive externalities, with corresponding justification for public action to facilitate such shift.

Currently with most or rice area being aquatic, highly emitting methane and opening slash and burn mountain rice cropping (tavy) with deforestation trends. Consequently, the rice sector is a main methane and carbon producer which is responsible for a significant part of country carbon track.

3. Carbon foot print and carbon balance

A carbon footprint is a measure of the impact human activities have on the environment in terns of the amount of greenhouse gases produced, measured in units of carbon dioxide. It is "the total set of greenhouse gases (GHG) emissions caused by an organization, event or product". For simplicity of reporting, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted.

Definition of carbon balance: The carbon balance, for a specific project (or scenario of action) in comparison with a reference, should be considered as the net balance of all GHG expressed in CO_2 equivalent computing all emissions (sources and sinks) with the atmosphere interface and the net change in C stocks (biomass, soil…). It can be realized at different scales, locally for an investment, an institution, or globally for a region, a value chain, a country, the planet. Within a dynamic process, it is also possible to appraise the global carbon balance effect of a new action, a project / programme, a strategy or a policy.

Carbon balance appraisal may help to build new strategies to adapt and prevent climate change consequences especially in developing agriculture sector. In this perspective, FAO has just developed EX-ACT, a tool aimed at providing ex-ante estimations of the impact of agriculture and forestry development projects on GHG emissions and C sequestration, indicating its effects on the Carbon-balance (Bernoux et al., 2010).

4. Rice carbon foot print per year

4.1. At global level (IPCC)

Anaerobic decomposition of organic material in flooded rice fields produces methane (CH4), which escapes to the atmosphere primarily by diffusive transport through the rice plants during the growing season. Upland rice fields which are not flooded and therefore do not produce significant quantities of CH_4, account for approximately 10 per cent of the global rice production and about 15 per cent of the global rice area under cultivation.

The remaining area is grown for wetland rice, consisting of irrigated, rainfed, and deepwater rice. The global wetland rice area harvested annually in the early 1980s was about 123.2 million hectares (total harvested area including upland rice is 144 Mha), over 90 per cent of which was in Asia (Neue et al., 1990).

Anaerobic decomposition of organic material in flooded rice fields produces methane (CH_4), which escapes to the atmosphere primarily by diffusive transport through the rice plants during the growing season. When rice grows it produces methane[2] (through anaerobic fermentation).

Of the wide variety of sources of atmospheric CH_4, rice paddy fields are considered one of the most important. The Intergovernmental Panel on Climate Change (IPCC, 1996) estimated the global emission rate from paddy fields at 60 Tg/yr, with a range of 20 to 100 Tg/yr. This is about 5-20 per cent of the total emission from anthropogenic sources. This figure is mainly based on field measurements of CH_4 all fluxes from paddy fields in the United States, Spain, Italy, China, India, Australia, Japan and Thailand (IPCC[3]).

4.2. A rough estimation of the Rice Carbon footprint of Madagascar for 2009

The current annual emission of GHG is estimated at 12.9 million Tons of equivalent CO_2 per year for the whole rice value chain; it translates in 4.8 Kg of CO_2 equiv per kg of paddy and 7.2 kg de CO_2 equiv per kg of rice.

This Carbon foot print is mostly generated by the methane production of aquatic rice (67%) and the deforestation effect (29%) due to the persistence of 149 000 ha of hilly slash-and-burn rice (Tavy).

The methane part of Rice GHG is estimated around 8.7 Tg/year which gives at least 8.7% of Rice based methane GHG produced in Madagascar.

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[2] *On average, the rice paddy soil is only fully waterlogged for about 4 months each year. For the rest of the time methanogenesis is generally much reduced and, where the soil dries out sufficiently, rice paddy soil can become a temporary sink for atmospheric methane*

[3] *http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch4ref5.pdf*

Figure 1: Madagascar rice chain Carbon footprint results 2009 (EX-ACT screenshot)

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq		CO2 Biomass	CO2 Soil	N2O	CH4
Deforestation	3823148	this is a source	3636556	62729	37498	86365
Afforestation and Reforestation	0		0	0	0	0
Other Land Use Change	368163	this is a source	322667	45496	0	0
Agriculture						
Annual Crops	-80541	this is a sink	0	-212048	36399	95108
Agroforestry/Perennial Crops	0		0	0	0	0
Rice	8739244	this is a source	0	0	0	8739244
Grassland	0		0	0	0	0
Other GHG Emissions			CO2 (other)			
Livestock	0		---		0	0
Inputs	42831	this is a source	26504		16327	---
Project Investment	0		0		---	---
Final Balance	**12892845**	**It is a source**	**3985727**	**-103823**	**90223**	**8920717**
Result per ha	**8.9**		**2.8**	**-0.1**	**0.1**	**6.2**

4.3. Comparison of annual carbon footprint on two Indian rice flooding options

In India a study was done to compare carbon footprint of two rice flooding options at national level. The use of DNDC model allowed to estimate impact of a wide scale switch from continuous flooding to intermittent flooding of rice field in India.

Continuous flooding of rice fields (42.25 million ha) resulted in annual net emissions of 1.07–1.10, 0.038–0.048 and 21.16–60.96 Tg of CH_4-C, N_2O-N and CO_2-C, respectively, with a cumulated global warming potential (GWP) of 130.93–272.83 Tg CO2 equivalent.

Intermittent flooding of rice fields reduced annual net emissions to 0.12–0.13 Tg CH_4-C and 16.66–48.80 Tg CO_2-C while N_2O emission increased to 0.056–0.060 Tg N_2O-N. The GWP, however, reduced to 91.73–211.80 Tg CO_2 equivalent.

This provides a carbon balance of 39-61 Tg of CO_2 per year (Pathak, Wassman[4], 2006) for India which 39-61% of the total methane produced by rice at world level.

[4] *Pathak, Li, Wassman, Greenhouse gas emissions from Indian rice fields: calibration and upscaling using the DNDC model,Biogeosciences, 2005*

5. The Carbon balance of a rice value chain upgrading scenario in Madagascar

5.4. Basic assumptions used in the two scenarios: BAU and Upgrading scenario

The upgrading scenario is built around a rice growth strategy which will allow an increase of over 50% of production between 2003 and 2020 (2.8% of growth per year, average yield increased by 37%), while the BAU scenario is built around a very low production growth trend of 0.4% per year.
The main land use management and cropping differences between the two scenarios are the following ones:

- The business as usual scenario with no-change on aquatic rice management dominated by continuous flooding system and flooding pre-season over 30 days and a "laissez aller" policy letting the slash and burn increase by 3.1% per year (up to 250 000 ha in 2020)
- The upgrading scenario with a dramatic change to stop any increase of slash-burn rice and a real switch of 300 000 ha from continuous flooding to intermitted flooding and longer non flooded preseason (total continuous flooding aquatic rice decrease from 1.01 million ha to 0.7 million ha) with improved organic amendment

The tables below give a detail of land use change and crop management practices applied

Table 1: Description of the land use change in the two scenarios

	Base year 2003 (Ha)	Business as usual 2020 (Ha)	Upgrading scenario 2020 (Ha)
Tavy (slash –burn rice)	149243 ha	250 000 ha	149 000 ha
Increase of Tavy		100 000 ha	0 ha
Deforestation generated per year for tavy (1/5 of Tavy area)		30 000 ha	18 000 ha
Deforestation generated on 17 years		510 000 ha	306 000 ha
part remaining in annual crops in 2020		(see tavy)	(see tavy)
part being in degraded land in 2020		410 000 ha	306 000 ha
Rainfall rice			
Traditional rainfall rice (no improved practices, residue burning)	136 003 ha	136 003 ha	60 000 ha
improved rainfall rice (improved practises, nutrient management, no tillage, no residue burning)			76 003 ha

Aquatic – irrigated rice			
Rice irrigated direct seeding (intermittently flooded)	128 767 ha	128 767 ha	94 490 ha
Aquatique en foule traditional (continuous flooding)	822 702 ha	822 702 ha	581 635 ha
Improved SRA Rice (continuous flooding	188 555 ha	188 555 ha	232 653 ha
Intensified SRI Rice (intermittently flooded)	23 246 ha	23 246 ha	174 490 ha
Improved direct seeding (intermittently flooded)			80 000 ha
New irrigated area (intermittently flooded)			30 000 ha

Table 2: cropping and irrigation Techniques used by type of irrigated – aquatic rice

	Water Regime During the cultivation Period	Before the cultivation period	Organic Amendment type (Straw or other)
Rice irrigated direct seeding (intermittently flooded)	Irrigated - Intermittently flooded	Non flooded preseason <180 days	Straw incorporated shortly (<30d) before cultivation)
« Aquatique en foule » traditional (continuous flooding)	Irrigated - Continuously flooded	Flooded preseason (>30 days)	Straw incorporated shortly (<30d) before cultivation)
Improved SRA Rice (continuous flooding	Irrigated - Continuously flooded	Non flooded preseason <180 days	Farm yard manure
Intensified SRI Rice (intermittently flooded)	Irrigated - Intermittently flooded	Non flooded preseason >180 days	Farm yard manure
Improved direct seeding (intermittently flooded)	Irrigated - Intermittently flooded	Non flooded preseason >180 days	Straw incorporated long (>30d) before cultivation)

An other main difference between the two scenarios is the net increase of input use in the upgrading scenario with high increase of Urea used per year from 7000 T to 50000 T per year and a growth of other fertilizers used (from around 2000 T of equiv Nitrogen per year to 5754 T). The manure-compost used in rice will stay stable at 763400 Tons per year in BAU scenario; it will increase up to 1 068 889 Tons by 2020 (+40%) in the upgrading scenario. This compost is estimates with around 5% of nitrogen (to be entered in inputs in Equiv Nitrogen). The use pesticide consumed will increase from 516 Tons to 2167 tons.

5.5. Carbon Balance results: What is the carbon impact of the rice growth scenario?

The rice growth scenario should allow to fix 5.6 million tons of equiv CO_2 per year during the period 2003 – 2020, with an aggregated Carbon balance of -83 millions tons of reduced emissions of equiv CO_2 by 2020.

45% of the carbon balance is due to reduction of methane emitted from aquatic and irrigated rice. 54% of the Carbon Balance is linked with reduction of deforestation due to tavy.

At an assumed opportunity price of 5 US$ per ton, it represents a public value generated of around 415 million US$ (equivalent of 28 millions US$ per year).

The appropriate Monitoring of the evolution of deforestation areas, tavy areas and aquatic rice flooded areas (preseason flooding and crop periodic unflooding) could be a basis of a reasonable rice value chain carbon MRV system.

6. Conclusions

The carbon balance appraisal realized on the rice value chain put forward a mitigation potential rising 5,6 millions tonnes of equivalent-CO_2 per year, during the period from 2003 to 2020, hence contributing to the global effort to decrease anthropogenic emissions and to fight against climate change.

The analysis underlines especially the possible synergies between sustainable land use management, food security and agricultural mitigation.

7. References

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All the related EX-ACT available material can be download with free access on the EX-ACT WebSite : www.fao.org/tc/tcs/exact

Figure 2: Carbon balance appraisal of rice value chain : Incremental Carbon impact of value chain upgrading (2003-2020)

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq		CO2 Biomass	CO2 Soil	N2O	CH4	Per phase of the project Implement.	Per phase of the project Capital.	Mean per year Total	Mean per year Implement.	Mean per year Capital.
Deforestation	**-45542545**	**this is a sink**	-34968413	-8468460	-637459	-1468212	-45542545	0	-3036170	-3036170	0
Afforestation and Reforestation	**0**		0	0	0	0	0	0	0	0	0
Other Land Use Change	**621693**	**this is a source**	0	621693	0	0	621693	0	41446	41446	0
Agriculture											
Annual Crops	**-2768081**	**this is a sink**	0	-1940163	-229156	-598762	-2768081	0	-184539	-184539	0
Agroforestry/Perennial Crops	**0**		0	0	0	0	0	0	0	0	0
Rice	**-37850922**	**this is a sink**	0	0	0	-37850922	-37850922	0	-2523395	-2523395	0
Grassland	**0**		0	0	0	0	0	0	0	0	0
Other GHG Emissions			CO2 (other)								
Livestock	**0**		---		0	0	0	0	0	0	0
Inputs	**2110979**	**this is a source**	1202125		908854	---	1976773	134206	140732	131785	0
Project Investment	**0**		0		---	---	0	0	0	0	0
Final Balance	**-83428877**	**It is a sink**	**-33766289**	**-9786930**	**42239**	**-39917897**	**-83563082**	**134206**	**-5561925**	**-5570872**	**0**
Result per ha	**-39.0**		**-15.8**	**-4.6**	**0.0**	**-18.6**	**-39.0**	**0.1**	**-2.6**	**-2.6**	**0.0**

Figure 3: Calculation of uncertainty

*	Low uncertainty	10
**	Moderate uncertainties	20
***	High uncertainties	33
****	Very high uncertainty	50

Indication of the level of uncertainty expected

Components of the Project	Main approach used	CO2 Biomass	CO2 Soil	N2O	CH4	CO2 Biomass	CO2 Soil	N2O	CH4
Deforestation	Tier 1	***	****	**	**	-11539576	-4234230	-127492	-293642
Afforestation and Reforestation	Tier 1	***	****	**	**	0	0	0	0
Other Land Use Change	Tier 1	***	****	**	**	0	310846	0	0
Agriculture									
Annual Crops	Tier 1	**	****	**	**	0	-970081	-45831	-119752
Agroforestry/Perennial Crops	Tier 1	****	****	**	**	0	0	0	0
Rice	Tier 1	**	**	**	**	0	0	0	-7570184
Grassland	Tier 1	**	****	**	**	0	0	0	0
Other GHG Emissions		CO2 (other)				CO2 (other)			
Livestock	Tier 1	---		***	***	---		0	0
Inputs	Tier 1	***		***	---	396701		299922	---
Other Investments	Tier 1	***		---	---	0		---	---

Problème of permanency may arise

Total uncertainty	-23893321
Global level of uncertainty (%)	29%