Philippines Agricultural Climate Change Project:
"Conservation and Utilization of Crop Residues as a Greenhouse Gas Mitigation Strategy in the Philippines"

Project #: 7014311

End of Project Report

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Executive Summary

The Philippine Agricultural Climate Change Project (PACCP) was conducted in the Western Visayas region of the Philippines from April 2001 to March 2003, to improve rural livelihoods and mitigate greenhouse gases (GHG) through the conservation and utilization of crop residues. The implementation of ecological farming systems in tropical regions is of paramount importance in helping mitigate global climate change. In countries like the Philippines, a massive volume of crop residues are conventionally being disposed of through open field burning which contributes to rising anthropogenic concentrations of carbon dioxide, methane and nitrous oxide. As well inorganic N fertilizer use in farming systems also plays a major role in rising GHG's emission levels.

Encouragement of ecological sugarcane and the introduction of an improved rice hull cooker are two strategies implemented to more efficiently use crop residues in GHG mitigation. The project was implemented with NGO's and farmer groups in Negros Occidental and Panay in the Western Visayas region of the Philippines. Project activities were mainly carried out in semi-feudal lands of Southern Negros. During the course of the programming, the agrarian land reform struggles between powerful local landlords, the local NGO partner and the farmers groups intensified in Southern Negros. This created a challenging situation to implement the project as the land reform struggles at times were overwhelming for the local NGO.

The project encouraged the development of ecological sugarcane farming (which included trash farming) through 20 on-farm demonstration sites, seven farmer-led plant material trial farms and extensive farmer trainings. In ecological sugarcane production systems, crop residues are conserved in the field and allowed to decompose. When used in this manner, they fulfill important ecological functions that lead to increased soil carbon levels; as well, biological N fixation is encouraged during the decomposition process. The project further created a biological N cycle to displace the use of inorganic fertilizer through the identification and propagation of Biological N Fixing (BNF) sugarcane cultivars. The introduction of ecological sugarcane farming changes sugarcane from a source to a sink for GHG by increasing C sequestration in the landscape and increasing the population of methane oxidizing bacteria. These bacteria play an important role in naturally regulating the methane levels of the biosphere.

The demonstration sites, variety trials and trainings were successful in helping develop ecological sugarcane farming. Five sugarcane cultivars were identified through the adaptability trials and field demonstrations that could be productively grown without inorganic fertilizer N. These varieties are suspected to be BNF varieties and are continually multiplied and distributed by the farmer networks involved in the project. To our knowledge this is the first effort in Southeast Asia to screen sugarcane germplasm for its BNF potential under ecological growing conditions. The approach of using single replication trials comparing a number of varieties across sites was a low cost and highly efficient mechanism for assessing improved germplasm that was adapted to ecological farming. A training module was developed on ecological sugarcane farming. During the five quarter field lifetime of the project, a total of 534 trainees received training on ecological sugarcane farming. Trainees also were successful in adopting trash farming. Assessments of farmers receiving training in the first year indicated that 32% of the

farmers adopted the system within the first 12 months of receiving the training. A total of 170 hectares of trash farmed (or ecological sugarcane) production was realized in year 1. 184, or 34% of farmers trained were women. The 534 ecological sugarcane trainings held during the project lifetime completed 42% of the targeted 1250 trainings for the project. The implementation of the training programs were somewhat challenged by the sensitivity surrounding the perceived promotion of cane monoculture by the project. The training aspect of this component of the project was reoriented towards the encouragement of ecological sugarcane farming within a diversified farming context to help address this issue.

Ecological sugarcane farming was found to be highly effective in mitigating greenhouse gases and to reduce sugarcane production costs. The implementation of ecological sugarcane farming was estimated to result in the prevention of 9.67 tonnes $ha^{-1}yr^{-1}$ of CO_2 with the implementation of trash farming in conjunction with the use of biological N fixing varieties. The projected GHG offset from the introduction of trash farming and BNF varieties was estimate to be 1643 tonnes of CO2 equivalents. Through the introduction of trash farming and the use of BNF sugarcane varieties, farmers were projected to save $130/ha on inorganic N fertilizer use. This represented a savings equivalent to 14% of the total annual revenues small farmers obtain from sugarcane farming.

The second component of the PACCP project was the introduction of an improved rice hull cooker (the LT-2000) to displace the use of fuelwood, charcoal and LPG (liquid petroleum gas) and kerosene fire-starter as household cooking fuels. On average, the LT-2000 was reported by communities to displace 76% of the cooking fuel used by their rural households. During the course of the project, REAP- Canada staff improved the LT-2000 cooker to create the Mayon Turbo Stove (MTS). It is an advanced combustion household cooker that provides greater convenience, economic savings and provides a high quality non-luminescent or blue flame.

Three rice hull stove fabrication workshops were established, and during the project 5403 stoves were produced, 3496 stoves were placed into distribution networks and 2645 stoves were in use in households by the end of the 5th quarter. Purchasers of the stoves received training at the point of sale to ensure proper use. A reflow program from the stove sales was developed for the stove component of the project to ensure continued collection of payments.

A total of 193 households using the LT-2000 rice hull stove were surveyed to assess fuel consumption changes and the economic impacts of the stoves introduction in Negros and Panay. The introduction of an improved rice hull cooker was found to reduce purchased fuel costs by 1142 pesos/yr in Negros. Savings on the rice growing island of Panay were projected to be higher, 1588 pesos per household, as more rural households buy charcoal and LPG as less fuelwood is available for local collection. In the Western Visayas, investing in a (US) $7 rice hull cooker appears to be saving approximately (US) $26 in annual household fuel cooking costs or approximately (US) $65.50 over the stoves projected lifespan. The annual savings represented approximately 4% of a households annual income. The net reduction in annualized cooking costs was 55% compared to current household cooking systems.

The rice hull cooker was also identified as a highly effective means to reduce GHG emissions in households. Each LT-2000 was projected to create a reduction of 982 kg CO_2 equiv/yr. This was mainly due to reductions in fuelwood burning. In Negros, the LT-2000 was found on average to displace the burning of 1734 kg of fuelwood/household.

The initial project design proposed that by the end of the project implementation, the adoption of ecological sugarcane farming and the use of rice hull cookers would be mitigating 5000 tonnes of CO_2 equivalent on an annual basis. The ecological sugarcane farming was found to reduce annual GHG emissions up to 1643 tonnes of CO_2 equivalent assuming trash farming with active BNF. It was determined that each rice hull stove prevented the emission of 982 kg CO_2 equiv/yr, and that the total GHG savings for all stoves sold was 2597 tonnes of CO_2 equiv/yr. The projected GHG being mitigated by the end of the 5th quarter from the two project components mitigated 4240 tonnes of CO_2 equivalents.

Aside from the benefits in reducing greenhouse gases, the Philippine Agricultural Climate Change Project also provided other benefits to rural development including: reduced deforestation, increased net farm income, reduced household expenditures, improved air quality, improved quality of life for women, and enhanced capacity of small farmers and their organizations.

RESULTS BASED WORK BREAKDOWN STRUCTURE (WBS)

IMPACT
REDUCED GREENHOUSE GAS EMISSIONS
from Ecological Sugarcane Farming
and Household Cooking

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OUTCOMES
Annual reductions in global warming commitment (GWC) of 5000 tonnes of carbon (as carbon dioxide) achieved by project completion

A. ECOLOGICAL SUGARCANE FARMING	**B. MAYON TURBO RICE HULL STOVE**
40% of farmers trained in ecological sugarcane farming (ESCF) adopt technology	Annualized household cooking costs for women decline by 25% for 9000 stove users

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OUTPUTS
- A1 Data gathered from 20 demonstration sites and 6 cane variety trial sites
- A2 10% increase in net income from adoption of ecological sugarcane farming (ESCF)
- A3 Increased awareness and skills in diversified integrated farming system/ecological farming system (DIFS/EFS)
- A4 Estimates provided for GWC reductions from adoption of ESCF

OUTPUTS
- B1 9000 stoves purchased and in use
- B2 Women enhance skills in training and biofuel cooking
- B3 Reduction in overall household fuel costs
- B4 Estimates provided for GWC reductions

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ACTIVITIES
- A1 Assessment of ESCF demonstration sites and variety trials
- A2 Survey of farmers to examine costs and field practices adopting ecological sugarcane farming
- A3 3000 farmers trained in EFS
- A4 Assessment of components to derive greenhouse gas reduction

ACTIVITIES
- B1 Manufacture and distribution of 3000 stoves per year for 3 years
- B2 9000 trainings to improve household cooking skills
- B3 Conduct surveys to examine fuel consumption and costs
- B4 Assessment of components to derive greenhouse gas reduction

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Glossary of Terms

BNF – Biological Nitrogen Fixation
C - Carbon
CARP - Comprehensive Agrarian Reform Program
CH_4 – Methane
CIDA – Canadian International Development Agency
CO – Carbon Monoxide
CO_2 – Carbon Dioxide
CPU - Central Philippine University
CR - Conversion Ratio
DIFS - Diversified Farming System
EF- Emission Factor
EFS - Ecological Farming System
eqv. – Equivalent
equiv. - Equivalent
ESCF - Ecological Sugarcane Farming
FAO – Food and Agriculture Organization
FY – Fiscal Year
GHG - Greenhouse Gas
GJ - Gigajoules
GWC – Global Warming Commitment
GWP – Global Warming Potential
ha - hectare
IPCC – International Panel on Climate Change
IRRI - International Rice Research Institute
kg - Kilograms
LPG – Liquid Petroleum Gas
LT-2000 - Lo Trau 2000 Stove
MAPISAN – Local farmer alliance of 13 farmer organizations in Negros
MASIPAG - National Philippine organization of farmer alliances and scientists on sustainable agriculture
MJ – Megajoule
MTS - Mayon Turbo Stove
N - Nitrogen
NCEF – Negros Centre for Ecological Farming
NGO – Non-Governmental Organization
NO_x – Nitrogen Oxides
N_2O – Nitrous Oxide
NMVOC – Non-Methane Volatile Organic Carbon
PACCP - Philippine Agricultural Climate Change Project
PATANOM - Local farmer alliance of farmer organizations in Panay
PCB - Provincial Consultative Bodies
PDG – Paghida et sa Kauswagan Development Group
PhP – Philippine Peso
PMC – Project Management Committee
PMF – Project Monitoring Framework

P.O. – People's Organizations
PTT – Project Technical Team
REAP – Resource Efficient Agricultural Production
RHS – Rice Hull Stove
SA – Sustainable Agriculture
SCTF – Sugarcane Trash Farming
SPPG - Systems, Policies, Procedures and Guidelines
SRA - Sugar Regulatory Administration
TF – Trash Farming
TNMOC – Total Non-Methane Organic Carbons
USAID – United States International Aid Agency
USD – United States Dollar
USEPA - United States Environmental Protection Agency
yr - year

1.0. Introduction

1.1. Purpose of Report

The purpose of this report is to summarize, assess and evaluate the performance of the Philippine Agricultural Climate Change Project over its course beginning April 1, 2001 and closing February 28, 2003. This report covers the two annual reporting periods of the entire project implementation.

The report will also explain the larger context under which project activities took place and the progress towards achieving the project's impacts, outputs and outcomes as detailed in the Results Based Work Breakdown Structure. These results will be evaluated using the indicators enumerated in the Performance Measurement Framework as well as those established for the activities in the first Annual Work Plan for 2001-2002. Major activities of each component will be described, including activities undertaken to achieve the outcomes, outputs and impacts set for the period. Recommendations based on lessons learned are also included in this report.

1.2. Summary of project status

Project activities were suspended in the field after the first quarter in the second year due to partnership difficulties encountered at that time. Because of this, not all activities could be completed as specified in the project proposal. This report details the activities completed to date, and their comparison to targets set for the three year period and adjusted for the 5 quarter actual field lifetime of the project.

2.0. Project Context

2.1. Project rationale

Increased concentrations of greenhouse gases in the atmosphere are affecting the global climate and have become a pivotal environmental issue. Carbon dioxide (CO_2) and Carbon monoxide (CO), methane (CH_4), and nitrous oxide (N_2O) are the main contributors to the greenhouse effect, constituting 72-83% of total greenhouse gas emissions (Weier, 1998), with their concentrations in the atmosphere increasing at an annual rate of 0.5% CO_2, 0.9% CH_4, and 0.25% N_2O. Approximately 20% of the annual increase in radiative forcing is attributed to agricultural activities and 14% is related to agricultural-related land use changes (Cole C.V. *et al*., 1997). Eighty percent of the radiative forcing created by agricultural activities arises in tropical agroecosystems (Duxbury, 1994).

The Philippine landscape has been dramatically transformed in the past 40 years by the widespread conversion of tropical forests into agricultural land. This has resulted in a major loss of standing carbon from the landscape. Land use pressure is intensive, as the population has risen to 80 million people on a land base that is only slightly largely than the state of Arizona. Unlike other areas of the world, there is little surplus land available in the Philippines for the planting of biological carbon sinks as a greenhouse gas abatement strategy. Strategies for greenhouse gas abatement will largely need to evolve from modified agricultural land use practices and fossil fuel substitution in rural and urban areas. Furthermore, these modifications to land use and resource utilization will have the best chances of successful implementation and replication if they contribute to poverty alleviation and to the rehabilitation of the natural resource base in the Philippines.

In the tropics, biomass burning is widely used in the agricultural sector for various activities such as forest clearing for crop production and ranching, shifting cultivation, pest, insect and weed control, energy production for cooking and heating, and for the disposal of agricultural waste. This widespread practice of burning produces large amounts of trace gases and aerosol particles that impact atmospheric chemistry and climate, in turn affecting human health and local environmental quality. Rice and sugarcane residues make up 31% and 11% of the agricultural wastes in the developing world (Crutzen and Meinrat, 1990), and in Southeast Asia, burning of residues in the field is the preferred method of waste disposal. It is estimated that 64% of the sugarcane fields and 90% of the rice fields are burned every year in the Philippines (Mendoza and Samson, 1999). This burning of approximately 3 million tonnes of sugarcane residues and 8.1 million tonnes of rice straw results in the loss of the energy equivalent of 30 million barrels of oil to the atmosphere.

This project minimized sugarcane and rice residue burning through the conservation and improved utilization of crop residues, thereby mitigating the release of greenhouse gas emissions in several ways. Through the breakdown of crop residues in tropical soils, emissions from burning are mitigated, organic carbon levels increased, and nitrogen fixation encouraged by soil organisms. N-fixation by soil organisms in turn leads to reductions in nitrogen fertilizer requirements (the most energy intensive input used in crop production). As well, the project assessed and distributed biological nitrogen fixing (BNF) sugarcane varieties, which reduced or eliminated the use of inorganic N fertilizer applications by small farmers. Dramatically reducing or eliminating inorganic fertilizer applications and the cessation of burning enhances methane consumption by encouraging the population of methanotrophic (methane consuming) bacteria in the soil. Thus greenhouse gas emission levels are affected in a multitude of ways through the introduction of ecological sugarcane farming. Since fertilizer applications represent 25% of the production cost for sugarcane, minimizing the need for purchased fertilizers can have major implications on improving farmers' livelihoods.

Additionally, this project lowers greenhouse gas emissions by utilizing crop residues in place of fossil fuels (kerosene and LPG) and wood based fuels (firewood and charcoal) in domestic cooking applications with the introduction of the Mayon Turbo Stove. A study by REAP Canada for USAID (Samson *et al.* 2000) identified the use of rice hulls for domestic cooking as a promising biofuel programming opportunity to help mitigate greenhouse gas emissions and poverty in the Philippines. Since household cooking costs can typically consume about 6% of a families household income, impoverished households are interested in low cost cooking approaches that can enable them to reallocate their scarce resources to other high priority needs such as food and education. An improved rice hull cooker also reduces the pressure on forest resources by lowering consumption of firewood and charcoal, and improves women's health by reducing household smoke.

2.2 Development Context

The main programming area for the project is the Southern part of Negros Occidental, which has a long history of social struggles. The perpetuation of sugarcane production for export by a handful of elites who owned vast tracts of land which brought about semi-feudalism and its associated difficulties. This brought massive landlessness to the peasantry and their exploitation in the form of substandard wages for the sugar workers. The region suffered severe malnutrition in the mid 1980's as a result of the collapse of the sugarcane industry. It follows today that promotion of the crop is still perceived by some to bear the stigma of maintaining the landscape of a sugarcane monoculture. The province of Negros Occidental has seen some level of diversification since the 1980's, however it ranks last amongst all the Philippine provinces in inplementation of Agrarian land reform. The region of southern Negros was a hotbed of insurrection in the 1980's and remains a conflict region of the Philippines. The activity of paramilitary groups and armed rebels is increasing. The paramilitary groups make their livelihood by protecting and expanding the interests of powerful landlords and other large local businessmen. NGO's like PDG who work to help small farmers gain access to land through the governments agrarian land reform program are finding themselves increasingly in a conflict situation with these powerful groups. On several occasions during the course of the project, farmers in the MAPISAN Alliance and staff of PDG were ambushed by "hired hands" of the landlords. This created an increasing security risk for all involved in the project, and staff were not able to travel alone and/or had restricted travel in some areas. In Panay there is no large sugarcane industry and more of a middle class is present. Agrarian land reform has been more widely implemented in Panay, and overall the island represents a much more socially balanced situation than exists in Negros.

2.3. Project description

Activity A: Assessment and Demonstration of Ecological Sugarcane Farming as a Greenhouse Gas Reduction Strategy

The project set out to encourage sugarcane trash farming (in field crop residue composting) as an alternative management approach to the traditional strategy of burning the residue in-situ. The trash farming practice has two components. Firstly, dead cane material is removed manually three months before harvest or through the introduction of self detrashing varieties. Secondly, after harvest, residual sugarcane biomass (leaves and cane tops) is again maintained on the field. As the project evolved the project partners developed the trash farming strategy within a larger framework of ecological sugarcane farming systems. Using this approach, fertilizer inputs were reduced or eliminated and farming systems diversification (including intercropping with food crops) was emphasized.

The elimination of crop residue burning and reduction in fertilizer inputs can be important strategies for GHG abatement by reducing the quantity of CO_2, CO, N_2O and CH_4 emanating from sugarcane production systems. Conservation of sugarcane residues prevents GHG emissions from the burning process, sequesters carbon in soils and fixes nitrogen during the decomposition process replacing the need for, and GHG emissions from, fossil fuel based nitrogen fertilizer sources (Refer to Appendix G1). Introducing biological nitrogen fixing (BNF) sugarcane varieties further helps reduce fossil based energy inputs. In addition, the combination of BNF varieties with ecological sugarcane management practices encourages high carbon sequestration and atmospheric methane consumption in soils. The greenhouse gas benefits associated with the adoption of ecological sugarcane farming are further outlined in Appendix G2.

The adoption of ecological sugarcane farming systems in southern Negros was encouraged using the following strategies:

A1) Development of 20 Ecological Sugarcane Farming Demonstration sites

20 Field demonstration sites were established in Negros to demonstrate trash farming in the years 2001 and 2002. The plots were used to demonstrate the technology of trash farming over a widespread area in central and southern Negros and to encourage the more extensive utilization of ecological sugarcane production.

A2) Assessment of Sugarcane Germplasm for Ecological Sugarcane Farming

Prior to this project, all sugarcane plant material evaluation in the Philippines was being performed on lowland soils under intensive management regimes by sugarcane research centers or the estates of large landlords. Typically these trials were burned after harvest, heavily fertilized and data gathered only from the plant (first year) and first ratoon crop. In this project, trial farms were established in cooperation with farmers associations of the MAPISAN Farmers Alliance at both lowland and upland locations and managed using an ecological farming systems approach. Adaptability trials were established at 7 locations during the first two years of the project and farmer trainers helped collect data and assess the materials at the respective sites. The material also served as germplasm for multiplication and distribution to the farmers for verification trials on their own individual farms. The approach of adaptability trials and verifications trials is being used for rice and corn evaluation by small farmers and was applied to sugarcane for this project.

A3) Training Programs on Ecological Sugarcane Farming for 1000 farmers per year

Training sessions were held in Negros and Panay with farmers receiving education on ecological farming and sugarcane production. The trainings incorporated the lessons learned from the on-farm research trials and field demonstrations and included field visits to the sites to provide the farmers with a solid basis from which to make effective decisions about their farm practices. The course was integrated within the farmer-to-farmer participatory training program of the MAPISAN Farmers Alliance.

A4) Estimates of Greenhouse Gas Reductions

Greenhouse gas reduction estimates from the introduction of cane trash farming were made to identify the mitigation potential of this strategy. This was done by:

1) Assessing greenhouse gas emissions associated with the practice of field crop burning and N fertilizer application. The IPCC Greenhouse Gas Inventory workbook (1996), as well as more recent and relevant data (USEPA 1999; USEPA 2000) was used to provide estimates of direct and indirect greenhouse gas emissions.
2) Developing estimates of the potential GHG reductions by CO_2 sequestering in soil organic matter and methane consumption by methane oxidizing bacteria from ecological sugar farming. The estimates were calculated using data from literature sources and from recognized experts in these fields.

Activity B: Manufacture and Distribution of Mayon Turbo Rice Hull Stoves

Household cooking is one of the most important energy issues in rural areas and can be a significant household expense for impoverished rural families. In addition, household cooking also contributes significantly to GHG emissions through its role in deforestation and the loss of standing biomass. As the population of the Philippines grows, GHG emissions from cooking are increasing from the expanding use of wood-based biofuels, LPG and kerosene. A promising approach for reducing GHGs while developing a low cost renewable energy source is the introduction of clean burning biofuel stoves which use agricultural residues as fuel. Given that there is approximately 2.3 million tonnes of rice hulls produced annually in the Philippines, and that much of it is dumped and burned in smoldering fires, its use as a biofuel has a large potential. In addition to rice hulls, other agricultural residues such as coconut husks (2 million tones) and maize cobs (500,000 tonnes) exist in large enough quantities to be used as biofuels (Mendoza *et al*., 2000).

The LT-2000 and Mayon Turbo Stove (MTS) are stoves capable of burning loose and porous biofuels such as rice hull and coffee shells. These biofuels can also be supplemented with sawdust, coconut shells, corn cobs and peanut shells in the cooker as a more environmentally and economically attractive option for rural cooking requirements. At the outset of the project, REAP-Canada staff reworked the original Lo-Trau stove to create the LT-2000 and subsequently with further design work created the Mayon Turbo Stove (MTS). The MTS is an advanced combustion appliance that is smaller in size with a high quality flame and reduced maintenance requirements. Each MTS can provide significant ecological benefits by displacing the annual use of 2 tonnes of fuelwood in households with approximately 1000-1200 kg of waste rice hull. Currently in the Philippines, fuelwood is mainly used in unimproved stoves or open fires with an average end use efficiency of approximately 9% (Samson *et al*., 2000). Unsustainable levels of fuelwood harvesting and charcoal production are contributing to the loss of forest cover. Reduced forest cover in turn, reduces the CO_2 storage capacity of the landscape and contributes to non-CO_2 greenhouse gas emissions (primarily methane produced during charcoal manufacturing and inefficient wood fuel combustion). The benefits of the MTS extend beyond GHG emission reductions to include: greater cooking convenience, reduced exposure to indoor air pollutants, and improvements in the lives of women[1].

B1) Manufacture and distribution of 3000 stoves per year for 3 years

The project aimed to manufacture and distribute 9000 improved rice hull stoves in Negros and Panay over a 3-year period. The stoves were made at a local small tool fabrication workshop operated by PDG and MAPISAN in Negros, as well as by farmers associations in Panay. The stoves were sold and distributed in Negros mainly by PDG, and affiliated farmer's federations belonging to the MAPISAN Farmers Alliance. In Panay, the sales network was established by MASIPAG-VISAYAS and organized through member organizations such as the PATANOM Farmers Alliance.

B2) 9000 trainings to improve household cooking skills

To ensure safe and optimal use, farmers were trained on stove use by farmer trainers and local project staff associated with the stove distribution networks in Negros and Panay. These trainings consisted of cooker demonstrations and pamphlets provided at point of sale. Ongoing support from local village

[1] In some villages of Negros women spend 5-10 days/month walking to collect fuelwood.

trainers was available to ensure proper stove use, helping users to minimize household smoke and improve convenience.

B3) Conduct surveys to examine fuel consumption costs

Fuel use surveys were conducted in target communities in Negros and Panay to determine the change in cooking patterns and fuel consumption practices due to the introduction of the rice hull stove. This information was supplemented with the fuel consumption data from a 1995 Philippine household survey to provide a baseline of greenhouse gas emissions and economics of the various fuels and cookers available to communities. Surveys also provided feedback to the stove marketing team and manufacturers to understand the user profile and the poverty alleviation impacts of the stove.

B4) Estimates of Greenhouse Gas Reductions

The fuel use surveys enabled an estimate of GHG emissions reductions due to the introduction of the stoves produced during the project. The data for the GHG emissions from the various primary fuels and kerosene fire starter were developed from recent reports on GHG emissions from household cooking systems and charcoal production.

The GHG benefits associated with the introduction of the Mayon Turbo Stove are outlined in Appendix H.

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3.0. Assessments of Results Achieved

3.1.Summary of Planned to Actual Achievements
(please refer to Annex A and B for the tabular form of planned vs. actual)

Ecological Sugarcane Farming

Although a pilot scale project implemented by project partners and farmers groups in Negros in 2000 had been implemented successfully, the sugarcane trash farming component of the project proved controversial and difficult to put into practice in the semifeudal sugarlands of Negros Occidental. The scale of the current project (training 3000 farmers on sugarcane farming) created resistance within key project staff in the local NGO partner as some of the staff had been working to implement agrarian land reform against powerful sugarcane landlords. The agrarian land reform struggles turned increasingly violent as the project evolved. To enhance the social acceptability of the ecological sugarcane farming, the component was reworked at the end of the first year to enable ecological sugarcane farming development to proceed, but only when the training and demonstrations were made within a Diversified Farming System (DIFS)/Ecological Farming Systems (EFS) approach. It was also mutually agreed by the project partners that several key project staff that strongly disliked the sugarcane industry needed to be moved onto unrelated projects. It should be stated that the vast majority of farmers appreciated the project as sugarcane is their most important income generating crop and is well adapted to the marginal upland areas of Negros. More than half of all the MAPISAN Farmers Alliance members grow sugarcane with typical planting areas of about 1ha. The crop is ecologically well adapted to the erosion prone and shallow soils of the upland areas of Negros compared to other upland cash crops such as corn, cassava, or peanuts. Prior to this project, the local partners had performed no crop improvement with sugarcane and the farmers welcomed this new undertaking.

Output A1: The ecological sugarcane farming component was largely completed as planned. This activity involved the participation of local farmer's groups that were interested in improving their agricultural practices and testing new plant materials.

Output A2: Sugarcane is an annual crop harvested October through April and the shortened project lifecycle did not enable the detailed household survey to be completed in the second year. However, it was evident that the identification and promotion of BNF sugarcane varieties by the project was enabling significant savings on N fertilizer for small farmers resulting in substantial improvements in net income.

Output A3: The training of 534 farmers in ecological sugarcane production during the lifetime of the project. The promotion of trainings on ecological sugarcane farming and land conversion from conventional to ecological sugarcane farming proved difficult. Midway through the first year, this component was revised to encourage the training of ecological sugarcane farming within a DIFS/EFS component. A new training module was developed and translated during the second year with significant leadership in this activity by experienced farmer trainers.

Output A4: A thorough analysis of GHG reductions was also made by REAP-Canada staff and ecological sugarcane farming was identified as a highly effective means of mitigating GHG on a per hectare basis.

<u>Rice Hull Stove</u>

The rice hull stove component was generally very well appreciated by all the project partners and proved much easier to implement than the ecological sugarcane farming component. For Output B1, local staff were trained to produce the stove and efficient production systems for the stove developed in three shops in the Western Visayas. By the 5^{th} quarter of the project 5403 stoves had been built, 3496 were distributed into marketing channels and 2645 sold. Given that stoves sales generally increase in a near linear fashion when a new small-scale stove is introduced, there likely would have been no difficulty in achieving the 9000 stove target for the project had the project been allowed to reach its completion. For example, stoves sales in Panay increased from 65 stoves per month in the first half of the first year to 75 stoves per month in the second half of the first year. In the 1st quarter of the second year, 148 stoves per month were marketed. The stove survey in Negros also indicated the stove was being used by households. The LT-2000 was found to displace 76% of the original fuels in use prior to introduction of the rice hull cooker. The project also developed the Mayon Turbo Stove, an advanced combustion stove which informal reports from communities indicated was capable of displacing even higher levels of the conventional fuels than the LT-2000 due to its greater convenience. The stove also enhanced women's skills in training and in biofuel cooking and marketing (Output B2). Women held 57% of the positions as distributors for the marketing and training aspects of the stove. The stove also offered major reduction in household cooking well beyond the projected target of 25% (Output B3). The background survey in Negros found households reduced their annual fuel cost by 63%. On average expenditures decreased from 1814 pesos per year to 672 pesos, for an annual savings of 1142 pesos. In Panay, households were found to have cooking expenses of 2592 pesos per year, and fuel savings were projected to be 1588 pesos per household. LPG and charcoal use was greater in these households as Panay is more of a rice growing area and firewood is lacking. Purchase of the Mayon Turbo Stove had an annualized cost of ownership of approximately 145 pesos while LPG users had annual stove costs of approximately 750 pesos per year. Estimates for GWC reductions were thoroughly assessed (Output B4) based on results from the Negros stove survey and review of the latest information on GHG accounting from the IPCC and international stove greenhouse gas reports. REAP reassessed its earlier GHG calculations based on feedback from the IPCC National GHG Inventory Program-Technical Support Group and the Pembina Institute for Appropriate Development. The values for Global Warming Potential (GWP) are now based on a 100 year time horizon (instead of a 20 year time horizon). Both direct greenhouse gases (CO_2, CH4 and N20) and indirect greenhouse gases (CO, NO_X, TNMOC) are reported. Each LT-2000 stove is projected to reduce emissions by 982 kg CO_2 equivalent/year (488 kg CO_2 equivalents direct GHG's and 494 kg CO_2 Indirect GHG's). With 2645 stoves sold, this would represent a greenhouse gas reduction of 2597 tonnes CO_2 equivalents. It is evident that the newly evolved Mayon Turbo Stove could be an important GHG mitigation option for the Clean Development Mechanism. The potential exists for marketing millions of stoves in countries that have large areas under rice cultivation. The economy the stove is providing to communities in the Philippines is excellent. Investing in a (US)$7 stove is saving approximately (US)$26 in annual household fuel costs or approximately (US)$65.50 over the projected lifespan of the stove.

3.2. Results achieved toward outputs
(please refer to Annex C for the PMF and its indicators)

Sugarcane Component

Output A1: Data gathered from 20 demonstration sites and 6 cane variety sites. Indicator: Health/productivity of crop from demonstration sites. Activity(ies): Development of ecological sugarcane farming demonstration sites, variety trial sites

Trash Farming Demonstration sites

Twenty demonstration sites were established in 11 upland and nine lowland areas in Southern Negros (Appendix A). Pre-harvest and post-harvest detrashing were carried out on all sites. Monitoring of the demonstration sites by the farmer trainers was ongoing during the project. Data was also collected regarding the productivity, as well as input and labor costs under the conventional system to help provide baseline data for future comparisons of economic performance between conventional and trash farming systems; however, an in depth analysis could not be completed due to project cessation.

As projected in the first year workplan, five intercropping demonstrations with food crops were included within the 20 demo sites to encourage farm diversification (Appendix C). Intercropping can increase food security and provide an additional source of income, and decrease the use of chemical fertilizers. Three upland and two lowland sugarcane areas were intercropped with mungbeans, cowpeas, soybeans, and corn. The intercrops grew relatively well despite harsh conditions during a long dry spell, and the farmers were pleased with the system. The initial data gathered was limited as the sugarcane sites were only preharvest detrashed before the harvest season commenced. More intensive data gathering of a complete cropping year could not be monitored due to project cessation, however, farmers were quite satisfied with the preliminary results obtained and were supportive of the multiple benefits ecological sugarcane farming could introduce. During the project, one hectare of the communal farm belonging to the Kasmabbi Community Association was dedicated to comparative studies between conventional (burning sugarcane residue) and trash farming systems. Only one side-by-side demonstration site was established because the farmers had gained confidence in ecological sugarcane farming systems, and were more interested in how to practically apply it. Data from the site could not be collected and analyzed due to project cessation.

Variety Trial Sites

At the beginning of the project, 23 varieties of sugarcane were established by the Kabuhian Association in Kabankalan. After 10 months of growth, ten promising varieties were selected for a second round of trials and harvested in January 2002. For the new sites, these varieties were supplemented with new commercial releases provided by breeders of the Sugar Regulatory Administration (SRA) in UPLB-La Granja. In January of 2002 during the second year of the project, 6 variety trials were established to assess cane varieties for being ecologically adaptable and productive. Four upland and two lowland areas were planted with 14 sugarcane varieties enumerated in Appendix B. These varieties were monitored for self-detrashing capacity, drought resistance, ratooning capacity, adaptability to low fertility soils, biological-nitrogen fixation (BNF) potential, lodging resistance and provision of high tonnage and high sucrose content. Varieties with high productivity and minimal N fertilizer requirements will greatly reduce production expenses and GHG emissions associated with N fertilizer production and use. At the time of project completion, most sites exhibited consistent results from the different cane plant varieties, indicating that varietal performance is somewhat independent of environmental conditions (especially compared to rice) because some varieties proved consistently good performers across sites.

At each site, approximately four to six varieties were observed to be performing well under ecological sugarcane management. Five varieties (8013, 84-947, 8839, 92-0751 and 93-3849) have been identified as possible Biological Nitrogen Fixing (BNF) varieties that are capable of supplying much of their own nitrogen requirements. These varieties have also been observed to be highly adaptable to the local environments. Planting material from these varieties were in strong demand by the local farmers. The farmer-led Adaptability Trial Farm system appears highly relevant for farmers aiming to develop ecological sugarcane farming. As well, this approach allows farmers to assess which varieties are adapted to their farm management and environmental conditions. It also helps build the social infrastructure of community organizations by fully empowering the local associations through a participatory process of plant material selection and propagation. Approximately 40,000 BNF cane stools were established in the first year of the project by farmer organizations. This enabled approximately 400,000 BNF cane points to be distributed through the MAPISAN Farmers Alliance in the second year of the project. This is sufficient material for planting 200 ha this planting season. This could subsequently be multiplied into 2000 ha of BNF varieties available for planting in the 2003-2004 planting season. There has been considerable interest in the BNF phenomena by the breeders at SRA who were previously unaware of the BNF potential of their commercial varieties and pilot releases. The small farmers in the project have greatly appreciated the opportunity to access this improved germplasm[2]. The farmers are interested in these materials because of their ease of cultivation under ecological sugarcane management practices and because the new SRA varieties are more productive and possess a higher sugar content than the materials they were previously planting. Data from the 6 trials was not available at the time of project closure as the trials were not yet harvested.

Output A2: 10% increase in net income from sugarcane.
Indicator: Relative profitability of cane production.
Activity: Survey of 75 farmers/yr to examine costs and field practices.

A formal survey of farmers was not completed during the second year of the project due to cessation of field activities. The sugarcane crop is a perennial crop and is typically harvested in the months of October through March. As such, no opportunity occurred for farmers to be trained in ecological sugarcane farming and to have a crop cycle to be harvested following the impact of the training However, individual farmers reported major savings in fertilizer use during the project through the combined implementation of trash farming and BNF varieties. No purchased N fertilizer was used on the varietal trial sites. Farmers can benefit economically from ecological sugarcane farming even assuming no net increase in yield because of substantial savings in N fertilizer use.

Decomposing sugarcane trash can dramatically improve nutrient cycling and provide a valuable source of nitrogen, which can substantially decrease the amount of fertilizer required for production with no appreciable loss of yield (Patriquin 2000). Certain varieties of sugarcane have shown to actively engage in Biological Nitrogen Fixation (BNF) through an association with the N-fixing endophytic diazotroph *Azospirillium spp.* (Urguiaga 1992; Boddey and Dobereiner 1995). These bacteria, found inside the tissue of roots, leaves and stems, can decrease and potentially eliminate the need for fertilizer by providing 150-270 kg $ha^{-1}yr^{-1}$ of available nitrogen to the plant. By using sugarcane varieties capable of fixing nitrogen (Muthukumarasamy and Revathi 1999), in conjunction with N fixation by decomposing trash (Patriquin 2000), farmers should be able to largely eliminate N fertilizer use altogether.

[2] Never before have they had early access to improved germplasm from plant breeders, usually they have to buy these materials from local landlords long after their release by the SRA.

The net reduction in fertilizer use can be determined by presuming that conventional sugarcane farmers in the Philippines use 186 kg N $ha^{-1}yr^{-1}$ (refer to Appendix G1) and that the experience of the farmers in this project is that it can be completely displaced through the introduction of trash farming and the introduction of BNF varieties. Given an N fertilizer cost of $0.70USD/kg actual N, the savings to farmers is $130/ha/yr. Many farmers would also experience considerable interest costs associated with purchasing fertilizer with typical rates of 20% or more not uncommon in Negros.

Given an average yield of 60 tonne sugarcane/ha and a cane-selling price of 800 pesos/tonne (15.68/tonne USD) farmers generate revenues of approximately $940USD/ha. The potential savings from eliminating N fertilizer use is $130/tonne, which represents 14% of the total revenue received for the crop. It appears that substantial increases in the profitability of sugarcane can be found from savings on N fertilizer as demonstrated in this project.

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Output A3: Increased awareness and skills in trash farming.
Indicator: Number of farmers undergoing training; level of satisfaction from trainings.
Activity: 1000 farmers trained per year in ecological sugarcane farming, development of trainers, and development of training module.

Trainings

There were 534 trainees who received training over the lifetime of the project, with 445 in the first year and 89 in the first quarter of the second year. Please refer to Appendix D for the list of trainings conducted over the lifetime of the project. Of the 445 trainees in the first year, 144 (32%) adopted sugarcane trash farming within the first 12 months following the training and 170 hectares were under trash farming or ecological sugarcane farming. Please refer to Appendix E for the list of trash farming adopters for the first year of the project. Data was not collected for the second year of the project due the to early discontinuation of activities and incomplete reporting by the southern partner in Negros.

During the five actual quarters of the project, 184 of the 534 trainees (34%) were female, indicating a high gender inclusion rate in the project activities. The education and training of women in farming can lead to a general empowerment of women through increased decision making and improved management on the family farm, ultimately contributing to improved gender equality and a higher quality of life.

The initial project design proposed that 1000 trainees would receive training each year of the project during its three-year duration, which would proportionally be equivalent to 1250 trainees receiving of trainings over the five-quarter actual lifetime of the project. At project termination, 534 trainees received training, 43% of the scheduled target. This was largely due to a considerable amount of time and effort required to get the trainings on schedule than originally conceived. Part of the lag in the number of trainings conducted was the decision to reorient the training aspect of this component towards a heightened promotion of diversification in an ecological farming systems context. However, even after this reorientation occurred, this component proved difficult to implement by the local NGO partner. Trainee numbers declined in the fifth quarter of the project to 29 per month from the second half of the first year when 37 trainees per month received training. In July 2002, farmers in five of the upland farming federations of the MAPISAN Alliance broke off their longstanding partnership with the local NGO. They felt the organization was no longer adequately supporting their programming interests around sustainable agriculture activities. Through the newly created Negros Center for Ecological Farming they are managing to continue the Ecological Sugarcane Farming/DIFS trainings independently.

Development of Trainers

During the lifetime of the project, 32 farmers were trained in providing trash farming/ESCF trainings, with 15 of them actively 'reechoing' diversified and ecological farming systems to their associations. To encourage adoption of trash farming and subsequently, diversification, a ladderized training program was developed so that ecological sugarcane farming could be used to help facilitate the development of diversified and ecological farming systems in the sugarlands of Negros.

On the level of the Project Technical Team (PTT) there was a shift at the end of year one, to begin conducting monthly technical meetings for assessment and planning, and to help further enhance technical capability. The intent of this was to equip the team with practical expertise for farm problems and to ensure that gaps were filled when one or several members of the team were not available.

Training Module

During the first year of project implementation, the project partners decided to revise the sugarcane training modules toward DIFS/EFS. The module contains an orientation on SA (a prerequisite for understanding DIFS), broader in-depth discussions on DIFS, as well as theoretical and technical information regarding sugarcane trash farming. This reorientation in direction from sugarcane to crop diversification entailed a major overhaul of the existing training module that was completed in January of 2002. The module has since been translated into the native dialect of Ilongo. The ecological sugarcane farming module has been taken up by the Negros Center for Ecological Farming.

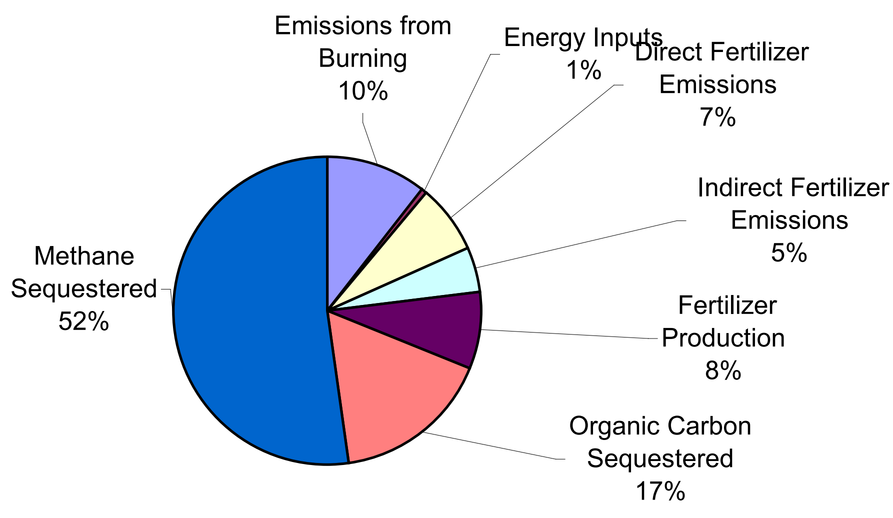
Output A4: Estimates provided for GWC reductions.
Indicator: Reduction of emissions to the atmosphere in tonnes of carbon (as CO_2) contributing to the GWC/ha, acreage under ecological sugarcane production, survey results of changes in farm practices

The introduction of ecological sugarcane farming as an alternative to current methods has been identified as an effective way to reduce GHG emissions in the Philippines. The predominant crop produced in Negros is sugarcane, and conventional farmers burn the sugarcane waste directly in the fields. Unfortunately, biomass burning produces large amounts of toxic and destructive chemicals including: particulate matter, aerosols, and greenhouse gases. Trash farming, on the other hand, eliminates these effects through the distribution of cane residues throughout the field where it is field composted.

The effects of trash farming can be directly measured by the reduction of GHG emissions (Appendix G1 and G2). Several important sources and potential sinks for carbon dioxide and other greenhouse gases have been quantified (the calculations were based on the methodology outlined by the 1996 IPCC Guidelines for National GHG Inventories, which are the most current and reliable to date) (Figure 1). Sources of emissions include: burning (*1.01* tonnes $ha^{-1}yr^{-1}$ CO_2 eqv), fossil fuel energy inputs (*0.07* tonnes $ha^{-1}yr^{-1}$ CO_2 eqv), N-fertilizer production (*0.76* tonnes CO_2 eqv $ha^{-1}yr^{-1}$), and N-fertilizer application (both direct (*0.69* tonnes $ha^{-1}yr^{-1}$ CO_2 eqv) and indirect (*0.47* tonnes CO_2 eqv $ha^{-1}yr^{-1}$)). Estimates have also been made for carbon sinking including: sequestration of organic carbon (*1.63* tonnes $ha^{-1}yr^{-1}$ CO_2 eqv), and methane sequestering by soil bacteria (*5.0* tonnes $ha^{-1}yr^{-1}$ of CO_2 eqv). When considering all of the significant sources and sinks of greenhouse gases, *8.54* tonnes $ha^{-1}yr^{-1}$ of CO_2 eqv. can be prevented from entering the atmosphere. If BNF varieties of sugarcane are also used it appears the entire N supply of the cane crop can be provided internally, further decreasing fertilizer use and hence increasing GHG reductions to *9.67* tonnes $ha^{-1}yr^{-1}$ of CO_2 eqv.

The initial project design proposed that the emission of 5000 tonnes of CO_2 would be mitigated annually over the three-year project term. Ecological sugarcane farming and the Mayon Turbo stove would each be expected to annually reduce 2500 tonnes. At project completion, it was found that from the 170 ha of converted land, 1643 tonnes of CO_2 had actually been mitigated, which is 66% of the targeted value. Although this value initially appears low, it is only the result of delays in implementation of the training, adoption rates by farmers of trash farming appear relatively strong following the first year training. The project identified that ecological sugarcane farming has a very large GHG mitigation potential per hectare, and can provide a promising means of mitigating GHGs while simultaneously improving the livelihoods and environment of small-scale Third World Farmers.

Figure 1. Prevention of GHG emissions associated with the adoption of sugarcane trash farming with BNF (9.67 tonnes CO2/ha*yr)



Stove Component

Output B1: 3000 stoves purchased/yr and in use. Indicator: Production of stoves; number of stoves purchased and in use; stove reflow levels; relative use of different fuel sources.

<u>Production</u>

During the first year of the project from April 2001, to March 2002, a total of 4080 stoves were produced, 1311 of those in Panay and 2769 in Negros. During April to June, 2002, 1323 stoves were produced, including 711 in Panay (353 in Passi and 358 in San Dionisio) and 612 in Negros, bringing the project total to 5403. REAP-Canada staff trained the shop teams at the outset of the project and sourced appropriate stove equipment for production to the shops. Three shops were producing stoves during the project: Barangay Imbang-Grande of Passi City (south central Panay) with the CARBA Association, San Dionisio (Northeastern Panay) with the IGARB Association, and Barangay Oringao of Kabankalan City (south-central Negros Occidental). Efficiencies in streamlining stove production were realized that reduced production costs from $13 to $11CDN/stove. The volume of stove production was not considered a barrier to developing the stove program. The only significant production problem that was experienced was stove quality at the Negros workshop. The workshop was not as directly involved in the stove marketing, which may have influenced the quality of their workmanship. In Panay, the associations were directly involved in the sales of their product and had stronger shop leadership and local supervision.

A new model of rice hull stove, the Mayon Turbo Stove (MTS) was developed by REAP-Canada staff working with the assistance of artisans at the Imbange Grande workshop (please refer to Box 1 below). The MTS model is proving highly popular with communities due to its greatly improved combustion efficiency, reduced emissions, improved fuel economy and reduced tending requirements. The achievements were largely achieved by reengineering the air supply. Sufficient (but not excess) air is introduced to the stove through the addition of twin air injectors in the ash pan and secondary combustion air holes drilled into the frustum (center cone). The MTS has a high quality flame that is largely non-luminescent during daylight hours. The MTS is a breakthrough in clean combustion technology for low cost household biomass stoves (please refer to Box 1).

Additionally, instructions on how to manufacture the stove have been designed and posted on the REAP-Canada website (www.reap-canada.com) for promoting the use of the stove. An instruction manual on how to use the stove has also been produced in both English and the native Visayan dialect of Ilongo.

Box 1: The Evolution of the Mayon Turbo Stove

To develop the stove, all major rice hull stove designs available in the Philippines were analyzed including versions from the International Rice Research Institute (IRRI), PhilRice, the Central Philippine University (CPU) and compared to the Lo-Trau model developed in Vietnam. All stoves were functional but suffered from one or more deficiencies including incomplete combustion, excessive air, uncontrollable fuelbed fires, high rice hull consumption, constant need for tending and high production costs.

Through an intensive research and development program several innovations were made. The inner cone was lengthened by approximately one third to increase residence time of gases and concentrate the flame under the pot. To prevent smoke events (as the porous rice hull turns to ash it restricts the air supply), twin "air injector" pipes were installed through the ash pan to draw air into the combustion zone above the burning fuelbed. The twin pipes increased the turbulence inside the inner cone, creating twin vortexes and slowing airflow out of the stove. Secondary combustion air holes were also drilled into the inner cone to add additional air to more completely combust the gases as they circulated in the top of the cone. The innovations of extending the inner cone and the strategic reengineering of the air supply to create an adequate (but not excess) air supply with effective air mixing provided the breakthrough in clean combustion for such an unsophisticated appliance. After a 3-5 minutes start-up period, a blue or non-luminous flame is now present throughout the inner cone of the MTS. Maintenance of the stove is also reduced, with tapping required only after 10-12 minutes from start-up to introduce additional fuel. The stove is now thought to possess a near ideal air flow; there appears to be no excess air and no oxygen deficient areas of the cone or oxygen deficient periods during the entire burn cycle. Following start-up, smoke only begins to appear again when additional fuel is required to maintain combustion. There are no smoke events related to lack of air when adequate fuel is present. The ash is now a whitish-grey colour, indicating more complete biofuel combustion. Finally, to minimize fuelbin fires and eliminate smoldering of rice hull in the hopper, a heat shield was added around the centerpiece. This was formerly a major problem with all rice hull stove designs when the centerpiece would heat up and smolder or ignite the hull supply.

The next steps in the program are to undertake tests at several testing facilities. A smaller model of stove the MTS 6000 (having a 6.5 inch diameter fuelbed) has been developed. The original MTS-7000 model (having a 7-inch diameter fuelbed) appears best suited to larger households or small commercial applications. There has been favorable feedback from the communities using the new MTS models with some reporting 100% substitution of conventional fuels. A new heatshield has also been added to the smaller 6000 model to prevent any fuelbed fires. The new MTS 6000 stove can allow a family of 6 to cook with approximately one tonne of rice hull per year. Households are experiencing up to 50% reductions in rice hull fuel requirements, less maintenance and less smoke compared to the LT-2000 model. With a simple level of training, families are now enjoying a high quality non-luminescent flame cooker that is becoming locally known as "the poor mans gas stove."

Marketing and Distribution

Throughout the project the marketing of the stoves has been largely organized by PDG in Negros and the Provincial Consultative Bodies (PCBs) of Masipag-Visayas in Panay. Stove marketing was created in Negros by developing a dealer network in towns through major centers in Central and Southern Negros and areas covered by the MAPISAN Alliance in Southern Negros. In both Panay and Negros, stove demand was highest in the areas that are the major centers of rice production in Panay and Negros.

The initial project design proposed that 3000 stoves per year would be purchased and in use at the completion of its three-year project duration with 2000 per year sold in Negros and 1000 per year sold in Panay. This would be proportionally equivalent to 3750 of these stoves marketed and distributed over the 5-quarter actual lifetime of the project. At project termination, 2645 stoves were reported as sold. In Panay stove sales reached 98% of the target from the initial levels agreed to by the partners at the beginning of the project; however, in Negros stove sales only reached 57% of their target (please refer to Table 1). The strong stove marketing results in Panay may have been the result of a strong and well organized marketing support by MASIPAG Visayas in cooperation with the local peoples organizations, and a better economy for stove production in Panay (where fuel rice production predominates and household cooking fuels are more widely purchased). Given that stove sales increase generally in a linear fashion when a new stove is introduced, stove sales in Panay were quite promising, while stove sales in Negros lagged somewhat behind targets.

Table 1: Production and manufacture of the Rice hull stove in both Panay and Negros over the lifetime of the PACCP project.

	Year 1		Year 2		Project lifetime (5 quarters)			
Shop location	Stoves produced	Stoves sold	Stoves produced	Stoves sold	Total produced	Total Sales	Target Sales	% of target sales achieved
Negros	2769	1228	612	190	3381	1418	2500	57%
Panay	1311	784	711	443	2022	1227	1250	98%
Total	***4080***	***2012***	***1323***	***633***	***5403***	***2645***	***3750***	***71%***

Revolving Loan Fund

The project created a revolving loan fund to enable stoves to be purchased by impoverished rural households. Based on the background survey on each island, the average household that purchased the stove had an annual income of 38,564 Pesos in Negros and 31,268 pesos in Panay. It was necessary to create a loan program as few households have adequate savings to make the 350–400 PhP capital outlay for a stove. The monthly savings on fuel purchases with the stove can however enable most households to justify the purchase. A revolving loan program was designed into the project to help encourage repayment as the reflows from the project were designated to be used for further loans for appropriate technology tools that will continue to benefit the farmers organizations on an ongoing basis.

The major challenge in the stove component of the project was the collection of reflows. Reflow reports received by REAP-Canada from the local Philippine partners indicated stove sales of 2645 units with revenues of approximately 864,160 PhP (approximately $27,000CDN) and reflows of approximately 267,697 PhP (or 31% overall). The main income for farmers is during the rice and sugarcane harvest season, which is typically between August and February. The months of April to July are lean as many farm households in the Visayas have significant difficulties achieving a reasonable level of food security during this time. Hence, the bulk of the second year revenues for farmers was not realized in these collection figures.

The overall slow repayment of the loans led to some delays in establishing the revolving loan funds for appropriate technology tools. Early in year two some small tools were being manufactured at the Kalibutan workshop in Negros such as Caribao (water buffalo) plows, and rice farming secondary tillage and field leveling tools and weeders. There was an education effort undertaken by the project team to educate the farmers that repaying the stoves was essential for the farmers groups to evolve a permanent revolving loan fund. In Panay, at the end of the fifth quarter of the project, no reflow utilization plan had been developed and funds had not yet been utilized for this purpose. For quarters three to five, the local partners had been putting most of their emphasis on improving the collecting of reflows to create resources for the reflow fund to be used for programming.

Table 2. Summary of RHS Collection for the period April 1, 2001 to June 30, 2002

Area of Mktg/Distribution	No. of Units Distributed	Number of stoves sold	Amt. Collected (in Php)	% Reflow
Negros-PDG*				
MPSN	893	**402	25,550.00	18.1%
Non-MPSN	1376	***826	98,935.00	34.2%
Iloilo-MASVIS	1227	1227	143,212	33.2%
Total	**3496**	**2455**	**267,697**	**28.1%**

* No collection reports were submitted by PDG for April-June 2002.
**Estimated 60% sold outside MAPISAN,
***Estimated 45% sold inside MAPISAN. In Iloilo stoves were sold at the time of distribution. In Negros they were put on consignment.

Output B2: Women enhance skills in training and biofuel cooking.
Indicator: The Participatory Rural Appraisal (PRA) will indicate the relative confidence and skills of women, number of trainings provided to women.

Trainings

A training component to the project was designed so that each stove user would receive adequate training to successfully use the stove. Training was provided through formal sessions administered to stove distributors by the local coordinators in each province. At the point of sale these marketers provided training to the stove buyers. This was supplemented with a stove users guide that was developed and given to buyers (an English version of the training guide has been placed on the REAP-Canada Website). It was through these two approaches that the 2645 stove purchasers received training. Feedback sessions for trainers/distributors were also conducted throughout the project to ensure effective communication and coordination between and among marketing, distribution and fabrication staff. This strategy was effective in bringing about improvements to overall stove design through the development of the improved version of the rice hull cooker (the Mayon Turbo Stove), and it also enabled stove trainers to understand key issues that users were having difficulty with. Women shared techniques to improve lighting of the stove and this subsequently was incorporated into the community demonstrations that followed.

Gender Impacts

It was found that the implementation of the Mayon Turbo Stove project and its introduction into rural households could benefit all members of the community, but the effects were more pronounced upon women. Thus the project gender strategy was designed with women in mind and focused on the involvement of women in the development of the project, and the impacts on women in the rural communities.

Difficulties surrounding the access of cooking fuels impact women most directly. Procuring firewood in the Western Visayas is a laborious and time-consuming task. Rural women in Negros are spending approximately 5-10 working days per month in the collection of firewood for cooking fuels. Aside from the difficulty of acquiring cooking fuel, women also face the hardships associated with indoor air pollution from burning low quality fuels in inappropriately designed cooking stoves. For families who depend upon LPG or kerosene for cooking, increased costs due to high oil prices is creating tremendous problems for women as they budget for their households. The introduction of the Mayon

Turbo Stove into rural households has been found to improve the lives of women by reducing the amount of harmful smoke they are exposed to while going about their daily routine. The use of the stove in rural communities has increased the training and biofuel cooking skills of women, which will continue to increase with widespread use of the stove. The stove can also have beneficial impacts on children who are often exposed to these harmful yet to be quantified, but has been consistently observed by the farmers with the new Mayon Turbo Stove (a.k.a. the "poor mans gas stove" in some communities).

During this project, the MAPISAN and PATANOM Farmer Alliances were involved in the production, training, development, and distribution of the Mayon Turbo Stove. Rural women were active and participated in local training and management in the farmer alliances, however their important family role limited their ability to travel to distant training sessions and participate as representatives. Women were involved in all aspects of programming, from project coordination to marketing and training stove users. Project managers in both Negros and Panay in the first year were women. Throughout the project, Julia Tabat, the stove's marketing officer in Negros lead the marketing and distribution, trainings, and collection of stove reflows. She was assisted by Mayumi Guilaran in project documentation and Cathalien Tabat in stove distribution and marketing. This illustrates the participation of women from collective decision making to field level project implementation. The high level of participation of women can also be seen in the number of women trainers/distributors developed in the first year, 123 out of 216 (57%). Women have been actively involved, not only in training their families how to operate and maintain the stoves, but also in training other women to promote environmental conservation.

Output B3: Reduction in overall household fuel costs.
Indicator: Surveys indicate relative use of different fuel sources, monthly expenditure on fuels

Surveys and Assessments

In 2001, two surveys were completed in Negros that interviewed 43 and 100 users respectively. The first 43 person survey was a pilot survey which was useful in developing the methodology of the survey and for further refining questions for the second survey. It was decided that it was unnecessary to separate the fuel assessment and stove user surveys as originally proposed and all questions were encompassed in one. The second 100 household survey in Negros was somewhat labour intensive to complete and took approximately 1 month of staff time in the field and an additional three weeks of data recording and analysis. A 75 household Panay survey was undertaken in year two. Some data from 75 household Panay survey was lacking; a detailed analysis was obtained in the two Negros surveys.

The surveyed households that purchased the stove in Negros and Panay were relatively poor. Households had an average annual income level of 31,268 pesos in Panay and 38,564 pesos in Negros and about six members per household. Prior to the purchase of an improved rice hull cooker, households were spending 1814 PhP and 2592 PhP per year on fuel cooking costs (Table 3), which represents an expenditure of 4.7% and 8.3% of their annual income in Negros and Panay, respectively. Fuel cooking costs are higher in Panay as the locals tend to have less access to fuelwood through gathering for the island has more land dedicated to rice production. As such, the Panay survey indicated significantly more spending on LPG and charcoal than in Negros. It is evident an improved rice hull stove can serve as an ideal means to mitigate poverty in the rice growing regions of Panay. At the time of the survey late 2001-early 2002, LPG costs were approximately 270-275 per 11kg tank. By March 2003, these costs had risen to approximately 320 peso per 11kg tank (an increase of approximately 16%).

Table 3: Average annual fuel expenditures and potential savings across surveyed households in Panay and Negros prior to and following the introduction of a rice hull stove.

	Negros Conventional Fuel Expenditures	Panay Conventional Fuel Expenditures	Average Conventional Fuel Expenditures	*Average Projected Fuel Savings after introduction of a rice hull stove
Fuelwood	993	887	940	677
Charcoal	252	368	310	237
LPG	386	1081	734	339
Kerosene (firestarter)	184	255	220	145
Total	1814	2591	2204	1398

* Based on the LT-2000 stoves displacing an average of 76% of charcoal use, 72% of firewood use, 46% of LPG use and 66% of kerosene firestarter use in households adopting the stove.

The Negros fuel use survey indicated that the introduction of the LT-2000 rice hull stove provided approximately 76% of a households cooking energy needs and reduced overall fuel expenditures by 1142 PhP per household, representing a 63% reduction in household cooking fuel costs (quite high considering 42 households were gathering free fuelwood). On average the rice hull stove was more effective at displacing firewood and charcoal purchases. Purchases of charcoal, fuelwood, and LPG were reduced by 76%, 72%, and 46% respectively after introduction of the rice hull stove. If these same fuel displacement figures are applied to the baseline data of Panay households, an annual households savings of 1588 PhP per household could be realized. Households also experience some changes in stove ownership costs. Maintaining a rice hull stove is estimated to cost 145 PhP per year, while maintaining an LPG stove and tank is estimated to cost 769 PhP per year. Thus on average, if no changes in stove ownership costs are included, the LT-2000 should be reducing household cooking fuel costs by about 1400 PhP per household per year in the Western Visayas. With more than 5000 stoves built as a result of this project, annual savings of seven million pesos could be realized by impoverished rural households in the region.

With the introduction of the new Mayon Turbo stove in 2002, the savings likely are now reaching approximately 1800 PhP per households year. This assessment is based on the recent 15% increase in costs of conventional fuels and a projected increased in fuel displacement to 85% with the new Mayon Turbo Stove. If 1800 PhP in household fuel cooking savings can be realized, it enables impoverished households to reallocate about 5% of their annual income to other priority needs such as food and education. The 55-65% reduction in household cooking costs greatly exceeds the output target of a 25% reduction. For some households, introducing the rice hull stove can provide major savings. For example, households adopting the rice hull stove as their dedicated cooker could save 92-94% compared to alternative cooking systems of 100% purchased firewood, charcoal and LPG. A separate report discussing in detail the positive impact of LT 2000 introduction in rural households' fuel consumption and expenditure and mitigation of GHG emissions can be found in Appendix H.

Output B4: Estimates provided for GWC reductions.
Indicator: Reduction of direct and indirect greenhouse gas emissions into the atmosphere. GHG emission reported in tonnes of CO_2 equivalent per year.
Activity: Assessment of components to derive GHG reduction.

The model used to calculate GHG emissions released during the combustion of traditional cooking fuels is based on the methodology presented in the 1996 IPCC Guidelines for National Greenhouse Gas Inventories. The IPCC states that two approaches can be taken when calculating GHG emissions: 1) REAP can submit its own GHG calculations and methodology with supporting documentation, or 2) REAP can follow the IPCC Source Categories Approach (volume 2, table 1-2) using default data. REAP has opted to follow option 1) for this report. REAP's methodology follows the IPCC Sectoral Approach methodology but calculates emissions based on mass of fuel consumed not on an energy equivalent of fuel consumed. REAP would like to follow the IPCC framework as closely as possible in order to formalize its internal procedures and ensure acceptable GHG accounting.

Six GHG emissions are covered in the guidelines, three direct greenhouse gases, CO_2, CH_4, & N_2O, and three indirect greenhouse gases, CO, NO_x & NMVOC's. When possible, REAP will calculate all six greenhouse gases and report the direct and indirect gases separately. GHG emission reductions were estimated using data collected for local fuel use and expenditures. The data collected from the Negros household fuel use survey was used for the baseline calculations for establishing the GHG emission reductions (Table 4).

Table 4. Annual Reduction in Conventional Fuel Use from Introducing a LT-2000 Rice Hull Stove in Negros Occidental

Statistic	Before	After
No. of households using fuelwood (buyers)	39	30
No. of households using fuelwood (gatherers)	42	24
No. of households using charcoal	20	7
No. of households using LPG	11	7
No. of households using rice hull	-	86
Average fuel use: fuelwood	2399 kg	665 kg
Charcoal	71 kg	16.8 kg
LPG	15.6 kg	8.4 kg
Kerosene	8.2 kg	2.8 kg
Rice hull	-	1722 kg

The model that was used assumed that fuelwood and charcoal are harvested from renewable biomass, and that rice mills dispose of the rice hull by burning. CO_2 emissions from the combustion of biomass are not counted because growing plants sequester the carbon emitted as CO2. The other GHG's (CH_4, N_2O, CO, & TNMOC) from biomass combustion are included. NO_x was not included as data was not available. Charcoal is a source of GHG, both when it is produced and when it is consumed. Kerosene is also accounted for as it is used as a firestarter by rural households. It should be noted that local data is preferred to IPCC default data, if it is properly referenced and documented.

The IPCC Sectoral Approach is a detailed GHG accounting methodology developed to help countries assess their national GHG inventories. It is also considered a standard methodology that can be applied to smaller projects. REAP proceeded with GHG calculations as follows:

Small-scale combustion of fuel is categorized by IPCC Reporting as a GHG Source (1-Energy, A-Fuel Combustion Activities, 4-Small Combustion, B-residential). The equation used to estimate GHG emission was:

$$E_i = (A_i – B_i) \times EF_I \times CR_i \times GWP_i$$

E = emission reduction (kg of CO_2 equivalents)
A = amount of fuel consumed per month after the LT 2000 stove was acquired
B = amount of fuel consumed before
EF = Emission Factor (i.e. carbon mass pollutant / mass fuel)
CR = Conversion Ratio (i.e. Molecular Mass pollutant / Molecular Mass of carbon)
GWP = Global Warming Potential (over a 100-year time horizon)
i = fuel type.

By using this equation it was determined that the LT 2000 stove can reduce direct GHG emissions by 487.8 kg CO2 equiv/yr and indirect GHG emissions by 493.9 kg CO_2 equiv/yr for a total reduction of 982 kg CO_2 equiv per year from conventional cooking methods (Table 5).

Table 5. Impact of the LT-2000 Rice Hull Stove on GHG Emissions

Fuel	Before (kg)	After (kg)	Fuel Use Reduction (kg)	Greenhouse Gas Emission Reductions (kg CO2 equiv)					GWC*
				CO2	CH4	N2O	CO	TNMOC	
Fuelwood	2398.8	664.8	1734	0	243.75	150.17	216.39	152.78	0.44
Charcoal	70.8	16.8	54	0	43.36	10.54	53.48	68.65	3.26
LPG	15.6	8.4	7.2	22.21	0.01	0.73	0.22	1.35	3.41
Kerosene	10.32	3.48	6.84	16.69	0.04	0.30	0.19	0.82	2.64
				Direct GHG = 487.8			Indirect GHG = 493.9		
				Total GHG Emissions = 981.7 kg CO2 Equiv per year					

*Global Warming Commitment = kg CO2 Equiv per kg of fuel

These values assume fuel use is homogeneous throughout the year. Over the five-quarter lifetime of this project, a total of 2645 stoves were introduced into the farming communities of the Western Visayas. The substitution of conventional cooking fuel with biomass residue over this five quarter reporting project period prevented the GHG emissions of 2597 tonnes of CO_2 equivalent emitted into the atmosphere. This represents 104% of the project GHG emission goal of the targeted value of 2500 tonnes annually for the stove component. The main source of emission reduction was the decrease in the use of fuelwood. Charcoal had a relatively large contribution because of the high GWC coefficient that includes production and consumption. Kerosene for fire starter offered similar abatement possibilities as LPG. Please Refer to Appendix H for additional information regarding the GHG emission reductions made possible by the introduction of the LT-2000 Stove.

There may also be other GHG mitigation benefits from introduction of the stove. Both fuelwood and charcoal production are contributing to the loss of standing biomass in the nation. This reduces the CO_2 storage capacity of the landscape and contributes to non-CO_2 greenhouse gas emissions through the release of other greenhouse gases (mainly through methane released during charcoal production and inefficient wood fuel combustion). If the fuelwood source is unsustainably harvested (i.e no replanting effort undertaken), it has the potential to load 2300 kg of CO_2 into the atmosphere per household. The introduction of the Mayon Turbo stove utilizing agricultural residues would displace these emissions.

3.3. Results achieved toward outcomes
(please refer to Annex C for the PMF and its indicators)

Greenhouse Gases from both components

Outcome: Annual reductions in Global Warming Commitment (GWC) of 5000 tonnes of carbon (as CO2) achieved by project completion Indicator: Reductions in fuel use from surveys, stove sales, changes in input use from farming surveys, land area in ecological sugarcane farming

Sugarcane Component

Sugarcane trash farming has the potential to considerably mitigate the greenhouse gases emitted by conventional agricultural practices in the Philippines. When considering all of the important sources and sinks of greenhouse gases, the implementation of ecological sugarcane farming would result in the prevention of *9.67* tonnes $ha^{-1}yr^{-1}$ of CO_2 with TF/BNF.

In 2001-2002, the adoption of trash farming and transition to ecological farming systems was undertaken by 144 farmers on Negros covering 170 ha. This conversion to trash farming prevented a total of 1440 tonnes of CO_2 equivalent emitted to the atmosphere with trash farming, and 1643 tonnes of CO_2 equivalent with trash farming and BNF. The mitigation of 1440 tonnes of CO_2 equivalent is 58% of the targeted value of 2500 tonnes annually for the sugarcane component, and 1643 tonnes of CO_2 equivalent would be 66% of the target. Though this value initially appears modest, it is only a reflection of the delayed implementation of the ecological sugarcane farmers trainings. The experience gained through the project has found that sugarcane trash farming has very large GHG mitigation potential per hectare, and can provide a promising means of mitigating GHGs while simultaneously improving the livelihoods and environment of small-scale Third World Farmers.

Stove Component

The introduction of an improved rice hull stove into communities has proven an effective tool in greenhouse gas mitigation. Each stove has been found to prevent the equivalent of 982 kg of CO_2 annually for the average rural household in the Philippines (with total GHG emissions equaling 487.8 kg CO_2 equiv direct GHGs, plus 493.9 kg CO_2 equiv indirect GHGs). Each stove has an anticipated lifetime of two and a half years. Over the five-quarter lifetime of this project, a total of 3496 stoves were distributed and 2645 stoves sold into communities of the Western Visayas. The substitution of conventional cooking fuel with biomass residue over this five quarter project period, prevented the GHG emissions of 2597 tonnes of CO_2 equivalent emitted into the atmosphere or 104% of its target. Please Refer to Appendix H for additional information regarding the GHG emission reductions made possible by the introduction of the LT-2000 Stove.

Project Outcomes

The initial project design proposed that the emission of 5000 tonnes of CO_2 equivalent would be mitigated annually over the three-year project term, with the sugarcane trash farming and the Mayon Turbo Stove each expected to annually provide about half this reduction. Over the five quarters of data collected for the Mayon Turbo Stove, it was determined that the stove prevented the emission of 2597 tonnes of CO_2 equivalent into the atmosphere. These numbers should substantially increase as the remainder of the built stoves are employed in households. The sugarcane component of the project was found to reduce annual GHG emissions by a maximum of 1643 tonnes of CO_2 equivalent (66% of its target), assuming trash farming with active BNF. This brings the total equivalent of CO_2 mitigated over the active lifetime of the project to 4240 tonnes. Thus by the fifth quarter of the project approximately 85% of the targeted GHG reductions had been made.

Outcome A: 40% of farmers trained in ecological sugarcane farming adopt technology
Indicator: Registry of farmers taking training and converting to trash farming in each federation.

During the first year of the project there were 445 farmers trained in SCTF and ecological sugarcane production, of which 144 (32%) adopted trash farming in the first year following training. This adoption rate represents 92% of the set target of a 40% ratio of trash farming adoptees out of the farmers trained. Data collection was incomplete for year two. A total of 170 hectares were also converted to trash farming or ecological sugarcane farming during year one. The farmer registry for year one is shown in Appendix E. No data was available from the project partner in Negros for the second year of the project regarding adoption levels of farmers on ecological sugarcane farming/trash farming. We consider first year adoption levels following training promising given that training in ecological farming often takes several years to be taken up by farmers.

Outcome B: Annualized household cooking costs decline by 25% for 9000 stove users.
Indicator: Cost of household cooking before and after stove introduction.

The 100 household survey in Negros found annual household fuel costs to decrease by 63% from 1814 PhP per year to 672 PhP per year representing a savings of 1142 PhP. If a charge for the annualized cost of ownership of the rice hull stove is included the annualized reduction in household cooking was found to be 55%. Higher peso savings were projected in Panay as the 75 households surveyed had background annual fuel costs of 2592 PhP (approximately 43% more than Negros households). With 2645 stoves reported sold by the end of the first quarter of the second year in the Western Visayas, the annual saving for households being experienced is approximately 3.4 million PhP. There is also is a great deal of household labour for women not being accounted for in these figures, given that firewood gathering is a laborious task for women and can consume 60-120 days per year of labour.

3.4. Results achieved toward impacts
(please refer to Annex C for the PMF and its indicators)

Impact: Reduced GHG emissions Indicator: Reduction of direct and indirect greenhouse gas emissions to the atmosphere (measured in kg CO_2 Equiv).

Sugarcane Component

The implementation of trash farming has been found to result in the prevention of 8.54 tonnes $ha^{-1}yr^{-1}$ of CO_2 equivalent emitted to the atmosphere, or 9.67 tonnes $ha^{-1}yr^{-1}$ of CO_2 with TF/BNF (please refer to Appendix G). In 2001-2002, the adoption of trash farming and transition to ecological farming systems was undertaken by 144 farmers on Negros with a land base of 170 ha. This conversion to trash farming prevented a total of from 1440 tonnes of CO_2 equivalent emitted to the atmosphere with trash farming, to 1643 tonnes of CO_2 equivalent with trash farming and BNF. The potential for scale up of this project is significant as the utilization of BNF varieties and widespread introduction of ecological sugarcane farm management systems has a high potential for replication across the Philippines. If ½ of the 300,000 hectares of sugarcane in the Philippines could be converted to ecological sugarcane farming where trash farming is practiced and BNF varieties utilized, emission reductions of up to 1.4 million tonnes of CO_2 equivalents could be realized. It would also have major impacts on poverty alleviation in Negros through substantial savings on fertilizer and increased long term productivity gains through soil fertility improvements and advances in plant materials adapted for ecological sugarcane farming.

Stove Component

The introduction of the Mayon Turbo Stove (previously the LT-2000) into rural communities has proven an effective tool in GHG mitigation. Each stove has been found to prevent the equivalent of 982 kg of CO_2 annually for the average rural household in the Philippines, considering both direct and indirect GHGs. There is a significant potential for a large adoption of this technology in rural areas of the Philippines. It is not unrealistic to believe that 200,000-500,000 stoves could be in use in the Philippines within 10 years if fossil fuel prices stay high, and deforestation and population growth occurs. The introduction of the Mayon turbo stove should put the GHG (direct and indirect) reduction levels over 1.1 tonnes per stove as the convenience of this stove is leading to greater conventional fuel substitution. With 250,000 stoves in use in 10 years time annual GHG emissions would be reduced by 275,000 tonnes of CO_2 equiv/yr. The poverty alleviation impacts on households could also be substantial with annual reductions in household cooking costs of 250 million PhP achieved mainly amongst impoverished rural families.

4.0. Lessons learned and recommendations

4.1 Early Project Closure

Project field activities largely ceased after the first quarter of the second year, or five quarters into the three year project. A number of events helped contribute to this early project closure that were outside of the normal working dynamics experienced in implementing this project. There were some significant relationship difficulties that evolved amongst the project partners as well as the major players in sustainable agriculture in the Philippines during the course of the project. Midway in the first year of the project, MASIPAG-VISAYAS broke off its partnership with the newly formed PATANOM Farmers Alliance. PATANOM was the main original farmer partner organization in Panay at the beginning of the project. As well in March 2002, a founding group of scientists in the MASIPAG organization disassociated itself with the MASIPAG organization because of a number of concerns including: the increasing advocacy role of the organization; and the lack of attention directed towards sustainable agricultural programming. There were ramifications for REAP in the Western Visayas on the PACCP project as this national split involved key farmer leaders and farmer trainers in Negros and scientists with whom REAP had longstanding relationships. REAP also had significant concerns about the increasing confrontations PDG was having with powerful landlords. There was an impasse reached between REAP and PDG regarding project management and performance in meeting projected targets. REAP requested that CIDA replace the lead Philippine executing agency on the project with alternative partners in Negros to serve the same beneficiaries. CIDA refused this request and the project was terminated early as no reconciliation between the partners could be realized. It is regrettable that an early closure to this project was reached as the project had very strong realized and potential environmental and poverty alleviation impacts.

4.2 Ecological Sugarcane Farming Component

1. The stigma regarding sugarcane plantations was identified in the first year's annual workplan; however, the only strategy identified by the partners to reduce it was the inclusion of the intercropping trials in the demonstration sites. A broader initiative at that time towards a reorientation of the trash farming component to an emphasis on DIFS/EFS for the remainder of the project may have enabled the poverty alleviation and GHG mitigation of the project to be best accomplished within a more appropriate social framework than the original design.

2. The process of balancing the social preparation with the technical requirements of the sugarcane component was originally left to the farmer trainers who were the technical experts in the project. There should have been deployment of community organizers who could have synchronized the project activities with the strengthening of the community social infrastructures.

3. From the farmer's perspective, there was widespread appreciation of the trial farms examining the adaptability of sugarcane cultivars to ecological sugarcane farming. They were highly interested in the BNF varieties identified and successfully multiplied them for use on their own farms. Most farmers appeared confident that through the combined use of decomposing

sugarcane field residues and the use of BNF varieties they could replace all their fertilizer N requirements. One farmer, Mr. Leopoldo Guilaran of the MAPISAN federation, began to breed rice varieties that, like sugarcane, were adapted to ratooning, trash farming and could grow on nitrogen impoverished soils. Breeding of BNF sugarcane and rice could be a major rural development opportunity to reduce poverty levels amongst small farmers and help mitigate GHG that should receive further support by development agencies.

4. From a greenhouse gas standpoint the conversion from conventional sugarcane farming to ecological sugarcane farming appears highly promising with projected emission reduction levels equivalent to up to 9.7 tonnes of $C0_2$ equivalents per ha/yr. This large reduction results from turning the sugarcane crop from a source to a sink for greenhouse gases through enhancing soil carbon organic matter levels and encouraging methane oxidizing bacteria. Holistic assessments of converting from conventional crop production to ecological crop production merits further investigation.

5. This analysis indicated that high levels of consumption of methane can be an important strategy to mitigate GHG from tropical agricultural ecosystems. Reducing the application of N fertilizer appears to be critical to encouraging this process as well as to help eliminate other GHG sources from fertilizer application and manufacturing. More investigation is required to find ways of restoring the levels of methane oxidizing bacteria in agricultural soils. Literature indicates conventional agricultural systems reduce the populations of methane oxidizing bacteria by approximately 70% compared to natural ecosystems. Increasing the presence of methane oxidizing bacteria in agricultural soils could be a practical means to help the biosphere reestablish its natural mechanisms for regulating methane levels.

6. Ecological sugarcane production appears to be an ideal means to help increase populations of methane oxidizing bacteria in agricultural landscapes as high levels of soil biological activity are experienced under decomposing trash; the crop tends to be managed as a longer term perennial crop with extended ratooning cycles; and N fertilizer and pesticides which severely depress methane oxidizing bacteria populations are not applied.

4.3 Mayon Turbo Stove

1. It appears the poverty alleviation impact of the stove in reducing cooking costs is greater than anticipated with a 63% fuel savings on average per household in the Western Visayas. Peasants in this area who invest in a $7USD stove could experience annual fuel savings of $26 USD in the Western Visayas or $65.50USD over the stoves productive lifetime. The introduction of improved rice hull stoves is a promising, low-cost poverty reduction strategy that could be encouraged by the Philippine government, as well as other agencies concerned with the well-being of impoverished households.

2. Utilizing an improved rice hull stove is also a promising strategy for GHG mitigation, as reductions of nearly one tonne of CO_2 equivalents per stove were identified with the LT-2000 stove assessed in the first year of this study. The stove displaced approximately 76% of the household energy used for cooking. Much of this was firewood with approximately 1750 kg of

wood saved per household following introduction of the stove. Thus the stove could have significant implications on helping restore forest cover if it is widely introduced.

3. The Mayon Turbo Stove (MTS) is a promising advanced combustion cooker that appears highly suited to low income households. It was admired by communities for its high quality flame, low smoke emissions, ease of maintenance, reduced size, and modest consumption of rice hull. The MTS, however does require further laboratory assessment to determine its combustion efficiency, as well as field assessment to determine its GHG emissions, impact on fuel consumption, and household fuel expenditures.

4. The MTS appears to be an excellent candidate for use under the Clean Development Mechanism as a GHG reduction strategy because it is relatively easy to implement, widely replicable, and has a large offset potential if scaled up in the major rice growing nations of the world (i.e. China, India, Indonesia, Bangladesh, Thailand and Vietnam.

4.4 Project Sustainability

A number of factors indicate that the project could have a high level of sustainability in terms of its impact on poverty reduction and greenhouse gas mitigation.

Sugarcane Trash Farming

In the ecological sugarcane farming component, the training module has been retained by the newly formed national PABINHI organization and its partner organization the Negros Center for Ecological Farming. NCEF consists of five upland farming federations in Negros who were formerly involved in PACCP. The PABINHI and the NCEF farmers are also continuing to evolve their skills on ecological sugarcane farming through farmer to farmer training and "Learning Center" farms which have received support from outside sources. The sugarcane cultivars identified to have BNF traits are continuing to being multiplied and have been widely appreciated by the small farmers of Negros. MAPISAN farmers could plant an additional 200 ha of BNF varieties during the 2003 planting season and even more are expected in 2004. To our knowledge, this is the first effort in Southeast Asia to identify BNF varieties and make them available to farmers. Breeders from the Sugar Regulatory Authority also visited the research sites and have developed an interest in creating a concerted breeding effort to develop varieties with the BNF trait. The farmer-led trial farm approach for assessing new releases from the SRA in a large number of single replication trials appears to be a low cost and highly efficient system for small farmer's organizations to use. Experienced farmer trainers involved in the project now believe ecological sugarcane farming is not difficult to achieve compared to growing other crops, such as rice or corn, ecologically. As well, they found assessing and multiplying promising sugarcane germplasm relatively simple and easier to make progress with than in their rice or corn improvement programs. For the MAPISAN farmers this work was highly relevant to, and effective in, enhancing their livelihood opportunities.

The project is also beginning to have an influence on rice cultivation practices. REAP Canada and NCEF farmers have evolved a new rice production system called ECO-RICE. The four pillars of the new ECO-RICE management system are:

1) use of N use efficient/N fixing varieties of rice,
2) ratooning the crop following harvest,
3) retaining the trash for in-field decomposition, and;
4) managing the rice under the System of Rice Intensification (SRI).

Thus the skills learned in ecological sugarcane farming are having significant influence on development of ecological crop production. This should have long term influences on reducing crop production costs and increasing crop yields. The widespread development of ecological sugarcane farming could be a major driver for reducing poverty in this region, as sugarcane remains the main income crop for small farmers. It is also evident that ecological sugarcane and rice farming approaches could have a major influence on GHG emission in many tropical countries which are largely agricultural.

Mayon Turbo Stove (MTS)

The MTS also appears to have a high potential for sustainability. It has been observed in the field by several rural energy specialists and is regarded by our peers as a genuine advance in combustion technology for low cost household stoves. Inquiries on the stove have been made from Indonesia, Sri Lanka, Thailand, Kenya, Ecuador, The Gambia, West Timor and Costa Rica. REAP Canada is examining the potential of the stove as a Clean Development Mechanism project because of its ability to reduce household cooking costs and mitigate GHGs.

The introduction of the MTS has the potential to improve the long-term well being of the rural poor, and to subsequently reduce the environmental impacts associated with fuelwood gathering on both watersheds and soil erosion. Rising household expenses from increasing fossil fuel prices is a major development challenge. The MTS is a response to that challenge. The introduction of one million stoves could displace the use of two million tonnes of fuelwood or 116 million kg of LPG imports per year (worth approximately $65 million USD/yr). It is evident as fuel prices for fossil based energy inputs continue to climb and the forest resources of the Philippines continue to dwindle, stoves like the MTS will play an increasingly important role in developing a sustainable fuel supply for low income rural households. Introduction of the MTS could develop a new local manufacturing industry and help recirculate money in the local economy. The project also adds value to rice hulls enabling it to become a commodity that could generate additional income for rice millers and farmers. Furthermore, the introduction of the MTS could be a successful way to mitigate GHGs as each stove can prevent the equivalent of 982 kg of CO_2/yr to the atmosphere. With widespread introduction of the stove, significant amounts of CO_2 could be offset and potentially accounted for as GHG reduction credits.

REAP has agreed to work in partnership with Sustainable Rural Enterprises based at Aklan State University to further develop the Mayon Turbo Stove and other biomass combustion technologies to support rural development in the Philippines. SRE has obtained funding to introduce the stove in Mindinao as a renewable energy livelihood and poverty alleviation project. REAP believes the existing experience developed through the PACCP project was invaluable in getting the Mayon Turbo Stove established as a clean burning advanced combustion appliance for rural households. The stove should be replicable in most major rice producing nations (i.e. China, India, Indonesia, Bangladesh, Thailand, and Vietnam). REAP is currently examining how best to develop these opportunities.

There is also further sustainability in the Western Visayas through the development of the reflow program that was created in the project. Funds from the sale of the cookers are revolved into appropriate technology equipment such as small tools for farmers that can include rice hull stoves.

Video Production

To promote public engagement surrounding the issues of poverty reduction and GHG mitigation in the Philippines, Canada, and around the world, the project initiated two documentary videos.

The first video outlines the development, use, and success of the MTS and its positive impacts on women, health, the environment, and local economies. It shows how the stove can improve the quality of life for rural peoples with rice as their staple food source, and visually creates the links between stable and sustainable food and fuel supplies. The video illustrates how the stove can mitigate greenhouse gases by combusting waste rice hulls as a cooking fuel when they would otherwise be burned, and how the use of these hulls can prevent deforestation. It also shows how the stove can have a major impact on poverty reduction by reducing family expenditures on fuel and how local production provides jobs and stimulates small-scale economies. Finally, the video illustrates how introducing the rice hull stove can bring about improvements in the lives of women and their families through the reduction in the workload of women who must search for firewood, as well as the improvement of indoor air quality through the complete combustion of the rice hulls (versus the typical smoldering combustion of wood).

The second video is centered on the rural farmers struggles to acquire land through the government's Comprehensive Agrarian Reform Program (CARP) and farmers efforts to diversify their farms crop production from the current practice of sugarcane mono-cash cropping. The majority of these farmers find themselves with no capital or technology to work their fields as their capabilities and skills are more suited for large hacienda operations, and their land is undernourished due to years of monocropping. The video illustrates the desperation of peasant families, many of whom return to being labourers, selling their lands back to the same compradors who previously owned them. Many also sub-contract their lands and exploit the soil in more extreme ways just to survive. The video also illustrates how interventions can bridge that critical transition and bring empowerment instead of poverty. It details the projects efforts on ensuring that food, on-farm energy, and income are secure. It shows how communities are assisted to maximize their potential through agro-ecological development, which will address the economic needs and the crucial long-term political and ecological issues. With the transition towards sustainable agriculture and agro-ecological villages, peasant communities deal not only with their own local issues but also with the global concern of minimizing local environmental impacts and greenhouse gas loading into the biosphere.

The production of the videos began in November 2001, when the storylines, sites and interviewees were identified, and the focus for the production was set. Footage for the videos was shot in December 2001, and final shots were taken in January and February of 2002. Dubbing, shot-listing and transcription of the interviewees occurred after shooting (in January and March of 2002) and script writing and sequence treatment took place in April. In May of 2002, the third phase of production (post-production) was begun, which included extensive video, photo, audio, and data research to detail the historical context. The videos require a modest level of effort to be completed. REAP anticipates that sufficient resources can be acquired through alternative funding sources to make this possible.

ANNEX A: SUMMARY OF PLANNED RESULTS				
EXPECTED RESULTS OF OUTCOME A: 40% of farmers trained in sugarcane trash farming adopt technology				
EXPECTED RESULTS FOR LIFE OF THE PROJECT	**RESULTS PLANNED FOR THE LAST PERIOD (5TH QTR)**	**ACTUAL RESULTS**	**VARIANCE OF PLANNED TO ACTUAL/EXPLANATION**	**PROGRESS TOWARDS RESULTS TO DATE**
OUTPUT A1 Data gathered from 20 Demonstration sites and 6 cane variety sites	Gather data from 20 demonstration sites and 6 cane variety sites	Ongoing data gathering from 20 TF demo sites and 6 cane variety trial sites.	The demo sites and variety sites were established as planned with positive feedback from the farmers.	All 6 trial farms & 20 demonstrations sites were established. Five BNF varieties have been identified and multiplied.
ACTIVITY A1 Development of trash farming Budget: $ 81,043	Develop trash farming demonstration sites Assess sugarcane germplasm	Trash farming sites were developed and sugarcane germplasm assessed	Demo sites were exclusively showing trash farming (not burn vs. no burn).	Trash farming was well received by the farmers & led to significant plant material improvement.
OUTPUT A2 10% increase in net income from sugarcane	Preliminary estimates from farmer surveys	Developed farmer survey on income levels, farm inputs and field practices	Delivery and analysis of survey could not be done due to early project cessation.	Savings on fertilizer use have been identified to be $130/ha which is 14% of the total net income.
ACTIVITY A2 Survey of farmers to examine costs and field practices Budget: $ 21,113	Conduct farmer survey	Developed farmer survey on income levels, farm inputs and field practices	Delivery and analysis of survey could not be done due to early project cessation.	Feedback from farmer trainers on standard farm practiced collected.
OUTPUT A3 Increased awareness and skills in trash farming	Conduct 1000 farmer training sessions during the year Conduct farmer survey to appraise success	89 Farmers trained in adopting ESCF, bringing project total to 534	Took longer time to get the implementation on schedule due to training reorientation, lack of community preparation, and lack of focus areas	Reorientation established, additional technical team hired to focus on sugar-intensive areas, & community organizers utilized to r increase community participation
ACTIVITY A3 1000 farmers trained per year for 3 years in sugarcane trash farming Budget: $ 44,600	Conduct 1000 farmer training sessions	87 trainings conducted bringing project total to 534. A total of 144 farmers adopted TF in year one or 32% of the trainees who received training.	Took longer time to get on schedule due to training reorientation, lack of community preparation. The enthusiasm for this component by farmers was not matched by the local NGO partner who was heavily involved in agrarian land reform issues.	The training reorientation was completed. A total of 534 trainees received training or 43% of the target number by the 5th quarter. Good adoption rates achieved considering 32% of the farmers adopted trash farming with the first 12 months following training.
OUTPUT A4 Estimates provided for GWC reductions	Review preliminary estimates for GWC reductions	Review of preliminary estimates for GWC reductions	Data was collected on schedule and researchers are comfortable with the values obtained.	Determined that the adoption of TF and active BNF could reduce GHG by up to 9.7 tonnes CO@ eqvlt.
ACTIVITY A4 Assessment of components to derive greenhouse gas reduction Budget: $ 18,678	Collect data from various sources	Data collected from various sources	Data was collected on schedule and researchers are comfortable with the values obtained.	With the conversion of 170 ha of land to TF this could reduce GHG by 1440 tonnesCO2/ annually, or up to 1643 tonnes CO2with TF/ BNF.

ANNEX B: SUMMARY OF PLANNED RESULTS B: MAYON TURBO STOVE				
EXPECTED RESULTS OF OUTCOME B: annualized household cooking costs for women decline by 25% for 9000 stove users				
EXPECTED RESULTS FOR LIFE OF THE PROJECT	**RESULTS PLANNED FOR THE LAST PERIOD (5TH QTR)**	**ACTUAL RESULTS**	**VARIANCE OF PLANNED TO ACTUAL**	**PROGRESS TOWARDS RESULTS TO DATE**
OUTPUT B1 9000 stoves purchased and in use by project completion	Manufacture and sell 3750 stoves by 5th qtr	Manufactured 5403 stoves and sold 2645.	Production was 144% of the target for 5 quarters. Sales were 98%of the targeted 1250 stoves in Panay and 57% of the targeted 2500 in Negros.	Produced stoves still being marketed in local areas and local shops still under production. Overall results in Panay were quite promising and behind targets in Negros.
ACTIVITY B1 Manufacture and distribution of 3000 stoves per year for 3 years Budget: $ 191,648	Manufacture and sell 3750 stoves by 5th qtr			
OUTPUT B2 Women enhance skills in training and biofuel cooking	Conduct 3750 household training sessions by 5th qrtr	Conducted 2645 household training sessions during the 5 quarters.	There was some variance in the way this activity was reported as trainings were provided for each stove sold. Data provided in error in year was based on stove distribution. and has been revised based on stoves sold.	Trainings will continue with each stove sold. Booklet containing usage instructions has been printed. Instruction on stove production published on the internet.
ACTIVITY B2 9000 training's to improve household cooking skills Budget: $ 37,100	Conduct 3750 household training sessions by 5th qrtr			
OUTPUT B3 Reduction in overall household cooking costs of 25%	Update results from preliminary survey to determine fuel costs and stove success.	Pls refer to Appendix H for stove's economic and GHG mitigation performance for updated results.	Data was collected on schedule and researchers are comfortable with the values obtained.	It was found that the average reduction in household cooking was 55% which exceeded the target of a 25% reduction.
ACTIVITY B3 Conduct surveys to examine fuel consumption and costs Budget: $ 32,796	Conduct household survey in Panay to appraise stove success in the home.	Conducted household survey in Panay of fuel costs and stove success.	Some gaps in data collection in Panay prevented accurate analysis of fuelwood collected.	Results indicate the stove has an equally large potential to reduce household expenditures by about 1398 P/yr, a savings of 4% of their annual income.
OUTPUT B4 Estimates provided for GWC reductions	Review estimates for GWC reductions	Completed review of estimates for GWC reductions	Data was collected on schedule and researchers are comfortable with the new methodologies used.	Determined that the introduction of one Rice hull stove can mitigate 982 kg of CO_2 annually
ACTIVITY B4 Assessment of components to derive greenhouse gas reduction Budget: $ 23,623	Collect data from various sources	Data collected from various sources	Data was collected on schedule and researchers are comfortable with the values obtained.	The introduction of 2645 stoves during the project has brought mitigation up to 2597 tonnes of CO_2/ annually (direct GHGs 1705 tonnes).

ANNEX C: RESULTS BASED MANAGEMENT SUMMARY
PERFORMANCE MEASUREMENT FRAMEWORK (PMF)
A: TRASH FARMING

PERFORMANCE FRAMEWORK	PERFORMANCE INDICATORS	REACH	DATA SOURCES	RESPONSIBILITY
IMPACT Reduced GHG emissions	Reduction of emissions to the atm in Tonnes of carbon (as CO2) contributing to the GWC	The Philippines	Data used in emissions calculations	REAP
OUTCOME A 40% of farmers trained in sugarcane trash farming adopt technology	Registry of farmers taking training and converting to trash farming in each federation	Small farmers of Western Visayas	MAPISAN and local federation registry Survey feedback	MAPISAN / PDG
OUTPUT A1 Data gathered from 20 demonstration sites and 6 cane variety sites	Health/productivity of crop from demonstration sites	Small farmers of Western Visayas	Actual data collected from demonstration sites	PDG
OUTPUT A2 10% increase in net income from sugarcane	Relative profitability of cane production vs. control	Small farmers of Western Visayas	Survey feedback	PDG / REAP
OUTPUT A3 Increased awareness and skills in trash farming	Number of farmer undergoing training Level of satisfaction from training	Small farmers of Western Visayas	Survey feedback	PDG / MAPISAN
OUTPUT A4 Estimates provided for GWC reductions	Reduction of emissions to the atm in Tonnes of carbon (as CO2) contributing to the GWC	The Philippines	Data used in emissions calculations	REAP

ANNEX D: RESULTS BASED MANAGEMENT SUMMARY **PERFORMANCE MEASUREMENT FRAMEWORK (PMF)** **B: MAYON TURBO STOVE**				
PERFORMANCE FRAMEWORK	**PERFORMANCE INDICATORS**	**REACH**	**DATA SOURCES**	**RESPONSIBILITY**
IMPACT Reduced GHG emissions	Reduction of emissions to the atm in Tonnes of carbon (as CO2) contributing to the GWC	The Philippines	Data derived from output B.4	REAP
OUTCOME B Annualized household cooking costs for women decline by 25% for 9000 stove users	Cost of household cooking before and after stove introduction (taking into account cost of inflation, food etc,)	Small farmers from the Western Visayas and their families	Survey feedback	PDG / MASIPAG
OUTPUT B1 9000 stoves purchased and in use	Production of stoves Number of LT-2000 Multi-fuel stoves purchased, and in use Stove re-flow levels	Small farmers from the Western Visayas and their families	Survey feedback	PDG / MASIPAG
OUTPUT B2 Women enhance skills in training and biofuel cooking	The Participatory Rural Appraisal (PRA) will indicate the relative confidence and skills of women	Women of Western Visayas	PRA Survey	PDG / MASIPAG / MAPISAN
OUTPUT B3 Reduction in overall household fuel costs	Collection of data from the Participatory Rural Appraisal (PRA) indicating household fuel use	Small farmers from the Western Visayas and their families	PRA Survey	PDG / MASIPAG / REAP
OUTPUT B4 Estimates provided for GWC reductions	Reduction of emissions to the atm in Tonnes of carbon (as CO2) contributing to the GWC	The Philippines	Data used in emissions calculations from various sources	REAP

Appendix A. List of Trash Farming Demonstration Sites

Name of farmers cooperator	Demo-sites area/location for project year one	Area per ha.	Status
1. Nicasio Ramirez	Kabasakan/ Macarandan	1	Pre/Post-harvest
2. Ernesto Gonzales	Kabasakan/ Macarandan	1.25	Pre-harvest
3. Sonny Moreno	Mabuhi-pa / Tapi	1	Pre/Post-harvest
4. Elizabeth Saludares	Dutang-saad/ Tapi	1.12	Pre/Post-harvest
5. Dutang-saad Ass'n	Dutang-saad / Tapi	.90	Pre/Post-harvest
6. Rolando Monton	Dutang-saad / Tapi	1	Pre/Post-harvest
7. Romeo Guilaran	Tuda I /Tapi	1	Pre/Post-harvest
8. Elsa Dungon	Marbep/ Pinaguinpinan	.40	Pre/Post-harvest
9. Antonio Guanzon	Tumpi/ Tagoc	3	Pre/Post-harvest
10. Dan Divinagracia	Bakas/ Orong	1	Pre/Post-harvest
11. Vergilio Sacadan	Bakas / Orong	1	Pre/Post-harvest
12. Jim Esmeralda	Pumoluyo/ Libas	1	Pre/Post-harvest
13. Elsa Magada	Pumoluyo/ Basak	1	Pre/Post-harvest
14. Herminia Alejandro	Safa / San Antonio	1.50	Pre/Post-harvest
15. Botoy Carpentero	Safa / San Antonio	1.57	Pre/Post-harvest
16. Mildred Evangelio	Safa / San Antonio	1	Pre/Post-harvest
17. Alfredo Panolino	Kabbuhian/ Bino	1	Pre/Post-harvest
18. Herman Fernando	Kabbuhian/ Bino	1	Pre/Post-harvest
19. Nelia Nemenso	Kabbuhian/ Bino	1	Pre/Post-harvest
20. Ronelo Caya	Mabakod/Bajay	1	Pre/Post-harvest

Appendix B1. Sugarcane Variety Trial Sites

Variety of sugarcane planted	Location /PO	Area/ha.	Status in year one
6723 7464 8013 8477 84-947 86-550 8839 91-0707 91-1091 92-0751 93-2737 93-3849 93-5155 9324	Marbep/ Elsa Dungon	.60	Ongoing monitoring; varieties with good performance are: 84-947, 8839, 86-550, 7464 & 6723.
	Cisfa/ Adam Samilo	1	Ongoing monitoring; varieties with good health/appearance/performance are: 8839 & 86-550.
	Mabuhi-pa /Mabuhi-pa communal farm	1	Ongoing monitoring; varieties with good health/appearance/performance are: 7464, 84-947, 8013, 8839, 86-550.
	Pumoluyo/	1	Ongoing monitoring; varieties with good performance are: 84-947,7464, &86-550.
	Kabbuhian/Kabbuhian communal farm	1	Ongoing monitoring; 84-947, 92-0751 and 8839 are doing very well
	Bakas Ass'n/ Bunga	1	Ongoing monitoring; 84-947, 92-0751, 93-3849 are doing very well and most other varieties are exhibiting relatively good early growth.

Appendix B2. Sugarcane Variety Trial Sites

Variety of sugarcane planted	Performance results after 7 months (August 2002) from MARBEP trial site	Recommended for scale up
8013	• Good BNF • Large stalks	✔
8477	• Short height	
8839	• Deep dark green color • Thick stalk • Medium height • Excellent BNF	✔
84-947	• Dark green • BNF • Medium stalk thickness • Good tillering • Upright leaves • Drought resistant	✔
91-1091	• Medium height • Tillers well	
92-0751	• Fast Grower • Tall height • BNF	✔
93-2737	• Short height	
93-3849	• BNF • Medium height • Thick stalk	✔
93-5155/93-3165	• Very short height	
93-2349	• Short height	
6723	• Medium height	

Appendix C. Sugarcane Sites with Intercropping

Location	Crops planted	Area (in has.)	Status at end of year one
Mabuhi-pa	Mongo & soybeans	1	For planting pending rainy season (upland area; rainfed)
Dutang-saad	Mongo & cowpea	.90	Sugarcane at 40 cm; mongo and cowpea at 10 cm
Pumoluyo	Mongo	2.5	Intercrop already harvested (yield = 200 kilos of mongo); ratoon at 6 months
Marbep	Mongo & soybeans	1	Intercrops at 1.5 months old; ratoon at 3 months.
Kabbuhian	Mongo	1	Intercrop at 1.5 months old; ratoon at 3 months
Cuyapan	Glutinous corn	.80	Intercrop harvested (yield = 150 kilos of corn); ratoon at 4 months

Appendix D. List of Trainings Conducted

PO's	Type	Attendance	Male	Female	Date conducted
Kabbuhian Ass'n	SCTF	44	32	12	11/30/021
Pumoluyo fed.	SCTF	39	10	29	03/14-15/02
Aspaca Ass'n	SCTF	14	10	4	09/12/01

Iarfba Ass'n	DIFS W/ SCTF	21	14	7	03-4-7/ 02
Marbep Ass'n	DIFS W/ SCTF	22	16	6	3/19-20/02
Cisfa Ass'n	DIFS W/ SCTF	21	17	4	2/22-23/02
Kasmmabbi Ass'n	SCTF	35	26	9	2/21-22/02
Kabasakan Fed.	DIFS W/ SCTF	20	13	7	3/21-22/02
Gresfa Ass'n	DIFS W/ SCTF	16	16	-	2/24-25/02
Tafas Ass'n	DIFS W/ SCTF	17	8	9	11/6-7/01
Safa Ass'n	DIFS W/ SCTF	11	6	5	11/12-15/01
Mapisan Trainers Training	SCTF	20	16	4	7/29-30/01
Bakas Ass'n	SCTF	22	11	11	1/28-29/02
Libas Ass'n	SCTF	19	3	16	12/22-23/01
Bugana Fed.	DIFS W/ SCTF	49	31	18	3/30-31/02
Tumpi Ass'n	DIFS W/ SCTF	13	11	2	2/18-21/02
Kabasakan fed.	CROSS VISIT	13	6	7	3/23/02
Miscellaneous		49			
TOTAL Year 1		**445**	**246**	**150**	
Akaka Ass'n	EFS	20	15	5	04/12-15/2002
Bakas Ass'n	EFS	20	11	9	04/20-21/2002
Kabasakan Fed.	EFS	32	20	12	05/13-15/2002
Cana-an Ass'n	EFS	17	9	8	06/6-8/2002
TOTAL Year 2		**89**	**55**	**34**	
PROJECT TOTAL		***534***	***301***	***184***	

Appendix E. List of Farmers Adopting Trash Farming/Ecological Farming Systems during year 1

Name of farmers	Area/Association	Average area under cane /crop production (ha)	Average area under trash farming (ha)
1.Virgilio Sacadan	Bino/ Kabbuhian	1	1
2.Noli Pabalinas	Bino/ Kabbuhian	1	1
3. Segundina Ocdex	Bino/ Kabbuhian	1	1
4. Argen Seron	Bino/ Kabbuhian	1	1
5. Alfredo Panolino	Bino/ Kabbuhian	1	1
6. Jimmy Yanson	Bino/ Kabbuhian	1	1
7. Herman Fernando	Bino/ Kabbuhian	1	1
8. Nelia Neminso	Bino/ Kabbuhian	1	1
9. Fructoso Mojillo	Bino/ Kabbuhian	1	1
10.Marites Mojillo	Bino/ Kabbuhian	1	1
11.Ronaldo Mojillo	Bino/ Kabbuhian	1	1
12.Jimmy Reyes	Bino/ Kabbuhian	1	1
13.Lauro Pabalinas	Bino/ Kabbuhian	1	1
14.Alfredo Lastimoso	Bino/ Kabbuhian	1	1
15.Rogelio Suasen	Bino/ Kabbuhian	1	1
16.Reynaldo Sinelong	Bino/ Kabbuhian	1	1
17.Ruben Pabalinas	Bino/ Kabbuhian	1	1
18.Candido Cuenca	Bino/ Kabbuhian	1	1
19.PO Kabbuhian	Bino/ Kabbuhian	1	1
20. Aspaca Assoc.	Hilamonan/Aspaca	.30	.30
21. Aspaca Assocn.	Hilamonan	.80	.80
22.Nicasio Ramirez	Macarandan/ Kabasakan	1	1
23. Eduardo Florendo	Gatuslao/Kabasakan	1.25	1.25
24. Rodolfo Oray	Bugana	3	3
25. Mamerto Dungon	Makimasa	1	1
26. Elsa Dungon	Makimasa	1	1

27. Antonio Guanzon	Makimasa	1	1
28. Abeth Saludares	Bugana	1.12	1.12
Name of farmers	**Area/Association**	**Average area under cane /crop production (ha)**	**Average area under trash farming (ha)**
29. Sonny Moreno	Bugana	1	1
30. Jim Esmeralda	Pumoluyo	1	1
31. Elsa Magada	Pumoluyo	1	1
32. Ronie Caya	Mabakod	1.10	1.10
33. Romeo Villadar	Mabakod	1.10	1.10
34. Emilia Andres	Mabakod	1.10	1.10
35.Felix Cañete	Mabakod	1.10	1.10
36.Julieta Paulino	Mabakod	1.10	1.10
37. Carmelita Amar	Mabakod	1.10	1.10
38. Roberto Tabio	Mabakod	1.10	1.10
39. Conception Ruben	Mabakod	1.10	1.10
40. Gerusito Ruben	Mabakod	1.10	1.10
41. Lilia Tabio	Mabakod	1.10	1.10
42.Leticia de La Cruz	Mabakod	1.10	1.10
43.Otilo Lachica	Makimasa	1	1
44. Dan Divinagracia	Bakas	.35	.35
45. Mabakod Ass'n	Bajay	.50	.50
46. Ignacio Tabor	Manambol, Tuyom	3	3
47. Demetrio Obado	Manambol,Tuyom	1	1
48. Aladino Monton	Manambol, Tuyom	1	1
49. Arsenio Gariega	Manambol, Tuyom	.50	.50
50. Rogelio Gustilo	Manambol, Tuyom	.50	.50
51.Feliciano Velle	Manambol, Tuyom	1	1
52. Claudia Along	Manambol, Tuyom	.50	.50
53.Buenaventura Monton	Manambol, Tuyom	.50	.50
54. Roberto Entes	Manambol, Tuyom	.50	.50
55. Nonito Villanueva	Manambol, Tuyom	.50	.50
56. Jim Esmeralda	Libas, Basak	1	1
57. Roberto Taño	Libas, Basak	1	1
58. Euberto Mondia	Libas, Basak	1	1
59. Ruby Banay	Libas, Basak	2	2
60. Hector Lazarito	Tuyom	3	3
61. Joaquin Penion	Tafas /Tabu	3	3
62. Samuel Cajenta	Grummacan/ Kabasakan	2	2
63. Florenio Jerez	Candoni/Kabasakan	3	3
64. Jose Gellada	Kabbuhian/ Bino	1	1
65. Arcado Bangalisan	Kabbuhian/ Bino	1	1
66. Edna Tadlas	Kabbuhian/ Bino	1	1
67. Myrna Villanueva	Kabbuhian/ Bino	1	1
68. Jose Titong	Kabbuhian/ Bino	1	1
69. Joeven Fernando	Kabbuhian/ Bino	1	1
70. Josephine Fernando	Kabbuhian/ Bino	1	1
71. Josephine Peduhan	Kabbuhian/ Bino	1	1
72. John Peduhan	Kabbuhian/ Bino	1	1
Name of farmers	**Area/Association**	**Average area under cane /crop production (ha)**	**Average area under trash farming (ha)**
73. Reynaldo Peduhan	Mabuhi-pa	1	1
74. Jeffrey Obligar	Mabuhi-pa	2.5	2.5
75. Jeddy Gepulani	Mabuhi-pa	3	3
76. Epifanio Bulahan	Mabuhi-pa	.50	.50
77. Gernani Bantulo	Mabuhi-pa	.40	.40
78. Communal farm	Mabuhi-pa	.80	.80
79. Ernesto Obligar	Mabuhi-pa	2.5	2.5
80. Dionesio Pamunin	Mabuhi-pa	1	1
82. Adonis Dequito	Mabuhi-pa	.70	.70

83. Ramonito Kilayko	Kabbuhian/ Bino	1	1
84. Rolando Kilayko	Kabbuhian/ Bino	1	1
85. Marcos Roberto Jr.	Kabbuhian/ Bino	1	1
86. Reynaldo Encarnado	Kabbuhian/ Bino	1	1
87. Apolonio Fernando	Kabbuhian/ Bino	1	1
88. Alfredo Panolino	Kabbuhian/ Bino	1	1
89. Jimmy Yanson	Kabbuhian/ Bino	1	1
90. Armando Senilong	Kabbuhian/ Bino	1	1
91.Vicente Senilong	Kabbuhian/ Bino	1	1
92. Reynaldo Senilong	Kabbuhian/ Bino	1	1
93. Angelino Senilong	Kabbuhian/ Bino	1	1
94. Angelina Almonia	Kabbuhian/ Bino	1	1
95. Gene Fernando	Kabbuhian/ Bino	1	1
96. Jose Mojello	Kabbuhian/ Bino	1	1
97. Zaloy Pabalinas	Kabbuhian/ Bino	1	1
98. Sally Peduhan	Kabbuhian/ Bino	1	1
99. Francisco Gayutin	Tuda I	3.9	3.9
100. Agapita Tabaque	Dutang -saad	2.20	2.20
101. Reymundo Estrada	Tuda I	2	2
102. Rolando Monton	Dutang-saad	2.75	2.75
103. Romeo Guilaran	Tuda I	1	1
104. Dolores Aquilo	Tuda I	2	2
105. Merlie Ignacio	Tuda I	1	1
106. Dutang-saad Ass'n	Tuda I	.90	.90
107. Julianita Guilaran	Tuda I	4.5	4.5
108. Gregorio Nim	Tuda I	5	5
109. Florenda Gepanaga	Tuda I	1.5	1.5
110. Armando Alpas	Tuda I	2	2
111. George Alpas	Tuda I	.50	.50
112. Jose Nim	Tuda I	2	2
113. Rosette Pancho	Dutang-Saad	1	1
114. Romeo Mojello	Kabbuhian/ Bino	1	1
115. Elias Lombo	Kabbuhian/Bino	1	1
116. Laurencia Lombo	Kabbuhian/ Bino	1	1
117. Lucia Lombo	Kabbuhian/ Bino	1	1
118. Frnacisco Aculit	Kabbuhian/ Bino	1	1
120. Bonifacio Gadon	Kabbuhian/ Bino	1	1
121. Nancy Vingno	Kabbuhian/ Bino	1	1
122. Joel Malacapay	Kabbuhian/ Bino	1	1
123. Ruben Pabalinas	Kabbuhian/ Bino	1	1
124. Toribio Emperado	Kabbuhian/ Bino	1	1
125. Federico Sta. Ana	Kabbuhian/ Bino	1	1
126. Jolito Senilong	Kabbuhian/ Bino	1	1
127. Rodolfo Nopable	Kabbuhian/ Bino	1	1
128. Donald Alpuerto	Kabbuhian/ Bino	1	1
Name of farmers	**Area/Association**	**Average area under cane /crop production (ha)**	**Average area under trash farming (ha)**
129. Elmo Dulinggis	Kabbuhian/Bino	1	1
130. Rogelio Chavez	Kabbuhian/ Bino	1	1
131. Rudy Sangga	Kabbuhian/ Bino	1	1
132. Joaquin Peduhan	Kabbuhian/ Bino	1	1
133. Hermenia Alejandro	Safa Ass'n	1.20	1.20
134. Estelita Samande	Safa Ass'n	1	1
135. Botoy Carpentero	Safa Ass'n	1.57	1.57
136. Samuel Victoriano	Safa Ass'n	1	1
137. Billy Macariola	Safa Ass'n	.15	.15
138. Dionesio Artanio	Safa Ass'n	.70	.70
139. Ma. Fe Victoriano	Safa Ass'n	.15	.15
140. Rodrigo Lucas Jr.	Safa Ass'n	1	1

141. Reynaldo Jolo	Safa Ass'n	1	1
142. Eliseo Maday	Safa Ass'n	1	1
143. Mildred Evangelio	Safa Ass'n	1	1
144. Rosalie Ruben	Mabakod Ass'n	1	1
	Total Hectares	**169.84**	**169.84**

Appendix F.1 Summary of RHS Distribution and Collection
For the period April 1, 2001 - March 31, 2002

MAPISAN Federation	Dealers	# of men	# of women	# of units	Amt. Collected (PhP)
Bugana, Kabankalan	7	6	1	156	5,850
Kabasakan, Candoni	16	7	9	110	6,970
Pumuluyo, Cauayan	3	2	1	90	3,100
Kabakod, Kabankalan	5	1	4	118	150
Kamada Sipalay	2	-	2	31	-
Mabuhi-ka, La Castellana	4	3	1	82	2,080
Makimasa,Kabankalan	2	2	-	52	7,200
Mainuswagon, Kabankalan	1	-	1	22	-
Kami, Cauayan	1	1	-	4	200
Pag-isa, Kabankalan	4	4	-	105	-
Pag-asa, Hinobaan	-	-	-	-	-
Penasahi, Himamaylan	3	3	-	122	-
Talamnan, Cauayan	1	-	1	1	-
Total	**49**	**29**	**20**	**893**	**25,550**

Appendix F.2 Summary of RHS Distribution and Collection
For the period April 1, 2001 - March 31, 2002

NON-MPSN	# Of dealers	# of men	# of women	# of units	Amt. Collected (PhP)
San Carlos	2	1	1	46	3,050
Bacolod	3	-	3	19	2,865
Bago	35	11	23	405	32,020
Pulupandan	2	-	2	21	-
San Enrique	6	2	4	34	2,000
Valladolid	2	-	2	25	200
Pontevedra	9	5	4	55	1,350
La Castellana	4	2	2	22	550
Moises Padilla	3	-	3	16	900
Hinigaran	6	1	5	51	2,600
Isabela	1	-	1	3	-
Binalbagan	7	3	4	73	9,200
Himamaylan	5	2	3	28	1,440
Kabankalan	24	11	14	72	11,030
Ilog	15	5	10	162	20,430
Cauayan	4	2	2	37	2,960
Sipalay	8	5	3	54	2,160
Hinoba-an	29	12	17	220	6,080
Basay oriental	2	2	-	27	100
Bayawan	1	1	-	6	-
Total	**167**	**64**	**103**	**1,376**	**98,935**

Appendix G2: The Mitigation of Greenhouse Gas Emissions by Ecological Sugarcane Trash Farming in the Philippines.

The introduction of sugarcane trash farming as an alternative to current farming methods has been proposed as an effective way to reduce GHG emissions in the Philippines. The predominant crop currently produced in Negros is sugarcane. Conventional farmers burn the sugarcane waste directly in the fields primarily to eliminate the work associated with removing the trash, as well as to prepare the field for the next season and to eradicate pests such as rats and snakes. Unfortunately, biomass burning produces large amounts of toxic and destructive chemicals including particulate matter, aerosols, and greenhouse gases. Trash farming eliminates these effects through composting the cane residue in the field. Trash farming also reduces the need for fertilizer and improves soil structure and quality by increasing nitrogen fixation, soil organic matter, and nutrient cycling and retention. Over time this can lead to an improvement in crop quality, development of the long-term integrity of the soil, and the promotion of sustainable agricultural practices. The effects of trash farming can be directly measured by the reduction in Greenhouse Gas (GHG) emissions seen in comparison to conventional sugarcane farming.

Sugarcane trash farming has considerable potential to reduce greenhouse gas (GHG) emissions to the atmosphere (Appendix G1). Several important sources and potential sinks for carbon dioxide and other greenhouse gases have been quantified for Negros Island in the Philippines. Sources include emissions from burning, fossil fuel energy inputs, and nitrogen fertilizer including fertilizer production and emissions from fertilizer application (both direct and indirect). Estimates have also been made for carbon sinking including the sequestration of organic carbon and methane. The subsequent GHG emission source/sinks associated with sugarcane trash farming, as well as the incorporation of trash farming with biological nitrogen fixation are illustrated in Figure 1 & 2 respectively.

The calculations were based on the methodology outlined in the by the 1996 IPCC Guidelines for National GHG Inventories. REAP's methodology follows the IPCC Sectoral Approach but calculates emissions based on mass of fuel consumed not on energy equivalent of fuel consumed. The information included in this report uses the best techniques currently available, however, some data may retain a degree of uncertainty and the figures generated in this report should accordingly be used with caution. REAP would like to follow the IPCC framework as closely as possible in order to formalize its internal procedures and ensure acceptable GHG accounting.

Figure 1. Prevention of GHG emissions associated with the adoption of sugarcane trash farming (8.54 tonnes CO2/ha*yr)

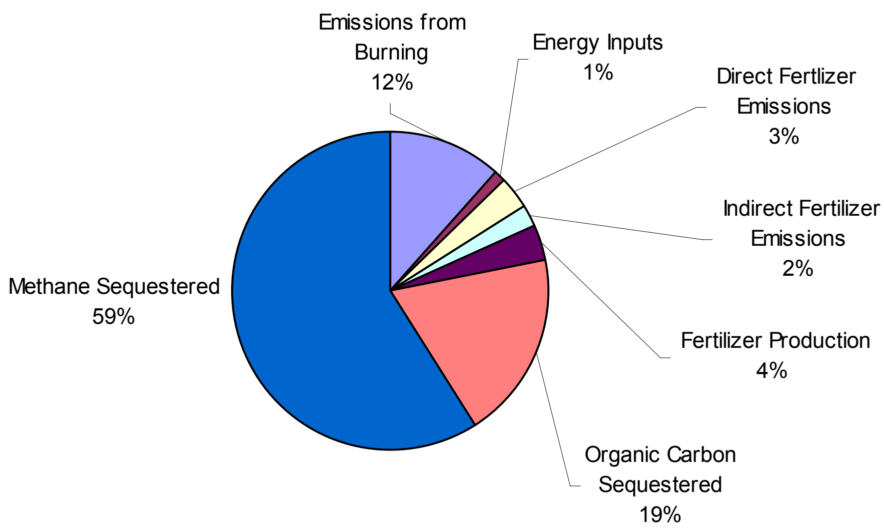
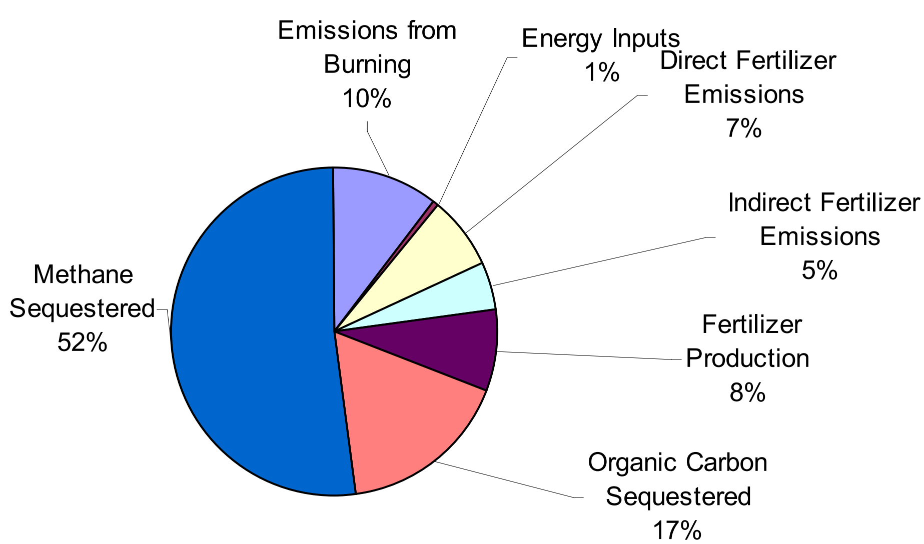


Figure 2. Prevention of GHG emissions associated with the adoption of sugarcane trash farming with BNF (9.67 tonnes CO2/ha*yr)



Carbon Sources

Emissions from Burning

The field burning of agricultural crop residues contributes a substantial amount of CO_2, CH_4, N_2O (direct GHGs) and CO, NO_x, TNMOC and particulate matter (indirect GHGs) to the atmosphere (IPCC 1996). Agricultural burning is not considered to be a net source of carbon dioxide as the biomass burned is generally replaced by regrowth during the subsequent year. CH_4, CO, and N_2O augment the global climate change that is occurring by increasing the heat retention and radiative forcing of the earth, and are more powerful than CO_2 in terms of their 'greenhouse' effects. Methane is a radioactively active trace gas with a high global warming potential of approximately 23 times more infrared-absorbing capability than carbon dioxide per molecule (100 year effects, IPCC 2001). Concentrations of atmospheric methane are currently increasing at approximately 0.5% per year (Steele *et al.* 1992). Nitrogen oxide is another important greenhouse gas that has a lifetime of 166 years in the atmosphere (Prinn et al., 1990), and has a global warming potential that is 296 times greater than that of CO_2 (100 year effects, IPCC 2001). The atmospheric concentration of N_2O is approximately 310 ppbv and is increasing yearly by 0.6-0.9 ppbv (Prinn *et al.* 1990).

The large amount of sugarcane residue produced in the Philippines is primarily disposed of by burning. Crop residue burning practices are an important source of greenhouse gas emissions produced by tropical agricultural (IPCC 1996). Using the methodology established by the IPCC, we can determine the emissions that would result from the burning of the sugar residues. This number would also represent the amount of emissions that would be prevented from entering the atmosphere if the residue was not burned, or in essence the total net emission reductions. Following from this, sugarcane trash farming would prevent the burning of *5.1* tonnes $ha^{-1}yr^{-1}$ of cane residue, and the release of the equivalent of *1.01* tonnes $ha^{-1}yr^{-1}$ of CO_2 to the atmosphere (IPCC 2001).

Because the overall radiative impacts of indirect greenhouse gases (CO, NOx, & TNMOC) are difficult to quantify, it appears that the IPCC has not committed to specific Global Warming Potential (GWP) value for any of these gases, and therefore they do not count as saleable units for carbon credits and are documented separately. However, based on a report produced by the IPCC (2001b) the 100-year GWP for CO is estimated to be between 1.0 to 3.0, therefore REAP used 2.0 (the median) as our GWP estimate for CO. Using this GWP the subsequent indirect GHG emissions from the burning of sugarcane crop residue resulted in the total release of the equivalent of *0.40 saleable* tonnes $ha^{-1}yr^{-1}$ of CO_2 to the atmosphere (in other words, only counting CH4 and N20).

Energy Inputs

Trash farming improves crop productivity by raising the overall yield and increases the number of ratoons (crop cycle) by approximately 1 year (REAP 2001). The extension of the ratooning cycle decreases the amount of energy expended in field preparation (plowing, harrowing, furrowing) and planting by one third, which translates directly into fuel conservation of *1.0* GJ $ha^{-1}yr^{-1}$. The emission reductions associated with this savings in fuel is the equivalent of *0.07* tonnes $ha^{-1}yr^{-1}$ of CO_2 (IPCC 2001). Although the greenhouse gas reductions from an extended ratoon cycle are relatively small, the decrease in soil tillage has additional benefits including an increase in nutrient cycling, water retention, soil stability and accumulation of organic matter.

Nitrogen Fertilizer

Decomposing sugarcane trash can provide a valuable source of nitrogen, which can substantially decrease the amount of fertilizer required for production with no appreciable loss of yield (Patriquin 2000). The average nitrogen gain associated with trash farming is estimated to be 125 $kgNha^{-1}yr^{--1}$. Certain varieties of sugarcane have also shown to engage in active Biological Nitrogen Fixation (BNF) through an association with the N-fixing endophytic diazotroph *Azospirillium spp.* (Urguiaga 1992; Boddey and Dobereiner 1995). These bacteria, found inside the tissue of roots, leaves and stems, can decrease and potentially eliminate the need for fertilizer by providing 150-270 $kgha^{-1}yr^{-1}$ of available nitrogen to the plant. By using sugarcane varieties capable of fixing nitrogen in conjunction with decomposing trash, farmers should be able to largely eliminate N fertilizer use altogether (Muthukumarasamy and Revathi 1999). Reducing the amount of fertilizer applied to the soil decreases the direct emissions from the soil, and the emissions indirectly induced by agricultural activities. Furthermore, the savings in fertilizer translate into GHG reductions by decreasing the emissions associated with fertilizer production.

Direct Fertilizer Emissions

The addition of synthetic nitrogen-based fertilizers to the soil increases the rate of nitrification/denitrification and encourages bacteria to produce nitrous oxide, a harmful greenhouse gas, which is then directly emitted to the atmosphere (IPCC 1996). Denitrification is most active when high amounts of labile (available) nitrogen levels are available under wet soil conditions (Steudler *et al.,* 1989). Typical fertilizer inputs for sugarcane production in the Philippines average 186 $kgNha^{-1}yr^{-1}$ (BAS 2001), which trash farming can reduce to 109 $kgNha^{-1}yr^{-1}$ (Patriquin 2000; REAP 2001), and active BNF can potentially reduce to 0 $kgNha^{-1}yr^{-1}$ (Muthukumarasamy and Revathi 1999). For the purposes of this assessment, the total nitrogen requirements of sugarcane have been set at 209 $kgNha^{-1}yr^{-1}$ (Boddey *et al.,* 1995; REAP 2001), and it has been assumed that natural inputs from cane residues and BNF are supplemented by synthetic fertilizer to obtain this amount in full. Direct soil emissions are assumed to come only from the addition of synthetic fertilizer and the ensuing increase in nitrogen availability; emission coefficients for other sources of nitrogen have not been quantified at this time. The decrease in fertilizer use associated with the conversion from conventional to trash farming corresponds to the prevention of *0.286* tonnes $ha^{-1}yr^{-1}$ of CO_2 emitted to the atmosphere, or *0.690* tonnes $ha^{-1}yr^{-1}$ of CO_2 when considering trash farming with active BNF (IPCC 2001).

Indirect Fertilizer Emissions

The application of fertilizer and other agricultural activities can indirectly lead to N_2O emissions from atmospheric deposition, volatilization and leaching (IPCC 1996). The atmospheric deposition of nitrogen compounds can fertilize soil, augmenting the biogenic formation of nitrous oxide. Nitrogen volatilization from soil surfaces in the form of ammonia, and the leaching of nitrogen into groundwater, riparian areas and wetlands are also considered as indirect sources of N_2O. Assuming a fertilizer savings of 77 $kgNha^{-1}yr^{-1}$ with trash farming, and 186 $kgNha^{-1}yr^{-1}$ with BNF, trash farming can prevent indirect N_2O emissions amounting to the equivalent of

0.195 tonnes of CO_2 $ha^{-1}yr^{-1}$, or *0.469* tonnes of CO_2 $ha^{-1}yr^{-1}$ when considering trash farming with active BNF.

Fertilizer Production

The production of nitrogen-based fertilizers appreciably contributes to global GHG emissions as each kilogram of fertilizer manufactured and transported releases the equivalent of *4.1* kg of CO_2 into the atmosphere (Nagy 2000). Assuming a fertilizer savings of 77 kg N $ha^{-1}yr^{-1}$ with trash farming, and 186 $kgNha^{-1}yr^{-1}$ with BNF, trash farming can prevent the equivalent of *0.32* tonnes of CO_2 $ha^{-1}yr^{-1}$ from entering the atmosphere, up to a maximum of *0.76* tonnes of CO_2 $ha^{-1}yr^{-1}$ when considering trash farming with BNF (IPCC 2001).

Carbon Sinks

Organic Carbon Sequestered

In virtually all ecosystems, the carbon from plant residues and other organic matter is incorporated back into the soil structure by various microorganisms. The average rate of sequestration, 0.3 tonnes C $ha^{-1}yr^{-1}$, varies with temperature, vegetation, soil type, soil moisture, and soil management practices (Batjes 1999). Trash farming would result in the return of 12.62 tonnes $ha^{-1}yr^{-1}$, which compared with conventional methods is a net return of 7.0 tonnes $ha^{-1}yr^{-1}$ of organic matter containing a net of 3.0 tonnes of organic carbon to the soil surface (IPCC 2000). Assuming that 15% of this carbon is converted to the humus fraction of the soil (Batjes 1999), a net of 0.44 tonnes of carbon $ha^{-1}yr^{-1}$ would be sequestered, which is equivalent to preventing *1.63* tonnes $ha^{-1}yr^{-1}$ of CO_2 from entering the atmosphere per year. The permanence of carbon sinking is still largely undetermined; these calculations assume an active sink of 25 years.

Methane Sequestered

Tropical dryland fields are potential net CH4 sinks (Dubey & Singh, 2000) accounting for approximately 40% of the CH4 sink capacity globally (Boeckx & Van Cleemput, 2001). CH4 in trash-blanketed soils has been measured to be 15-105 kt/yr, suggesting that trash-blanketed soils are acting as a net sink for atmospheric CH4 that merits further investigation (Weier, 1999).

The two most important groups of organisms that oxidize CH4 are the methanotrophs and the nitrifiers (Willison et al., 1995). Methanotrophs proliferate in the oxic and rhizospheric portions of the soil, and around plant roots when the soil is dry (Holzapfel-Pschorn et al. 1985, Dubey & Singh 2000, Gilbert & Frenzel, 1998; Kumaraswamy et al., 1997). Nitrifiers not only oxidize methane, they also are important components of the N2-cycle influencing the availability of nitrogen to plants and hence agricultural productivity (Willison et al., 1995).

The rate at which these organisms can oxidize atmospheric methane is determined by: CH4 partial pressure (Gilbert & Frenzel, 1998; Wassman et al., 2000); free oxygen concentration (Gilbert & Frenzel, 1998; Wassman et al., 2000); soil water content (Boeckx & Van Cleemput, 2001; Smith et al, 2000; Wassman et al., 2000; King & Schnell, 1994); tillage/compaction (Boeckx & Van Cleemput, 2001; Smith et al, 2000; King & Schnell, 1994), ammonium inputs (Gilbert & Frenzel, 1998; Boeckx & Van Cleemput, 2001; Willison et al., 1995; Smith et al, 2000; King & Schnell, 1994); pesticide usage (Prieme & Ekelund, 2001; Kumaraswamy et al., 1997); temperature (Wassman et al., 2000); pH (Boeckx & Van Cleemput, 2001; Willison et al., 1995; Smith et al, 2000; Wassman et al., 2000; Gilbert & Frenzel, 1998); as well as plant characteristics (Dubey & Singh, 2000). Keeping these factors in mind, as well as the finding that trash blanketed sugarcane soils can sequester up to 0.6 kg CH_4-C $ha^{-1}day^{-1}$, or 0.22 tonnes CH_4-C $ha^{-1}yr^{-1}$ (Weier 1996), the PACCP sugarcane trash farming project had the potential to mitigate considerable GHGs emitted by conventional agricultural practices in the Philippines, some 5.0 tonnes CO2 eq $ha^{-1}yr^{-1}$.

Although 0.6 kg CH_4-C $ha^{-1}day^{-1}$ appears to be very high when compared to oxidation rates found in other tropical systems (Table 2), no other rates have, as of yet, been quantified for trash farming therefore this number was subsequently used for our analysis. More research to validate this number is a priority if rates of sequestration in trash-blanketed sugarcane systems are as high as projected by Weier (1996)

Conclusions

When considering all of the important sources and sinks of greenhouse gases, the adoption of trash farming can result in the prevention of *8.54* tonnes $ha^{-1}yr^{-1}$ of CO_2 equivalent emitted to the atmosphere, or *9.67* tonnes $ha^{-1}yr^{-1}$ of CO_2 equiv with TF/BNF (direct GHGs = 7.93 tonnes $ha^{-1}yr^{-1}$ of CO_2 equiv). The adoption of trash farming by 144 farmers on Negros over the one-year lifespan of the project gives a land base of *170 ha*. This conversion to trash farming prevented a total of *1440* tonnes of CO_2 equivalent (direct GHGs = 1349 tonnes $ha^{-1}yr^{-1}$ of CO_2 equiv) emitted to the atmosphere, or *1643* tonnes of CO_2 when considering trash farming with BNF. These values are promising and appear high when compared with alternative bio-fuel, land-use, or forestry sequestration mitigation measures. As well, given the holistic nature of the project, beyond mere GHG mitigation, this appears to be a successful and efficient means of reducing GHGs while simultaneously improving the livelihoods of small-scale Third World Farmers.

Table 2. Methane oxidation rates found for various tropical ecosystems.

Tropical Ecosystems					
	Original Value	**Agricultural**	**Arable Land**	**Grassland**	**Forest**
Thailand					
Flooded Rice[5]	0.144 mg/m^{2}/day	0.144 mg/m2/day			
Deciduous[5]	0.236 mg/m2/day				0.236 mg/m2/day
Evergreen[5]	0.209 mg/m2/day				0.209 mg/m2/day
Pine[5]	0.161 mg/m2/day				0.161 mg/m2/day
Fallow[5]	0.517 mg/m2/day		0.517mg/m2/day		
Field Crop[5]	0.240 mg/m2/day	0.240 mg/m2/day			

Table 2 (con't). Methane oxidation rates found for various tropical ecosystems.

Tropical Ecosystems					
	Original Value	**Agricultural**	**Arable Land**	**Grassland**	**Forest**
No Description[3]	0.190 mg/m2/day	0.190 mg/m2/day			
Oxisol[4]	24 µg/m2/hr *				0.576mg/m2/day *
Alfisol[4]	11 µg/m2/hr *				0.264mg/m2/day *
Burned Pasture[4]	12 µg/m2/hr *		0.144mg/m2/day *		
Unburned Pasture[4]	13 µg/m2/hr *		0.096mg/m2/day *		
Brazil					
Amanzonia[3]	0.35 mg/m2/day	0.35 mg/m2/day			
Amanzonia[2]	1.71 mg/m2/day				1.71 mg/m2/day
Indonesia					
Sugarcane[1]	30µg CH4/m2/hr	0.72 mg/m2/day			
Primary[1]	50 µg CH4/m2/hr				1.2 mg/m2/day
Secondary[1]	110 µg CH4/m2/hr				2.64 mg/m2/day
Old Rubber Jungle[1]	90 µg CH4/m2/hr				2.16 mg/m2/day
Upland Rice[1]	30 µg CH4/m2/hr	0.72 mg/m2/day			
Queensland, Australia					
Trash Farmed Sugarcane[6]	**0.6 kg/ha/day**	**60 mg/m2/day**			
Puerto Rico					
No Fertilization[4]	4.3 µg/m2/hr			0.103 mg/m2/day	
With Fertilization[4]	3.8 µg/m2/hr			0.0912 mg/m2/day	
Unknown					
No Specific Location[2]	0.25-0.5 mg/m2/day				0.25-0.5 mg/m2/day
Data Ranges					
		0.144 - 60.0 mg/m2/day	0.096 - 0.517 mg/m2/day	0.0912 - 0.103 mg/m2/day	0.161 - 2.64 mg/m2/day

* CH4 Uptake Rates

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Appendix H. Impact of a Rice Hull Stove on Fuel Expenditures and Greenhouse Gas Emissions in Rural Households in Negros Occidental, Philippines

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Introduction and objectives

The Philippine Agricultural Climate Change Project is a CIDA supported project aimed at eliminating field burning of sugarcane field residues and rice hulls. Its goal is to reduce greenhouse gas emissions and poverty through more effective use of these residues. An improved rice hull stove is being introduced into the Western Visayas region of the Philippines as a means to prevent field burning of rice hull. It is being used as a substitute fuel for rural households as a means to replace firewood and charcoal use. The adoption of an improved rice hull stove is projected to have a positive impact on the household economy and on the reduction of GHG emissions from the reduction in use of traditional cooking fuels. The objective of this study is to quantify the influence of the improved rice hull stove on household fuel use and expenditure, and on GHG emission mitigation. The study will seek to answer three main questions:

1. What is the impact of the rice hull stove on the use of other fuels for cooking (fuelwood, charcoal and LPG)?
2. How have household cooking expenditures changed after the acquisition of the rice hull stove?
3. What are the GHG emission reductions derived from substituting rice hull for other cooking fuels using the LT 2000 stove?

<u>Fuel and energy models</u>

The improved rice hull stove used in the survey, the LT-2000, was an improved version of the Lo Trau stove from Vietnam. None of the recently introduced Mayon Turbo Stoves were being used in communities at the time the survey was taken. A comparison of the types, quantities and costs of cooking fuels used by households before and after the acquisition of the LT 2000 stove was used to determine the fuel types rice hulls substituted for, the quantity of fuel replaced, and the change in cooking fuel expenditures.

The comparison was very simple (in mathematical terms) and encompassed data on types of fuel used, and on quantities and costs for each fuel both in Philippino Pesos and US dollars (at an exchange rate of 51:1). A time frame of one month was considered a reasonable period for households to report their fuel use and expenditures. An important assumption used in the analysis is that other factors affecting fuel use and expenditures remained constant before and after a household acquired a LT-2000 stove. The validity of the results of the analysis depends on the accuracy of this restriction.

Household energy use, energy cost, and GHG emission reductions were estimated utilizing the results on fuel use and expenditures as input for simplified models of cooking and GHG emissions. The model to estimate energy use and cost was based on the assumption that fuels have a uniform energy content and deliver heat output to the cooking pot with a uniform thermal efficiency. Energy content and thermal efficiency values for each fuel were obtained from the available literature (End Note 2). In the case of rice hull stove the thermal efficiency was estimated based on the amount of delivered energy it displaced from charcoal, firewood and LPG and the quantity of rice hull utilized.

The equation used in the analysis is:
household energy use/ month (MJ) = Σ (fuel use (kg) x energy delivered (MJ/kg))
where Σ is the summation for all fuels (fuelwood, charcoal, LPG and rice hull).

GHG emission reductions were estimated using data collected for local fuel use and expenditures. The model that was used assumed that fuelwood and charcoal are harvested from renewable biomass, and that rice mills and farmers dispose of the rice hull by burning. CO_2 emissions from the combustion of biomass are not counted because growing plants sequester the carbon emitted as CO2. NO_x was also not included as data was not available. However, the other GHGs from biomass combustion (CH_4, N_2O, CO, & TNMOC) are included. Charcoal is a source of GHG, both when it is produced and when it is consumed. Kerosene is also accounted for as it is used as a firestarter by rural households. It should be noted that local data is preferred to IPCC default data, if it is properly referenced and documented.

The IPCC Sectoral Approach is a detailed GHG accounting methodology developed to help countries assess their national GHG inventories. It is also considered a standard methodology that can be applied to smaller projects. REAP proceeded with GHG calculations as follows:

Small-scale combustion of fuel is categorized by IPCC Reporting as a GHG Source (1-Energy, A-Fuel Combustion Activities, 4-Small Combustion, b-residential). The equation used to estimate GHG emission was:

$$E_i = (A_i – B_i) \times EF_I \times CR_i \times GWP_i$$

E = emission reduction (kg of CO2 equivalents)
A = amount of fuel consumed per month after the LT 2000 stove was acquired
B = amount of fuel consumed before
EF = Emission Factor (i.e. carbon mass pollutant / mass fuel)
CR = Conversion Ratio (i.e. Molecular Mass pollutant / Molecular Mass of carbon)
GWP = Global Warming Potential (over a 100-year time horizon)
i = fuel type.

Fuelwood and Charcoal Price Survey

A visit was made to local markets in Negros to assess the price of fuelwood and charcoal in urban markets and the trading weights of these commodities. No data was gathered in rural markets as prices were assessed from the survey of rural households using the stove.

The Household Survey

To obtain data on household fuel use and expenditures a survey was conducted among households that had acquired the LT 2000 stove by December 2001. The questionnaire had three sections. The first section gathered demographic data of the household. The second section obtained data on fuel types used, quantities consumed, and expenditures incurred per month both before and after the purchase of the LT 2000 stove. The final section collected user's feedback about the performance of the LT 2000 stove and alternatives to improve the marketing strategy (see End Note 1 for a copy of the questionnaire).

The selection of the sample was done following a two step process. First, the Province of Negros Occidental was divided into geographic zones. Second, the number of households was chosen according to the quantity of stoves distributed to each zone. Households were contacted by the marketing team during the marketing tour in each zone and asked whether they wanted to participate in the survey. The selection process was rather random, therefore the sample chosen is considered to be representative of the population of LT 2000 users. In December 2001 and January 2002, personal interviews were conducted by the PDG marketing team staff of 99 households mainly in rural upland areas of southern Negros Occidental.

The Results

Background information

Of the 99 responses collected, 86 were usable and were subsequently used for the final analysis. The average household buying a stove had 6 members, earned a total annual income of P38564 ($756 USD), had a per capita income of P7241 ($142 USD), and derived 53% or P20482 ($401 USD) from farming. The average income of users was lowest (data not shown) for those who were mainly firewood users (P36959 annual income) while those using LPG was highest at P51218. Those described as charcoal users (consuming more than two sacs, or approximately 30 kg per month) were also of a higher income bracket at P50700 of annual income. Nonetheless most charcoal users burnt firewood to meet a large part of their cooking fuel needs. Households in the Philippines tend to use several cooking methods for reasons of convenience and taste. LPG is sometimes used for convenience to ease the rural households ability to get children hot meals before they go off to school early in the morning. Charcoal is a preferred fuel for grilling chicken and fresh fish and often used in the rainy season as a primary or supplemental cooking fuel in rural areas because of problems of accessing dry fuelwood.

In Negros Occidental the rice hull stove has mainly been marketed to date in rural areas of southern Negros Occidental. As such, data was collected from a variety of markets to better understand local fuel pricing. The average cost of a sack of charcoal was 61 pesos (4.18p/kg) in rural areas (Table 1). The market study of urban markets indicated a higher price of 86 PhP (5.85p /kg) in urban areas. Firewood prices were on average 1.49p/kg in rural areas and 2.00p/kg in urban markets in Negros Occidental. These prices are in a similar price ratio of urban to rural, and firewood to charcoal, as the 1995 household survey (Table 2). The biofuel prices are lower today as the peso has depreciated from 25.7:1 USD (1995 average) to 51:1 USD (December 2001) in the past 6 years.

Overall rural prices are roughly about 1/3 rd less than urban markets owing to higher marketing and transport costs. In larger urban centres, firewood prices tend to increase more as the commodity is not as transportable as charcoal. It would appear that if rice hull would be accessible near urban areas it would be a highly effective at reducing household cooking costs.

Table 1. Price of Firewood and Charcoal in Rural and Urban Negros Occidental

Location	*Fuelwood (price in pesos/kg)*	*Charcoal (Price in pesos/kg)*
December 2001 PACCP Survey		
Negros Occ(Rural)	1.49	4.18
Kabankalan City (urban)	1.70	5.01
Hinigaran (urban)	Na	6.29
Pontevedra (urban)	2.19	6.35
Bago City (urban)	2.12	5.87
1995 Department of Energy Household Survey		
Western Visayas (Urban)	2.85 (1.44)	7.22 (3.64)
Western Visayas (Rural)	2.48 (1.25)	7.28 (3.67)
Philippine (Urban)	3.23 (1.63)	9.76 (4.93)
Philippine (Rural)	2.29 (1.15)	7.38 (3.73)

Note 1: figures in brackets are adjusted to a 2001 peso exchange rate versus the dollar.
Note 2. The average weight of a sac of charcoal was 14.7kg and the average weight of a bundle of firewood was 6.7kg. Firewood weights are generally more variable as they are often sold in 10 peso bundles.

Users' feedback on the Stove

Respondents were asked a series of questions regarding their experience with the LT 2000 to help improve understanding of the consumer acceptance of the stove (End Note 4). The majority of respondents (72%) had been using the stove for less than 6 months and expected the stove to last for at least 2 years (77%). All but one user considered their stove to be in good condition. On average, respondents used the LT 2000 to perform 76% of their cooking. Approximately half the users mentioned experiencing difficulties starting the fire. Smoke emissions and accessing fuel was also mentioned as problems by 12 % and 10 % of the users respectively. Controlling heat output and putting out the fire were also mentioned as problems by approximately 5% of users. Overall, LT 2000 users found the stove advantageous for heating up quickly, lowering fuel cost, and reducing smoke emissions compared to their previous cooking system. Stove owners thought that providing a user's manual with the stove and offering public demonstrations were the best ways to enhance the acceptance of the stove among potential consumers.

Fuel use and expenditure variation

The information about household fuel use and expenditures is summarized in Tables 2 and 3. The number of households using each fuel type and the average household fuel use indicate that the fuel switch happened mainly from fuelwood to rice hull. However, the rice hull stove appeared to be an effective substitute for the use of charcoal. Overall, consumption of firewood, charcoal, and LPG decreased by 73%, 76% and 46% respectively. The number of households using charcoal also declined by 65%, indicating that the rice hull stove is highly effective at reducing charcoal use for daily cooking needs. Poor upland families in Negros seldom enjoy fresh fish and chicken, which tend to be grilled with charcoal by wealthier families. In the case of LPG, the number of users and consumption decreased more moderately which indicates that these households enjoy the convenience of LPG for many cooking applications. A more convenient rice hull cooker could likely reduce LPG use further as there appears to be considerable savings from the switch. In an average household, 143.5 kg of rice hull replaced 144.5 kg of fuelwood, 4.5 kg of charcoal and 0.6 kg of LPG on a monthly basis (Table 2). Thus a rice hull stove would be projected to save 1734 kg of firewood, 54 kg charcoal and 7.2 kg LPG on an annual basis.

Table 2. Impact of the Rice Hull Stove on Fuel use Patterns/month

. Statistic		Before	After
Number of households using	fuelwood (buyers)	39	30
	fuelwood (gatherers)	42	24
	charcoal	20	7
	LPG	11	7
	rice hull	-	86
Average fuel use:	fuelwood	199.9 kg	55.4 kg
	charcoal	5.9 kg	1.4 kg
	LPG	1.3 kg	0.7 kg
	rice hull	-	143.5 kg

An estimate of the rice hull cooker use efficiency was made of 13%. This was based on the assumption that the total amount of delivered energy used before and after the introduction of the rice hull cooker remained the same.

According to the survey prior to introduction of the stove. Households were using an estimated 4656 MJ/year of energy given the average fuel consumption and estimated thermal efficiencies of energy use of 10.25%, 15% and 60% for fuelwood, charcoal and LPG respectively. This quantity of energy was 46% higher than the estimate used in a previous analysis (3170MJ) of household energy use for cooking in the Philippines (Samson et al 2001). This may be explained by the fact that low income upland Negros families are on average larger than the national average, that a major group of the energy users was fuelwood gatherers (as they do not pay for their fuel, they may not restrain their fuel consumption) and that some of the fuel gatherers also use firewood for cooking pig feed (primarily kangkong a leafy vegetable). This initial fuel and energy survey did not fully allow for distinguishing fuelwood consumption between the buyers, gatherers and households who met there fuelwood needs by both buying and gathering. However, the data indicated on a yearly basis those only gathering used on average 2945 of fuelwood compared to 2119 kg used by buyers, and that the former consumed 21% more energy for cooking than the latter.

Economic Impacts from the Introduction of the Rice Hull Stove

Average total cooking cost fell by 63% when using the LT 2000 stove (Table 3). The drop is explained by the low cost of rice hull, which can be obtained for free from rice mills and transported for a low price. Using the LT 2000, households saved on average $1.87 per month on cooking fuel and firestarter costs. Firestarter represented 11% of the savings. Assuming that cooking costs remain constant throughout the year, the monthly savings were extrapolated to $22.41 per year. Households cooking with the LT 2000 saved at least 33% (compared to gathered fuelwood) and as much as 96 % (compared to charcoal). Rice hull cooking is less expensive than gathered fuelwood for cooking because paper is primarily used for firestarting with rice hull. In the case of fuelwood, it is commonly ignited with kerosene.

Table 3. Effect of Introduction of a Rice Hull Stove on Fuel Expenditures/year

. Statistics	Before	After
Average total fuel cost	P 1631 ($31.98)	P 593 ($11.62)
Average fire starter cost	P 184 ($3.60)	P 79 ($1.55)
Average total cooking cost	P 1814 ($35.58)	P 672 ($13.17)

Estimated Annual Costs of Various Purchased Fuel Systems

The annualized cost of cooking represents the annual fuel costs for operating a stove and the annual cost of the stove over its given lifespan. Stove costs were obtained through a market assessment in Kabankalan, Negros Occidental, during December 2001. Annual stove costs were determined using an annuity formula. The interest rate used was the average lending rate published by the Central Bank of the Philippines. Stove lifetimes were assumed to be 6 years for an LPG stove, 1 year for a charcoal stove, and 3 years for the LT 2000 stove.

A greater difficulty in assessing differences between the annualized cooking costs between the various cooking systems were the aforementioned differences in the amount of energy used per household by fuelwood gatherers and purchasers. As such for this analysis, comparisons are only made between purchased fuel systems. We assume all purchased fuel systems use the same amount of delivered energy as fuelwood buyers. Thus the average household energy required is the equivalent of 2119kg of fuelwood, 826 kg charcoal and 127 kg LPG based on thermal efficiencies of 10.25%, 15% and 60% for fuelwood, charcoal and LPG. Rice hull was estimated at 2031 kg of fuel based on a thermal efficiency of 13%. These values are similar to the 1995 Household energy consumption survey for fuelwood (2022 kg in rural households having an income <P60,000 P), and LPG (national average of 116 kg and a rural average of 106).

Annual cooking cost

The results are presented in Table 4 and Figure 2. LPG annual cost is the highest ($77.32), which is partly explained by high fuel price and partly by high stove price. Stove cost is very low in Negros for households cooking with fuelwood and charcoal, because they use very cheap and simple clay stoves or improvised stone and iron bar stoves (Samson et al 2001). The annual cost of firewood and charcoal cooking systems were very similar at $61.98 and $67.54. The annual cost of cooking with rice hull ($4.87) is divided in almost equal parts between fuel consumption ($1.95) and stove cost ($2.92).

Overall, the cost of cooking with a rice hull cooker is projected to reduce household cooking costs by 92-94%. Cooking with a rice hull cooker was similar to fuelwood gatherers (data not shown), who experienced an annual cost of ($2.73) for kerosene consumption[3]. These results show that households cooking with rice hull can save $57.11, $62.67 and $72.45 per year, compared to purchasing LPG, fuelwood and charcoal respectively. It should be noted that the

[3] The annual cost of gathered fuelwood corresponds to the cost of fire starter. The annual cost of rice hull includes transportation and fire starter costs.

analysis assumed all the cooking is done with the selected fuel. Therefore, the savings calculated apply to households that switch from cooking exclusively with LPG, fuelwood or charcoal, to cooking exclusively with rice hull. However, this is not always the case. For example, the survey done in Negros Occidental indicated that households generally use a mix of cooking fuels. Many households partially switched to using rice hull but still continued cooking with other fuels.

Table 4. Estimates of Annualized cooking costs for various primary fuel cooking options available in Negros Occidental

	LPG	Fuelwood buyers	Charcoal	Rice Hull
Cost of fuel per year[c]	62.25	61.98	67.21	1.95
Annual cost of Stove[d]	15.07	0.00	0.33	2.92
Total Cost (US$) [e]	**77.32**	**61.98**	**67.54**	**4.87**

Assumptions:

1) The cost of equipment was annualized considering their expected life-span and using an average of the lending interest rates published by the Central Bank of the Philippines.
2) Cooking equipment life-span: LPG (6 years), charcoal (1 year), rice hull (3 years).
3) Stove prices are market prices in Negros Occidental (December 2001): LPG and tank (P3015), charcoal (P15), rice hull (P350).
4) Fuel consumption for LPG and charcoal was estimated at 127 kg and 826 kg (Samson et al 2001). These consumption estimates were based on the estimated fuel conversion efficiencies of these fuels in comparison to wood. The baseline of wood fuel purchased was 2119 kg/yr with an efficiency of 9.5%. The efficiency of rice hull use was estimated to be 13% and 2031 kg were consumed.
5) Fuel prices were calculated from the survey of households in Negros Occidental: LPG (25PhP/kg), purchased fuelwood (1.49PhP/kg), gathered fuelwood (almost zero, it includes only fire starter cost), charcoal ($4.18 USD/kg), and rice hull (almost zero, it includes transportation and fire starter costs).

The cost estimates of the various cooking systems differ somewhat from those obtained by Samson et al (2001) (with the exception of LPG) mainly due to the devaluation of the peso that has dropped the value of charcoal and firewood when converted into US dollars. However, the actual cost of operating a rice hull stove was only $4.87 USD/year compared to the estimated $17.56 USD in the aforementioned study. This low cost was due to rice hulls being freely available, as well as a lower stove cost than projected. Overall, it appears an improved rice hull cooker has significant potential to reduce cooking costs compared to the alternative purchased cooking systems presently in use.

Impact on greenhouse gases emission

Table 5 shows that each household using the LT 2000 stove reduced direct GHG emissions by 487.8 kg of CO_2 equiv/year and indirect GHG emissions by 493.9 kg CO_2 equiv/year, for a total of 981.7 kg CO_2 equiv/year. The main source of emission reduction was the decrease in the use of fuelwood. Charcoal had a relatively large contribution because of the high GWC coefficient that includes both its production and consumption. Kerosene for fire starter offered similar abatement possibilities as LPG.

Table 5. Impact of the LT-2000 Rice Hull Stove on GHG Emissions

Fuel	Before (kg)	After (kg)	Fuel Use Reduction (kg)	Greenhouse Gas Emission Reductions (kg CO2 equiv)					GWC*
				CO2	CH4	N2O	CO	TNMOC	
Fuelwood	2398.8	664.8	1734	0	243.75	150.17	216.39	152.78	0.44
Charcoal	70.8	16.8	54	0	43.36	10.54	53.48	68.65	3.26
LPG	15.6	8.4	7.2	22.21	0.01	0.73	0.22	1.35	3.41
Kerosene	10.32	3.48	6.84	16.69	0.04	0.30	0.19	0.82	2.64
				Direct GHG = 487.8			Indirect GHG = 493.9		
				Total GHG Emissions = 981.7 kg CO2 Equiv per year					

*Global Warming Commitment = kg CO2 Equiv per kg of fuel

There are also other areas for further investigation. The assumption that rice mills and farmers burn the rice hull needs verification. A survey of a representative sample of rice mills and farmers would achieve this objective. In addition, GHG emissions from burning rice hull needs to be determined for the stoves. There is also evidence that fuelwood and charcoal are not sustainably harvested at present exploitation rates in the Western Visayas. If this is the case, substituting rice hull for these fuels would have an important influence on CO2 emissions particularly if it helped lead to afforestation.

Conclusions

The largest absolute impact from introducing the LT 2000 was a drop in fuelwood consumption. The average rice hull stove was found to save 1734 kg of firewood, 54 kg charcoal and 7.2 kg LPG per year in fuel. However, in relative terms, charcoal consumption suffered the biggest reduction in usage. Households using charcoal for cooking fell by 65% and charcoal consumption decreased by more than 76%. This result is consistent with the concept of the energy ladder[4]. Rice hull is a better substitute of fuelwood and charcoal than it is of LPG. LT 2000 users displaced 73% of the energy used for household cooking and made significant household savings even though many households that adopted the stove are fuelwood gatherers. On the average, households adopting the rice hull stove saved P1078 ($21.13 USD) per year if fuel expenditures and stove costs are included. This savings of 1078 pesos represents an average savings of about 2.8% of total household income. Annualized cooking cost estimates of purchased fuel systems (using only one fuel for all cooking requirements) found cooking with a rice hull stove to be 248 PhP ($4.87 USD) or 92-94% cheaper than using LPG (3943 PhP or $77.32 USD), charcoal (3444 PhP or $67.54 USD) and firewood (3160 PhP or $61.98 USD). This savings would represent 7.6% to 10.4% of the total average household income. Finally, an average household

[4] The energy ladder is an imaginary ladder whose steps are occupied by the different cooking fuels. Agricultural waste and fuelwood occupy the lower steps, whereas LPG and electricity occupy the highest steps.

adopting the rice hull stove was able to reduce their emission of GHG by 982 kg of CO_2 equiv./year. The decrease in emissions came mainly from the substitution of fuelwood for rice hull. The potential for inaccurate estimates of fuel consumption and expenditure from respondents is an important limitation to the study. Future surveys will attempt to improve on the methodology used in the current study. An improved rice hull stove, The Mayon Turbo, has superseded the LT 2000 in the Western Visayas and will be used for these surveys.

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End Note 1:

Questionnaire

DEMOGRAPHIC DATA

1) Name: ______________________________________

2) Civil status: ___________________

3) Education:
None __
Elementary __
High School __
Technical/University __

4) Number of household members: _____

5) Number of children in household: ____

6) Number of women in household: _____

7) Location of household: ____________________________________

8) Annual household income: _____

9) Income sources: ______________________ P _____________
______________________ P _____________
______________________ P _____________

FUEL USE AND COOKSTOVE QUESTIONS

10)

Types of fuel used	quantity of fuel used per month	cost of fuel per month	fire starter used	quantity of fire starter per month	cost of fire starter per month
1.					
2.					
3.					
4.					
5.					

11) Who does usually cook for the household? ________________________

12) How long have you been using the rice hull stove?

Less than 3 months __
3 to 6 months __
6 months to 1 year __
more than 1 year __

13) What is the condition of your stove?

Very bad __
Bad __
Good __
Very good __

14) From today, how long do you estimate the rice hull stove will last?

Less than 6 months __
6 months to 1 year __
1 to 2 years __
More than 2 years __

15) Roughly speaking, how much of your cooking do you do with the rice hull stove?

10%	__	60%	__
20%	__	70%	__
30%	__	80%	__
40%	__	90%	__
50%	__	100%	__

16) Which foods do you find easy to cook with the rice hull stove?

Rice	__	Fish	__	Vegetables	__
Meat	__	Eggs	__	Boiling water	__

Others ____

17) Have you ever experienced problems: (answer yes or no to each choice)

Starting the stove __
Putting out the fire __
Controlling the heat output/fire __
Stability of the stove __
Diameter of the potholder __
Smoke emissions __
Getting fuel __

Others ____

18) How did you deal with the above problems?

.____
____
____
____.

19) What are the advantages of using the rice hull stove?

Heats up quickly __
Low fuel cost __
Less smoke emissions __
Good design/aesthetics __
Cleaner __

Others ____

20) Have you shown the stove to neighbours, friends or relatives?

Yes __ No __

21) If yes, what was their reaction?

Interest __ Curiosity __ Indifference __
Rejection __
Other _______________________

22) What comments did your friends or relatives make?

____
____
____
____

23) Which of the following aspects do you consider necessary to enhance the acceptance of the rice hull stove among consumers:

Service to consumers __
Providing a user's manual with the stove __
Public demonstrations __
Warranty __
Other ____

End Note2:

Energy values:

	LPG	Kerosene	Fuelwood	Charcoal	Rice Hull
Units	kg	lt	kg	kg	kg
Energy content (MJ/unit)	45.5	35	16	28	14.7
Thermal Efficiency (%)	0.6	0.5	0.1025	0.15	0.15
Energy delivered (MJ/unit)	27.3	17.5	1.64	4.2	2.205

Source:

http:\\www.rwedp.org/acrobat/p_weground.pdf
http:\\www.nri.org/NRMD/eneg-pov.pdf
http:\\www.iitb.ernet.in/~ctara/products.html
http:\\www.sei.se/red/red9408e.html
http:\\www.tifac.org.in/offer/tsw/thai16.htm

Physical equivalences:

Fuelwood: 1 bundle = 6.7 kg
Charcoal: 1 sac = 15.2 kg
LPG: 1 tank = 11 kg
Rice hulls: 1 sac = 9.3 kg

Source: REAP-Canada, 2001. Field observations, Negros Occidental, December 2001.

End Note 3:

Annual Greenhouse Gas Emission Reductions Resulting from the LT2000 Rice Hull Stove in Negros Occidental, Philippines

REAP Canada 2001-2002

****Local Data Used When Available***

Carbon Sources	Fuel Displaced Per Year (kg)	Wood to Charcoal Conversion Ratio (fuelwood mass /charcoal mass)	Wood for Charcoal Production (dry kg)	Carbon Fraction	Carbon Content of Fuel (kg)	Net Energy Content (MJ/kg)
Charcoal Production	***54.0***	3.4	181.4	0.44	79.83	
Charcoal Combustion	***54.0***					25.72
Fuelwood	***1732.8***					15.22
LPG	***7.2***					45.84
Kerosene	***5.51***					43.12
Source	*REAP 2001*	*Smith et al, 1999**	*B10 * C10*	*Smith et al, 2000***	*D10 * E10*	*Smith et al, 2000***

		Emission Ratio	Emissions *kg C or N*	Conversion Ratio *MW gas / MW C*	Emissions from Burning *kg/year*	GWP (100 years)	CO2 equiv for each gas *kg CO2 equiv*
Charcoal Production							
Direct GHG's:	CO2	-	-	-	-	-	-
	CH4	0.0137	1.094	1.3	1.458	23	33.54
	N2O	0.0000179	0.001	3.7	0.00524	296	1.551
Indirect GHG's:	CO	0.0638	5.093	2.3	11.885	2	23.77
	TNMOC	0.0526	4.199	1.5	6.299	10	62.99
Source		*Smith et al, 1999** see note 1) & 4)*	*[total C*E(ratio)]*	*IPCC 1996*	*kg C;N * Conv(ratio)*	*IPCC 2001 IPCC 1990 see note 5)*	
Charcoal Combustion							
Direct GHG's:	CO2	-	-	-	-	-	-
	CH4	0.00593	0.320	1.3	0.427	23	9.82
	N2O	0.0001534	0.008	3.7	0.03037	296	8.990
Indirect GHG's:	CO	0.1179	6.367	2.3	14.855	2	29.71
	TNMOC	0.006987	0.377	1.5	0.566	10	5.66
Source		*Smith et al, 2000* see note 2)*	*[total C*E(ratio)]*	*IPCC 1996*	*kg C;N * Conv(ratio)*	*IPCC 2001 IPCC 1990 see note 5)*	
Fuelwood							
Direct GHG's:	CO2	-	-	-	-	-	-
	CH4	0.004587	7.948	1.3	10.598	23	243.75
	N2O	0.00007985	0.138	3.7	0.50733	296	150.171
Indirect GHG's:	CO	0.02676	46.370	2.3	108.196	2	216.39
	TNMOC	0.005878	10.185	1.5	15.278	10	152.78
Source		*Smith et al, 2000* see note 3)*	*[total C*E(ratio)]*	*IPCC 1996*	*kg C;N * Conv(ratio)*	*IPCC 2001 IPCC 1990 see note 5)*	

LPG		Emission Ratio	Emissions kg C or N	Conversion Ratio MW gas / MW C	Emissions from Burning kg/year	GWP (100 years)	CO2 equiv for each gas kg CO2 equiv
Direct GHG's:	CO2	0.8414	6.058	3.7	22.21	1	22.21
	CH4	0.0000375	0.0003	1.3	0.000	23	0.008
	N2O	0.0000935	0.001	3.7	0.00247	296	0.731
Indirect GHG's:	CO	0.006399	0.046	2.3	0.108	2	0.22
	TNMOC	0.01252	0.090	1.5	0.135	10	1.35
	Source	*Smith et al, 2000* see note 2)*	*[total C*E(ratio)]*	*IPCC 1996*	*kg C;N * Conv(ratio)*	*IPCC 2001 IPCC 1990 see note 5)*	
Kerosene							
Direct GHG's:	CO2	*0.8255*	4.551	3.67	16.689	1	16.69
	CH4	0.000216	0.0012	1.3	0.00159	23	0.037
	N2O	0.0000503	0.0003	3.7	0.00102	296	0.301
Indirect GHG's:	CO	0.007564	0.042	2.3	0.097	2	0.19
	TNMOC	0.009907	0.055	1.5	0.082	10	0.82
	Source	*Smith et al, 2000* see note 2)*	*[total C*E(ratio)]*	*IPCC 1996*	*kg C;N * Conv(ratio)*	*IPCC 2001 IPCC 1990 see note 5)*	

Annual Direct GHG's:	**487.80**	kg CO2 equiv
Annual Indirect GHG's:	**493.88**	kg CO2 equiv
Total Annual GHG's:	**981.68**	kg CO2 equiv

References cited:

Smith, KR, Pennise DM, Khummongkol P, Chaiwang V, Ritgee K, Zhang J, Panyathanya W, Rasmussen RA, and Khalil MAK, 1999. Greenhosue Gases from Small-Scale Combustion in Developing Countries: Charcoal making Kilns in Thailand. Research Triangle Park, NC: U.

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REAP (Resource Efficient Agricultural Production) 2001. Strategies for Enhancing Biomass Utilization in the Philippines. Manuscript funded by National Renewable Energy Laboratory Subcontract #AXE-0-30001-01.

Notes:

1) Emission factors are based on unit of carbon from fuel consumed (i.e. kg-C pollutent / kg-C fuel). Take average value of 3 earth mound trials.

2) Emission factors are based on unit of fuel consumed (i.e. kg-C pollutent / kg fuel).

3) Emission factors are based on unit of fuel consumed (i.e. kg-C pollutent / kg fuel). Philippine conditions are considered similar to a 3 rock stove using Acacia and Eucalyptus fire wood (take average value).

4) Smith et al, 1999** presents emission factor for TNMHC. The emission factor used for TNMOC is actually an emission factor for TNMHC. This is considered a conservitive assumption.

5) GWP values for CH4 & N2O are taken from Table 3 of 2001 IPCC Technical Summary. GWP for CO is the average of three reported values in Table 6.9 of IPCC 2001. GWP for TNMOC is taken from IPCC 1990. It is understood that the uncertainty for CO & TNMOC G

End Note 4

Summary statistics

Demographics

Statistic	Result
Average household members	6
Average annual income	P 38564
Average per capita income	P 7241
Average income from farming	P 20482 (53%)

Users' feedback

Statistic	Result
How long have you been using the rice hull stove?	
Less than 3 months	23%
3 to 6 months	49%
6 months to 1 year	16%
more than 1 year	12%
What is the condition of your stove?	
Very bad	-
Bad	1%
Good	92%
Very good	7%
From today, how long do you estimate the rice hull stove will last?	
Less than 6 months	-
6 months to 1 year	*6%*
1 to 2 years	17%
More than 2 years	77%
Percentage of cooking done with the rice hull stove?	**76%**
Have you experienced problems…?	
Starting the stove	*50%*
Putting out the fire	5%
Controlling the heat output/fire	6%
Stability of the stove	-
Diameter of the potholder	-
Smoke emissions	12%
Getting fuel	10%
Others	-
What are the advantages of using the rice hull stove?	
Heats up quickly	*81%*
Low fuel cost	79%

Less smoke emissions	81%
Good design/aesthetics	56%
Cleaner	21%
Others	-

Which of the following aspects do you consider necessary to enhance the acceptance of the rice hull stove among consumers:

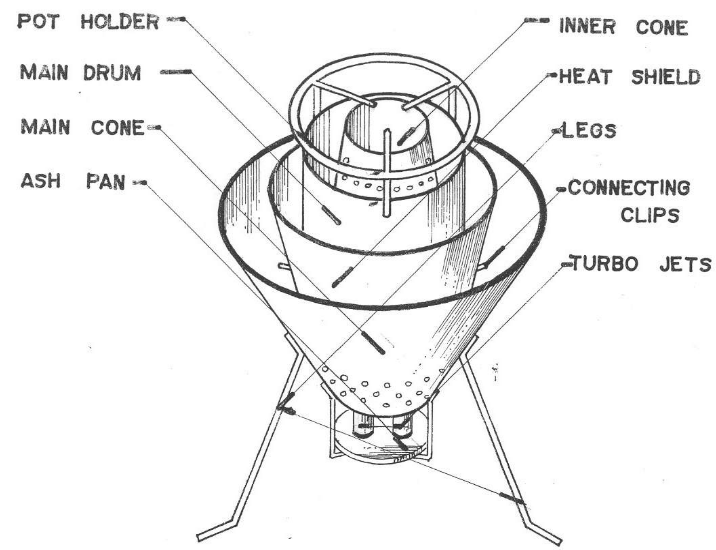
Service to consumers	14%
Providing a user's manual with the stove	33%
Public demonstrations	55%
Warranty	7%
Other: reduce price	**6%**

Fuel use and expenditures by Month

. Statistic		Before	After
Number of households using	fuelwood	81	54
	charcoal	20	7
	LPG	11	7
	rice hull	-	86
Avg fuel use:	fuelwood	199.9 kg	55.4 kg
	charcoal	5.9 kg	1.4 kg
	LPG	1.3 kg	0.7 kg
	rice hull	-	143.5 kg
Average total fuel cost		P 135.9	P 49.4
Average fire starter cost		P 15.3	P 6.6
Average total cooking cost		P 151.2	P 56
Average cost of cooking with rice hull			P 7.6

Appendix I

How to Use the Mayon Turbo Stove



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2003

The Mayon Turbo Stove was developed in the Philippines in 2002 with support from the Canadian International Development Agency

Features of the stove

- ***Efficient and clean burning:*** high quality, swirling blue flames are created from the advanced combustion design
- ***Economical***: The stove costs about $10 (US), lasts 2.5-3 years and has very low fuel costs. It saves the average household about $25/year in the rural Visayas. Some households are saving $60-100/yr (US) that formerly purchased all their fuel in the form of charcoal and LPG.
- ***Fast boiling:*** 1 litre of water can boil in 5-7 minutes
- ***Convenient to use:*** tapping to introduce new fuel is required 8-10 minutes after start-up and then every 4-6 minutes until the cook is finished
- ***Low fuel consumption:*** Approximately 2.5 sacks/family/week of rice hull
- ***Portable and lightweight:*** All steel construction, weighing approximately 4 kg.
- ***Safety***: A double ring support structure provides excellent pot stability
- ***Environmentally friendly***: replaces the use of 2 tonne of fuelwood per year in households

Proper Maintenance of the Stove

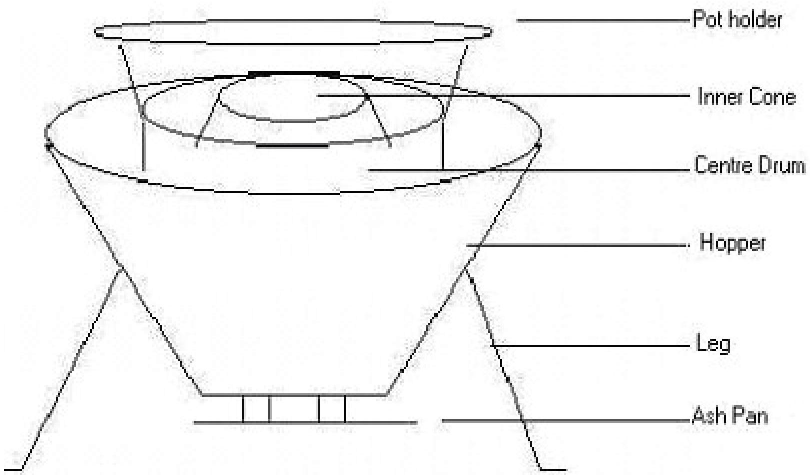
The stove has an estimated lifespan of 2.5-3 years. If you want your stove to last it is important to treat it well! Here are a few tips to help you maximize your stove's lifespan:

- *The stove should be stored in a dry location to prevent rusting.* Storing your stove inside is always best but outside in a well-covered location (where it won't be exposed to the rain) is also sufficient.
- To clean the stove use a *dry* rag and wipe the surface*, DO NOT use water.*
- DO NOT sit on the stove, or put excessive weight or pressure upon the stove.
- DO NOT bang the stove excessively.
- Note: The inner cone is exposed to the highest temperature and generally wears out earlier. The inner cone however can be replaced to extend the life of the cooker.

Fuel

The stove was designed to burn rice hull but can also burn coffee shells. They are both loose bulky fuels. Other fuels such as peanuts shells, corn cobs and sawdust can be mixed in with these fuels (Table 1). Rice hulls can be obtained from most rice mills often for just the cost of transport, but sometimes for a small fee (₱ 1-2/sack). Rice hulls can also be collected from mobile rice mills. To collect the hulls, lay a tarpaulin on the ground and bag the hulls into sacks. *Once home, store the hulls in a dry place as they are difficult to burn when wet.*

Parts of the stove



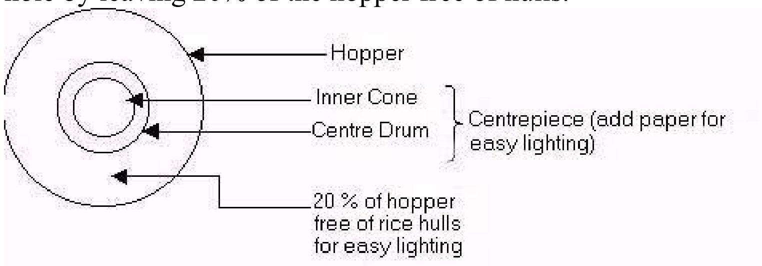
Stove location

A Mayon Turbo Stove can be used both indoors and outdoors:
Out of doors ash is easily disposed of and smoke exposure is minimized. When cooking outdoors, it is best to be in a sheltered location as windy conditions make lighting difficult and cooking less efficient.

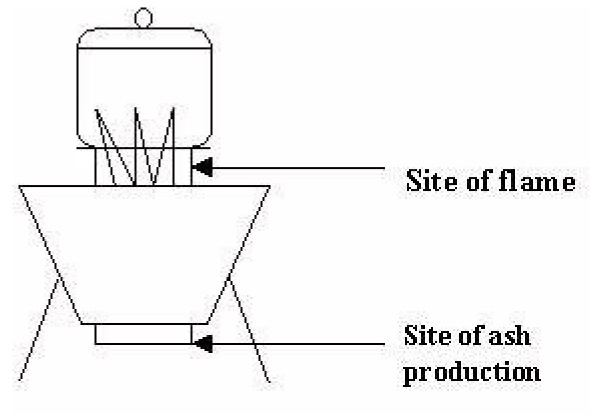
Indoors, airflow is more easily controlled, but ashes become messy and air quality can be affected. If cooking indoors, use the stove in a well-ventilated location with a chimney if possible, as smoke from household cooking can cause respiratory and eye diseases. Care should be taken not to disturb or inhale the ashes. Some users mount the stove above a steel barrel to collect ashes. Ashes can be used as a soil conditioner, fertilizer, cleaning instrument for pots and pans, and ant repellent (eg. sprinkled around the base of eggplants).

Lighting the stove

1. Fill the stove with rice hull approximately half way up the hopper. Take care not to fill the entire space between the centre drum and the hopper (as this will lead to smoke formation during the burning process). To facilitate airflow into the centerpiece at startup, create a hole by leaving 20% of the hopper free of hulls.



2. Drop or poke a small amount of burning paper, wood shavings or fronds into the inner cone (between the turbo jets) and watch for the rice hull to ignite to a glowing red colour. If the rice hull is cold or somewhat damp (eg. a morning start in the rainy season) it may require supplementary starter to be added to get the rice hull properly ignited. Continue to drop starter into the inner cone until a steady flame and draft is created. W*atch and wait for the rice hull to catch fire*.
3. When the stove is well lit, the ignited rice hulls will turn a glowing red colour (usually after about 1 minute). The air opening between the hopper and the centre drum can then be filled in with rice hull and the cooking pot placed on the cooker. *However, make sure the rice hull combustion is well underway before filling the remaining gap with rice hulls and putting the pot on the stove.*
4. If the rice hull is just ignited and then the flame immediately goes out, fresh rice hull should be exposed again on the surface to ease the restarting process.



5. If the stove goes out while cooking it is almost always because of lack of fuel. If tapping to introduce new fuel does not immediately restart the fire, the opening between the hopper and centrepiece can be reopened. Usually the glowing embers will restart the cooker if an air draft and fresh fuel are present. The stove can also be restarted as indicated in steps 1-3 above.

Note: The stove is easiest to start when the rice hull is dry and warm. Starting the stove early in the morning or in rainy weather may take extra patience and practice. *With proper ignition technique, kerosene does not need to be used as a fire starter.*

Cooking with the stove

1. As the fire develops, the rice hull will initially produce a yellow-orange flame. This will gradually shift to a light yellow colour after 3-5 minutes. Swirling flames should be observed with vortexes forming between the air injectors within the next few minutes. The flame can sometimes then become near colourless.

2. Supplementary solid fuels such as small pieces of wood, dried coconut husks, can be placed in an upright position in the inner cone. These fuels should be added in small quantities as they can make the cooker smoky if too much fuel is added. To use sawdust, peanut shells, or pieces of corn cob, mix them with rice hulls in the hopper.

3. The burning fuel eventually produces a grey or white ash at the bottom of the centrepiece after about 8-10 minutes. To allow the entry of new fuel during the remainder of the cook, tap the stove about every 4-6 minutes. This is best performed when the fuelbed (the rice hull inside the inner cone) is beginning to turn to a grey colour as the energy is released from the hull. Periodically (about every 10-15 minutes) some of the rice hull ash can also be cleared away from the bottom of the ashpan with a cooking utensil or stick to enable new fuel to be introduced. *Take care however not to release burning ash as this can extinguish the fire if the burning fuelbed is removed.*

4. Periodically check the ash build-up around the ash pan and remove the ash from under the ashpan by flattening or clearing it away with a cooking utensil or stick. *Too much ash build-up under the ash pan can cut off the airflow feeding the fire and cause the fire to go out!*

5. The cooker is designed to be relatively smokeless once it is lit. As long as fuel remains to be burnt it should not smoke. Most smoke will occur during the start and at the finish of the cook.

- If the flame is *dark yellow* with some smoke you are adding too much fuel. Stop tapping the stove to allow the rice hull to complete the combustion process and the smoke should disappear. Smoke mainly occurs when too much carbon-rich fuel is added to the centre cone (i.e. coconut shells, leaf matter, etc.).

- If a small amount of smoke begins to appear after an *extended* period of cooking, you likely need to introduce more rice hull. If this is the case, the rice hull inside the inner cone will likely be a grey colour. Rice hull can be introduced by tapping the side of the stove with a stick, using sufficient force so as you can visibly see the rice hull go down the sides of the hopper.

- If the flame dies out and a lot of smoke is produced you are most likely out of fuel. To introduce more fuel to the inner cone, keep tapping the hopper till the flame has reignited or until you can see unburned rice hull inside the inner cone when looking down from above. If you do have a smoke problem and have fuel, the flame has most likely been suffocated; check to make sure that rice hull ash or an object is not blocking the air injectors pipes under the ash pan.

6. The heat output of the stove is controlled in several ways:

- If cooking rice, reduce the supply of rice hull towards the end of the cooking session

- The pot can be suspended on a hook above the flame to decrease the amount of heat reaching the pot.

- A thin metal plate can be place on top of the centerpiece, between the pot and the flame. This also reduces the flame contact with the pot.

- Burning more carbon rich fuels such as coconut shell and firewood will increase the heat output of the stove and reduce tapping frequency when extended boiling is required for cooking large seeded beans or meat.

7. Refill the cone with rice hull and other fuels as required to ensure a steady supply of ignitable material.

8. After an extended period of cooking, rice hulls in the hopper can sometimes ignite or turn black and smoke excessively. These small surface fires can be covered with new rice hull or buried in the unburned hulls. It is best to keep the fuel bin about half full and add additional fuel as required.

9. Near the end of the cooking period, do not add any additional rice hull. When finished cooking, open up the airspace between the hopper and centerpiece and ignite the residual rice hull. These practices will minimize the waste of rice hull and reduce smoke exposure in the household.

10. Ashes should be disposed of with care to avoid inhaling them.

Table 1: Alternative Fuels for the Mayon Turbo Stove			
Type of fuel	Use	Advantages	Disadvantages
Rice hul	Primary hopper Fuel	• Easy to access and handle	• High ash content • Some health risk with the ash
Coffee shells	Primary hopper fuel	• Easy to handle • Low ash	
Corn cobs	Supplementary Fuel	• Good energy content and low ash content	• Can be smoky upon ignition
Peanut shells	Supplementary Fuel	• Low ash content	
Sawdust	Supplementary Fuel	• Hotter burning	• Can be smoky upon ignition
Coconut husks	Supplementary Fuel	• Hotter burning	• Can be smoky upon ignition
Firewood	Supplementary Fuel	• Sustained heat output • Requires less attention	• Increases smoke • May reduce stove longevity
Charcoal	Supplementary Fuel	• Sustained heat output • Requires less attention	• High cost
Kerosene	Fire Starter	• Helps to ignite cold/wet fuel	• High cost • Releases noxious fumes

Appendix J. Project Photographs

Sugarcane harvest in the Philippines.

Conventional crop residue burning in the Philippines.

Preharvest detrashing of sugarcane.

Decomposition of sugarcane residue using trash farming management practices.

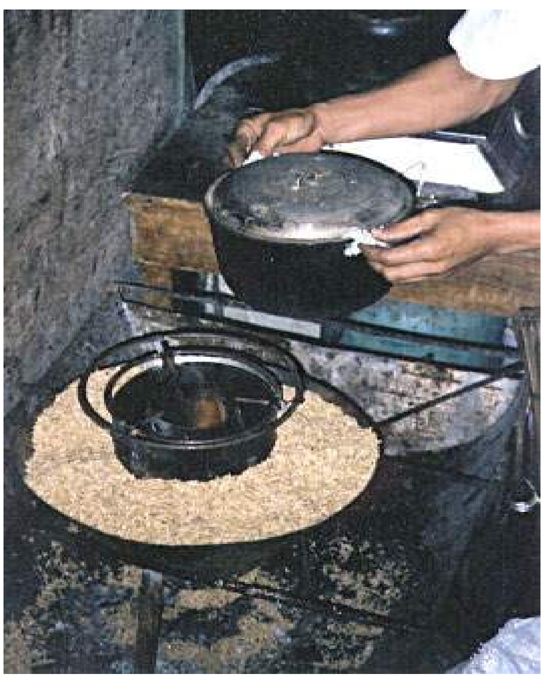
A trash farmed sugarcane field.

Sugarcane variety trials used to determine local varieties capable of BNF.

Inefficient combustion during cooking leads to a high level of indoor air pollution.

Conventional cooking over crudely designed low efficiency wood stoves

Charcoal production on Negros Island increases CH_4 emissions.



The efficient and clean burning MTS replaces inefficient cooking fuels such as wood and charcoal.

Large piles of waste rice hull that can be used as a cooking fuel.

Efficient combustion in the MTS

Stove production facilities on Panay Island in the Philippines.

Stove technician with the revised MTS 9000.

Local villagers with MTS on Negros Island, Philippines.