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Forest Management and Conservation Agriculture

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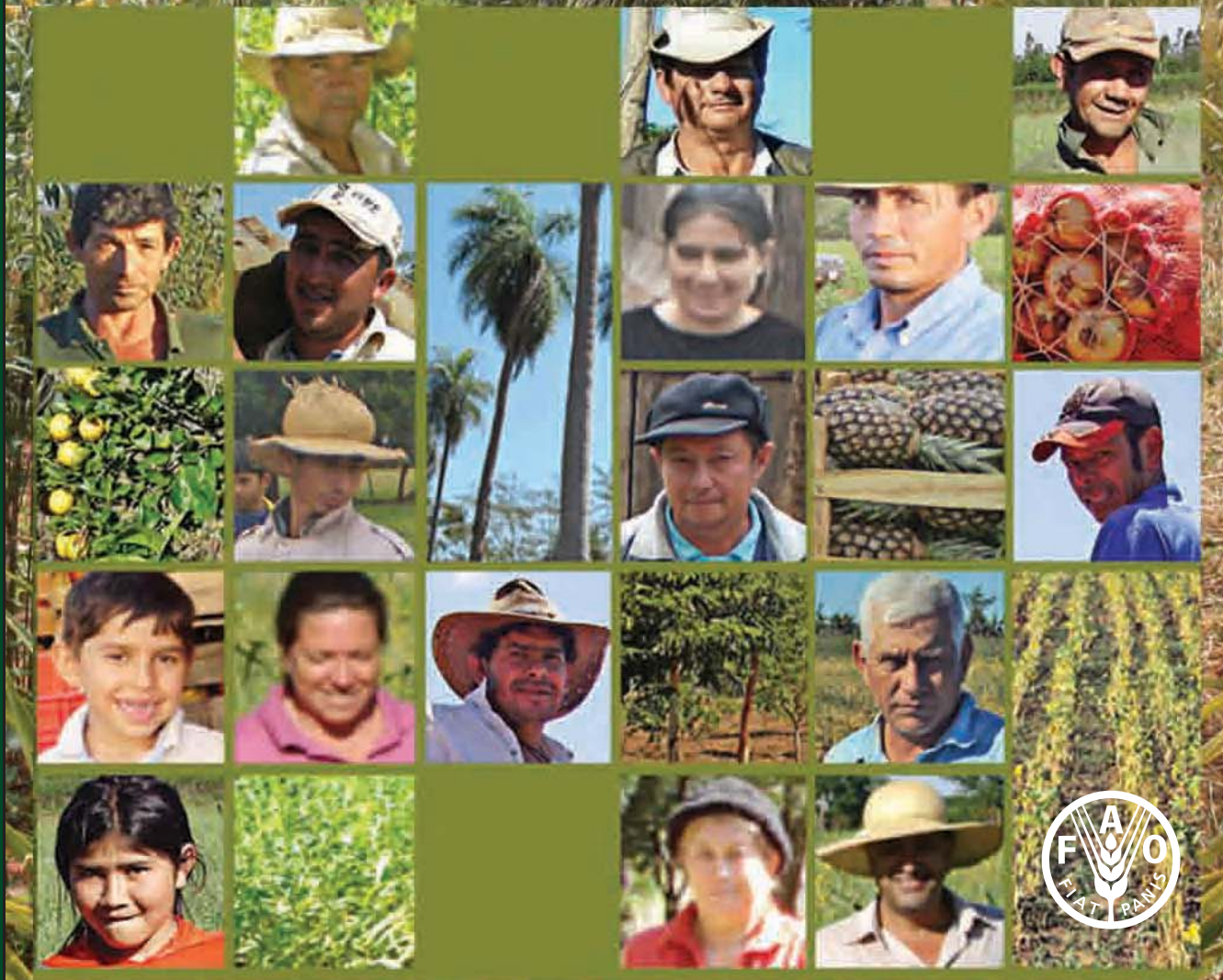

Integrated Crop Management Vol. 18-2013

Forest Management and Conservation Agriculture

Experiences of smallholder farmers in the Eastern Region of Paraguay

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PLANT PRODUCTION AND PROTECTION DIVISION
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FOREWORD

This publication is a summary of the experiences lived during the seven years (2003-2010) of implementation of the Sustainable Natural Resource Management Project (PMRN), managed by the Ministry of Agriculture and Livestock (MAG) and supported by German Technical and Financial Cooperation (GIZ and KfW).

The PMRN operated in seven Departments in the Eastern Region of Paraguay, attending some 17 000 smallholder families in aspects related to the recuperation and management of degraded soils and the production and management of forestry systems. The Project was implemented under various modalities of technical assistance, described in this document, which determined the success of the execution of the measures being promoted, both in the activities related to soil as well as forestry.

The implementation of this Project and the active participation of the technicians in their day-to-day contact with the farmers, contributed to the confirmation of the obsolescence of the actual production systems. The introduction of Conservation Agriculture as a production concept for the smallholder farmer, changed to a large extent the dynamic of the farms attended. This resulted in good yields both for home-consumption and commercial crops, a reduction in the costs of production, the generation of higher incomes, an improvement in family diet, and lastly the firm establishment of smallholder families.

This book benefited from the active participation and collaboration of the Project and MAG for the elaboration of the contents and many of the aspects mentioned are the result of a workshop held in 2010. This had the aim of compiling the experiences accumulated in the different areas of action of the aforementioned technical staff, and to shape them in this document. In this way it can serve as a legacy for future generations of extensionists dedicated to the difficult, but at the same time agreeable and satisfying, job of rural extension.

Doris Becker
Resident Director
German Development Cooperation (GIZ)

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The original Spanish document was prepared within the framework of the Sustainable Natural Resource Management Project (PMRN) of the Ministry of Agriculture and Livestock (MAG) of Paraguay with technical assistance from German Technical and Financial Cooperation organizations (GIZ, KfW). The authors Paul Borsy and Rafael Gadea helped immensely with explications of Paraguayan terms during the translation process undertaken by Brian Sims. Amir Kassam edited the document and Magda Morales formatted it for printing and we express our appreciation for their efforts.

The authors of the original, Paul Borsy, Rafael Gadea and Esteban Vera Sosa make the following statement:

To save space and make for more fluid reading we have not differentiated between the genders. So that instead of "he/she" we have opted for the masculine as the classical generic term on the understanding that all references to that gender always represent both men and women. We emphasize the importance of not using language that discriminates between men and women.

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ACRONYMS AND ABBREVIATIONS

AGEC-ECO	German Consultants
AZPA	Paraguayan Sugar Company
BCP	Paraguayan Central Bank
BNF	National Development Bank
CA	Conservation Agriculture
CAH	Agricultural credit for equipment
CECOPROA	Marketing centre for associated producers
CGR	Comptroller General of the Paraguayan Republic
CIF	Forestry degree course
cm	centimetre
CODIPSA	Company for the development and industrialization primary products
COVEPA	Smallholder farmers neighbourhood cooperation
COVESAP	Neighbourhood cooperation of San Pedro
DAP	Draught animal powered
DBH	Tree diameter at breast height
DEAg	Directorate of Agricultural Extension
DIA	Directorate of Agricultural Research
DINCAP	National Directorate for Administration and Coordination of Projects
EU	European Union
FCA	Faculty of Agrarian Science
FDC	Smallholder Development Fund
Gs	Guaraníes (4600 = US$1.00)
GIZ	Deutsche Gessellschaft für Internationale Zusammenarbeit
GM	Green manure
GMCC	Green manure cover crop
hp	Horse power
IASA	Industrial Oils SA
IDB	Inter-American Development Bank
IICA	Inter-American Institute for agricultural Cooperation
IMAGRO	Agricultural income tax
IMO	International Mennonite Organization
INDERT	National Institute for Agricultural and Land Development
INFONA	National Forestry Institute
IPTA	Paraguayan Institute for Agricultural Technology
IRPC	Small contributors' income tax
IVA	Value added tax
KfW	Kreditanstalt für Wiederaufbau
l	litre

m	metre
m^3AP	Alto Paraná cubic meter. A local measure of the volume of timber logs
MAG	Ministry of Agriculture and Livestock
MH	Ministry of Finance
MIC	Ministry of Trade and Industry
NT	No-till, direct seeding
PES	Payment for environmental services
PBG	Good Government Programme
PMRN	Sustainable Natural Resource Management Project
PRNT	Relative neutralizing capacity (of lime)
PRODESAL	Programme of assistance for the development of smallholder cotton producers
PRONAF	National programme of family farm support
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDIEX	Network of investment and export
RUC	Unique taxpayers register number
SEAM	Environment secretariat
SENAVE	National service of seed quality and health
SIGEST	Integrated management system for agricultural and rural development
TA	Technical assistance
TRNP	Total relative neutralizing power
UNA	National University Asunción
US$	US dollars
UTI	Territorial unit of intervention
UTT	Outsourced technical extension units


Concepción
San Pedro
Canindeyú
Caaguazú
Guairá
Paraguarí
Caazapá

SUMMARY

This book is a richly detailed account of a forestry, agroforestry and Conservation Agriculture (CA) project for smallholder farmers in eastern Paraguay. Initiated in 2003 it now supports some 17 000 smallholder farm families. The project channels financial resources to farmers organized in committees to enable them to acquire inputs (including machinery) for CA, native forest management, reforestation and agroforestry as a means of diversification, long-term income and natural resource conservation. Implementation has not been without some teething problems and these are examined in detail in order to avoid or minimize them in future, similar projects.

Farmers were organized into associations, or committees, in order to better plan, receive technical assistance and financial incentives, gain access to credit, and buy and sell inputs and farm products on advantageous terms. The basic concept was to consider the farmer as a business person and to smooth the path from individual production towards the formation of profitable strategic alliances.

The CA practices promoted, (and adopted) include the selection and performance of green manure cover crops (GMCCs). Both research station results and many on-farm case studies show the value of leguminous and other GMCCs in weed control and yield increases. Details are given of their performance, management, advantages and disadvantages. The use of tools and machinery has contributed greatly to the development of family agriculture. Implements adopted include: subsoilers, knife rollers, lime-spreaders, direct planters. Other inputs include lime, fertilizers and herbicides. Mono-cropping is one of the main reasons for disease build up in smallholder farms and rotations are a basic pillar of CA. The rotations established by the project are based on maize production and crops that farmers consider to be their important cash crops; these are associated with summer and winter GMCCs. Finally, some farmers' committees asked for orientation on organic CA and so this aspect was included in the technical assistance package.

The association of animal production with CA crop production is an interesting proposition for the family farm as a source of both improved family nutrition and income earning potential. The synergies between CA production with animal feeding is discussed as is the integration of small livestock and cattle into the farming system.

Forestry and agroforestry are major components of the project and the establishment of nurseries as a business is dealt with in detail. Nurseries then allow degraded (and other) land to be reforested and existing forests to be rehabilitated. Species selection, sites and spacings are all examined as is the management of the forest (pruning and thinning). Native forest

management requires sustainable extraction to maximize income and ensure future exploitation. Agroforestry is considered to be a fundamental part of the integrated process of conservation and improvement of the soil. Different systems are considered, including: agro-fruit forestry; agro-silvo-pastoral; wind-breaks and living fences. Forest products are described and assessed, starting with firewood and charcoal through to timber logs and sawing. There are also non-timber forest products such as medicinal plants, honey, fruits and animal protein and the raw materials for organic phyto-sanitary products. Ecotourism also becomes a possibility with well managed forests in attractive locations.

Of very high importance are the economic, social and ecological impacts of the project components and these are given high priority with analyses of the impacts on yield and labour, adoption, diversification, farmers' perceptions, adaptation and innovation, impact on family income and on the environment. Throughout, the story is enriched by detailed case studies of real farmers' situations.

The final two chapters of the book deal with the lessons learnt and the factors contributing to success or failure. During the execution of the project several difficulties arose and were dealt with. These were a mix of political, administrative, technical and organizational factors. By dealing openly with these questions the authors hope to raise awareness of the importance of the work and its political, social and economic impacts. At the same time the experiences and challenges and how they were dealt with should be useful in the design, planning and execution of future projects. Success factors include: organizational consolidation; group homogeneity; management leadership; permanent technical assistance; positive on-farm results; the technology package; and the quality of the management team. Some of the negative factors include: desertion; skeptical neighbours; absence of leadership and lax operation of the committees; intermittent technical assistance; poor selection of participants, lack of effort; lack of training; erroneous beliefs about CA; poor resource management; and the creation of a dependency culture.

CHAPTER 1

Historical outline of the Project

The Sustainable Natural Resource Management Project (PMRN) has been operational since 2003 in the Eastern Region of Paraguay. It works in seven Departments and supports some 17 000 families with the aim of improving their productive base. The need is to introduce sustainable agricultural and forestry systems to improve the income and the quality of life of smallholder farm families, and at the same time contribute to the conservation and rehabilitation of natural resources.

With financial incentives channelled to farmers organized in committees, the aim is to finance inputs and machinery to introduce the Conservation Agriculture (CA) system and measures for native forest management, reforestation and agroforestry as means of diversification and a source of long-term income. Farmers request the practices according to their needs and receive technical assistance (TA) for three years.

It has been confirmed that the objectives have been achieved. The beneficiaries are applying conservationist measures with their own resources, improving their agricultural output using less labour and at the same time increasing family income. In addition they have introduced new enterprises for self-consumption and cash-cropping which have improved their diet and increased market sales. The environmental impact has been positive as there have been reductions in erosion, burning, ploughing, and an increase in soil organic matter and forestry species on the farm. Degraded soils and forests are being rehabilitated to return to productivity in the long term. The measures adopted are those for adaptation and mitigation of the effects of climate change through carbon sequestration in the soil and forest.

This document presents the results of the Sustainable Natural Resource Management Project (PMRN) implemented by the Ministry of Agriculture and Livestock (MAG) with German Development Cooperation (GIZ) and financial support (KfW) and the consultancy AGEG/ECO.

BACKGROUND

The Soil Conservation Project (MAG – GIZ) worked with great success from 1993 to 2001 in the Eastern Region, above all with large scale producers with the introduction of no-till direct seeding (no-till – NT) in Paraguay. Today 95 percent of the mechanized area is working with this system and so is achieving a reduction in burning, erosion, chemical fertilizer application and is resulting in the maintenance and enhancement of soil fertility and the high

profitability of NT for the production of soya, wheat, maize, canola and other crops.

Nevertheless, there are still challenges to be dealt with: the problem of the destruction of native forests in recent decades; the increase in weed resistance to herbicides as a result of their indiscriminate use; little crop rotation and an increase in pest and disease incidence as a result of poor application of the system, all need a more detailed discussion between the public and private sector stakeholders involved in the subject.

The Soil Conservation Project prepared a proposal for NT systems for smallholder producers in the Eastern Region. This was successfully implemented; however the system was not widely taken up. The PMRN is applying, adapting and scaling out these NT technologies at the smallholder level.

As regards the forestry component, there have been good results from a previous European Union (EU) project with the National Institute for Rural and Land Development (INDERT); the ALA project; and the experience gained over many years of cooperation between GIZ and the national University of Asunción (UNA), the MAG and the Environmental Secretariat (SEAM). These experiences have been analyzed and adapted to the needs of smallholder producers through extensive promotional efforts.

The PMRN was originally set up, above all, for the implementation of forestry practices. It started with the signing of a financial contact between MAG and KfW in 2000 which foresaw the transfer of incentive funding to producers with farms of up to 20 ha in the Eastern region to implement direct sowing and forestry practices.

The PMRN can be divided into three main stages:

TABLE 1.1
Stages of the PMRN Project

2000 to 2003	**Start up** phase without payments with problems associated with the means of transferring incentives. Technician training.
End of 2003 to end of 2005	Stage of the **first payments**. Technical assistance through the Programme of support for the Development of Cotton Farmers (PRODESAL). Learning and adjustment phase.
2006 to 2010	**Consolidation** phase with technical assistance contracted directly and payments made without serious problems.

First phase

It was foreseen that the technical assistance would be supplied by PRODESAL, financed by the Inter-American Development Bank (IDB) with US$23 millions[1]. This programme contracted 16 consultancy companies, called outsourced technical units (UTTs) working in territorial intervention

[1] US$1.00 = 4600 Gs

units (UTIs) of approximately eight technicians each and so attending 600 families per UTI. The cost was approximately US$100 000 per year per UTI. PRODESAL worked in the following areas: 1) Organization; 2) Marketing; 3) Technical improvement; and 4) Environmental sustainability. The last coincided with the objectives of the PMRN and for that reason it was agreed to implement the Project with the technical assistance already established.

The lack of definition of the modality of transferring incentives to the committees resulted in a delay of almost three years. It was not until 2003 that it was possible to transfer the first incentive funds to organized committees.

At first the UTTs perceived the PMRN as an additional work load given that the correct implementation of the financial measures by the Project were not recognized in the evaluation of the companies and there were no additional payments. Furthermore, the technical staff, already overloaded with parallel activities, could not be monitored or supervised directly by the PMRN. This was confirmed in the PMRN Phase I mid-term review report: "*Consequently it was clear that the activities within PRODESAL were always given priority over those programmed by the PMRN; and… the high turnover of UTT staff made it difficult and often inefficient to train them. Furthermore, many UTTs gave little importance to the natural resource component of the PMRN which limited the satisfactory transfer of technologies*".

The results of the first phase of the PMRN with PRODESAL were not very successful: low implementation; little quality; and inadequate follow-up. This was in spite of the fact that in those plots where the measures had been applied correctly, remarkable improvements could be seen. At the same time, problems with the delay in payments contributed to this situation.

Second and third phases

The situation changed with the termination of PRODESAL in 2005. On the one hand the Project overcame the administrative difficulties from 2006 on, when KfW permitted the direct hiring of technicians to replace the UTTs. From January of that year a total of 89 technicians, 14 coordinators and 3 inspectors were hired with KfW funds to enable the technical assistance to continue. Today (October 2010) there are 3 inspectors, 35 technicians and 12 coordinators contracted.

At the same time, the Project is being implemented through Technical Assistance of the MAG and the Agrarian Extension Directorate (DEAg), especially in the Departments of Caazapá, Caaguazú and Paraguarí. Between 2000 and 2005, Caazapá was supported by GIZ in a rural development programme in which the two Projects' activities were complemented and displayed good success with the trained DEAg staff.

1.1 DESCRIPTION OF THE PMRN PACKETS AND CHANGES TO THE PACKETS

Technology packets were designed as proposals for farmers. They consisted of: i) soil management with no-till; ii) reforestation; iii) native forest management; and iv) agroforestry systems. Each farmer, organized in a committee can request, via technical assistance staff, the proposal most suited to their needs. Then a formal request is sent to the Project, a formal contract is signed, and funds are transferred to the committee's bank account to buy inputs, machinery and for forestry incentives.

Soil management

The aim of applying the technology packets on soil management is to recuperate soil fertility which has declined to the point where the smallholder farmer can barely produce enough for family subsistence. With the application of organic matter (through green manures) it is possible to recuperate soil fertility, maintain soil moisture, reduce the incidence of weeds and improve yields. The packets include the use of chemical fertilizers which help to accelerate the recuperation process.

The Project did not finance soil analyses on each farm due to the high costs and the time needed. For this reason it was important to establish a 'standard packet' which could be applied across the country. Also, for administrative reasons, it was not possible to design individual solutions for each farmer.

For the introduction of NT, the Project offers four defined packets, financed in three stages:

1. Management of degraded soils.
2. Management of fertile soil.
3. Degraded soil management for organic growers.
4. Fertile soil management for organic growers.

As an indicator to define the fertility of the soil, minimum reference yields were established:

Chipá maize >1500 kg/ha
Pytá maize >2000 kg/ha
Cotton >2000 kg/ha
Cassava >20 000 kg/ha

Costs for a 10-member committee: 5 600 000 Gs per ha.
Each farmer should apply the packet to 1 ha on their farm.

Management of fertile soil:
This comprises good practices to conserve and improve soil fertility. The technology packet lasts for two years and is implemented as for degraded soil management in the second year.

TABLE 1.2
PMRN technology packet for degraded soil (1ha)

Inputs per ha	Year 1	Year 2	Year 3	Total Gs
	Pigeon pea 60 kg	Mucuna 90 kg	Oats 50 kg Lupin 80 kg Radish 10 kg After a cash crop	
Fertilizer NPK	200 kg	200 kg	-	
Urea	100 kg	100 kg	-	
Herbicide	-	4 litres	8 litres	
Total Inputs in Gs	**1 650 000**	**1 700 000**	**550 000**	**3 900 000**
Implements				
Jab planter	1 per member	-	-	260 000
20-litre sprayer	1 per member	-	-	550 000
600-kg silo	-	1 per member	-	500 000
1 knife roller	1 per committee	-	-	2 600 000
1 subsoiler	1 per committee	-	-	1 300 000

Soil management for organic growers:

This could be both for fertile and degraded soils. It comprises the same as the previous technology packet, where chemical products are replaced with those permitted by the certifiers.

Group machines as prizes:

In addition to the group machines of the first donation, there were also envisaged one or two-row animal traction planters, 50 to 200 litres animal traction sprayers or human-pulled sprayers. In Phase 1, delivery of these machines was included in the contracts of all the committees. In Phase 2 the equipment was delivered only by way of prizes to excellent committees. (See section 1.2).

TABLE 1.3
Machinery and equipment awarded to outstanding committees

Implements	Number	Estimated value, Gs
2-row planter, or	1 per committee	15 000 000
1-row animal traction planter	1 per 5 members	4 500 000
200-litre animal traction sprayer,	1 per committee	8 000 000
50-litre animal traction sprayer, or,	1 per committee	4 700 000
Human-pulled sprayer	1 per 5 members	2 500 000

Forest management

The aims of introducing forest management measures were: to assure the energy requirements of smallholder farm families in terms of firewood; to diversify production on the farms (timber as a cash crop); to maintain and improve the biodiversity of the farm; to assure non-timber production from the forest and introduce a long-term income stream with little additional labour requirement. Five measures were defined and promoted by the Project:

1. Management of native forest
2. Enrichment of native forest (in Phase 1, then this was discarded)
3. Reforestation
4. Agroforestry
5. Forest nurseries

Management of native forest: This comprises the sustainable and rational management of native forests. It starts with a rapid inventory to then apply strategies that are propitious for a rational exploitation and the enrichment and management of natural regeneration of desirable timber species. The packet includes logging, rapid forestry inventory, marking future trees, cutting creepers, weeding, elimination of competing trees, and maintenance of the natural regeneration.

Reforestation: Comprises the establishment of plantations of native and/or exotic forest species. Species selection, spacing and total area covered will depend on the smallholders, their objectives and the available area. The packet includes: land preparation, planting, maintenance, ant control, pruning and thinning.

Agroforestry: Comprises the establishment of forest plantations at spacings that allow the association of agricultural and fruit crops and so making it possible to harvest various products in the same plot. The packet includes: land preparation, planting, maintenance, ant control, pruning and thinning.

Forest nurseries: Comprises the transfer of incentives to acquire the inputs and equipment necessary for the production of forest seedlings. The amount depends on the request presented by the farmers, it is flexible and the criterion is that the cost of production (PMRN's investment) should not exceed the cost of plants in the market.

The support afforded by the PMRN for the development of forestry activities is through the transfer of incentives to cover the initial costs as can be seen in Table 1.4.

TABLE 1.4
Incentives for forest management measures by year

Forestry measure	Incentives, Gs		
	Year 1	Year 2	Year 3
Management of native forest	350 000	350 000	200 000
Reforestation	450 000	350 000	350 000
Agroforestry	250 000	250 000	100 000

Each farmer can request forestry measures for up to 3 ha in total.

1.2 ADJUSTMENTS TO THE PACKETS

The technology packets were adjusted after evaluations made by farmers and technicians, and observed by experts, in field visits and recommended in their reports. The modifications were:

Reduction in the quantity of compound fertilizer and urea

In the calculation of incentives for the packet, the amount of fertilizer was reduced from 300 to 200 kg/ha in the first two years and from 200 to 0 kg/ha in the final year. The reduction was made after consideration of the high cost of the input which made it difficult for farmers to acquire after the end of the Project. Furthermore it was possible to observe and confirm the effect of green manures in the final year of the technology packet. This was an indication of the sustainability of the system and showed farmers that sustainable management of the soil can be achieved without recourse to chemical fertilizers. At the same time, the application of 300 kg/ha of chemical fertilizer was difficult for farmers given the imprecision of the metering systems on the jab planters which, in some models, could only apply up to 200 kg/ha.

The reduction of the amount of fertilizer financed by the Project also allowed soil fertility recuperation to be achieved without chemical inputs; the drawback is that the process takes time. In Phase 2 of the Project farmers were obliged to **increase their area of GM (pigeon pea), without chemical fertilizer, to demonstrate its effect**. In this case it is recommended to leave the GM in the plot for two years. If the farmer needs the plot to produce a crop, the pigeon pea is pruned and maize sown between the rows. Nevertheless, competition from the pigeon pea reduces maize yields.

Elimination of incentives for agricultural lime and lime spreader

The decision was made to eliminate the incentives for lime and spreader after an analysis of the results of recent trials at the Choré experimental station. These indicated that the application of lime in sandy soils has no significant effect on maize yields. Also the high cost of transport of the spreader and the difficulty of obtaining one at certain times of the year, was also taken into account. There was no defined work for the spreader after the application of lime. Only a few committees used it for the application of organic material or manure (See 3.2 and 3.3).

Change to the delivery of silos for individuals

On request from the farmers the decision was made to change the two 2000 kg metal silos per committee to one 600 kg metal silo for each farmer. It was considered that this arrangement was easier to manage and that individually-owned silos would be better cared for and used.

Review of the delivery of incentives for acquiring group-owned machinery in the second phase:

In the second year of Phase 1 of the Project the delivery was foreseen of group machines to each committee (two-row no-till animal traction planter and pedestrian-pulled 6-nozzle sprayers). This was to facilitate a reduction

in labour requirements and an expansion of the cultivated area. When monitoring these machines it was seen that various committees who had received them were not using them fully and so their purchase could not be justified (See 3.2).

In Phase 2 of the Project this arrangement was changed, machines were only supplied to excellent committees under some conditions. Each farmer should have de-stumped and levelled fields with a minimum area of 2 ha each. Each farmer should have nurseries of three species of GM and each committee should have a place to store the machines, funds to maintain them, and the documentation of the committee should be up-to-date.

Selection of the measures

At the beginning of the Project, the majority of requests were for the measures for fertile soil management due to the lack of experience of the technicians and the limited time available for the contracted TA. Nevertheless, as a result of experience gained in the first years, it was observed that **the mucuna and the winter GMs generally did not prosper in degraded soils** and so did not supply enough organic matter to recuperate soil fertility.

Subsequently criteria for selection of the measures were established, based on the yields mentioned in point 1.1. In Phase 2, in the majority of cases, measures for degraded soils were applied as these supply more biomass, help to feed both humans and animals and their root development has a positive effect on de-compacting the soil. In the same way, promotion of the initiation of the measures for fertile soil in winter (with oats, radish and lupin) was discontinued. Instead the measures were initiated in summer (with mucuna and pigeon pea) in order to guarantee success in the first year.

Forest enrichment

This measure was recommended systematically in Phase 1 of the Project. It started with opening strips 3-4 m wide at 25 m intervals and planting 1 m high saplings of high-value species at a spacing of 4-6 m. This was based on the rapid inventory of the forest (if there were fewer than 150 future trees per hectare). Even so, in practice it was found that in almost all the plots, the number of natural regeneration plants was sufficient and in many cases the enrichment was not carried out with high-value species, but with common species that were already present in the plots (See point 6.8). Also the saplings planted grew more slowly than the natural regeneration with a high percentage of losses (30-40 percent).

In Phase 2 this measure was eliminated, with the recommendation to apply enrichment with high-value species only in spots where it was needed.

1.3 FINANCING

The funding of the Project is based on an agreement between the Governments of Paraguay and Germany underpinned by contracts for financial assistance,

separate agreements, proceedings of agreements and implementation contracts. KfW, the financial cooperation arm of GIZ (technical cooperation) have invested non-returnable funds in the following way:

TABLE 1.5
PMRN financing

Phases	KfW, millions of Euros	Years	GIZ, millions of Euros	Years
Phase 1	10.17	2000 to 2007	2.0	2000 to 2007
Phase 2	6.7	2008 to 2012	1.3	2007 to 2010

The contracted TA was assigned 3 million Euros from KfW funds from 2005 to 2010.

The Project is implemented in conjunction with GIZ through the AGEG/ECO consultancy company. The Ministry of Agriculture and Livestock contributes with staff for the implementation unit, offices, running costs and technical assistance from DEAg in the Departments of Paraguarí, Caaguazú and Caazapá. Counterpart funds from the Ministry amounted to approximately 1 million Euros in total.

Financial resources operating system

The incentives modality has been by payment to a committee account in the National Development Bank (BNF). The MAG received the funds from Germany through an account in the Paraguayan Central Bank (BCP), a special Euro account, managed by the Finance Ministry (MH). Following a request from MAG, the BCP funds were transferred to an account available to the Project managed by the executive director of the Project and an administrator. The funds were deposited in Guaraníes to be later transferred to the accounts of the beneficiary committees.

The committees accounted to the Project which in turn accounted to MAG, MH and KfW in order to be able to receive the next payment.

The agreement on the modality of transfer of the funds for incentives was a long, complicated and painful process from December 2000 to May 2003. During this period there were no payments made and the Project was on the point of being closed due to not fulfilling its basic preconditions.

The transfer of incentives was the major problem throughout the implementation of the Project due to:

- Excessive bureaucracy
- Changing and contradictory laws and rules
- Frequent changes of personnel and authorities
- Slow and inefficient processes
- Duplication of steps and responsibilities in the MAG
- Ignorance
- Sluggishness
- Overwork of key staff.

As a result **the late transfer of incentives at the wrong times (out of season) was one of the principal problems for the effective execution of the Project**.

It took from 3 weeks to 8 months for the transfer of funds from Germany to the BCP and the committees. In several years the committees were not able to correctly implement the measures because of this. With the latest changes in the National Directorate of Administration and Coordination of Projects (DINCAP) in 2010 and the formation of a unit (sub UAF) to maintain a direct line of communication with the MH, the problem was solved, or at least reduced.

1.4 TECHNICAL ASSISTANCE

Technical assistance played an important part in changing the attitudes of farmers during the change from conventional production to CA. Through technical assistance there were many training days on soil and forest management, field days, educational tours, informative meetings, etc. as a means of securing the evolutionary processes of the system.

Technical assistance has been the fundamental pillar of the Project. Without doubt, when speaking of the success of the Project in achieving its aims and goals, it is essential to analyze the modality and type of technical assistance, as well as the ethics, moral and technical capacity of those who carried out this task.

In one study of group surveys, 100 percent of the interviewees attributed the success of the PMRN to technical assistance (Nizz and Calegari, 2009).

The Project employed different modalities of technical assistance:

1. TA outsourced through PRODESAL
2. TA of the DEAg
3. TA through agreements with projects, cooperatives and local governments
4. TA directly contracted.

As a policy, the MAG formed alliances for the execution of the PMRN by means of technicians contracted by out sourced companies within the framework of the PRODESAL project (MAG/BID/IICA). With the end of PRODESAL, the PMRN was obliged to use its own technical assistance as the staff of the DEAg was not able to provide it, and this gave rise to a restructuring of the modality of execution. For this, technicians were contracted through the consultancy AGEG (which was implementing the Project for GIZ) financed by German Cooperation (KfW). Also, agreements were signed with cooperatives – San Pedro Neighbourhood Cooperation (COVEPA), La Norteña, governments and municipalities so that their technicians could deliver the promoted technology packets to farmers, resulting in both good and bad experiences. From the start, one form of implementation was the alliance with DEAg technicians from the Departments of Paraguarí, Caazapá, Caaguazú, San Pedro, Concepción and Guairá.

In the case of direct contracted technical assistance, the Project linked with 14 coordinators, each one responsible for 60 to 150 committees. Three to eight technicians worked under each coordinator, each attending 10 to 20 committees or approximately 150 farmers. The technical teams were supervised by three contracted inspectors and by permanent Project staff.

The technical assistance contracted directly by the Project has been that which had better obligation and responsibility and whose dedication and exclusive focus on its activities were largely a result of its own demands.

To maintain specialist staff carries a cost and without doubt it is necessary to invest in a permanent training regime. As a result technicians can be sure of their knowledge and so have more confidence with those assisted, and this is noticed by farmers. Over the years, the technicians have gained much experience, respect and work security. At the outset, many had doubts about the success of the measures to be implemented, and now all can speak with confidence about the success of their correct application. It's worth pointing out that the majority of the technicians did not have formal forestry training and only via the Project did they become proficient in the subject. Today they all understand and manage the technologies adequately and have mastered the terminology of the theme.

In an evaluation of the technical assistance of the PMRN in 2010, consultant Carlos Cubillos stated: "*the PMRN achieves an important efficiency in the utilization of human and financial resources, due principally to two factors. The continuity of the technical team (some have been with the Project since the time of PRODESAL) guarantees an understanding of the context in terms of production problems, and at the same time of the relations with farmer organizations and other players present in the region, in particular local governments, cooperatives and agro-food companies. At the same time, a well defined and pertinent technical proposal facilitates its adoption by the technical team and the monitoring of achievements in the field.*"

Another fundamental point with all programmes and projects is the continuity of the technical assistance without interruption and, even more important, in the most important months of the agricultural calendar. Without doubt this resulted in the success that the PMRN achieved as its technicians remained in the field without breaks in their labour which did not happen with PRODESAL and with the technicians contracted by the DEAg.

It cannot be forgotten that the human qualities that a work team should possess, something that the PMRN achieved, are fundamental and time should be taken to work on this aspect so that it can be seen that small acts can make big differences.

TABLE 1.6
Technical assistance costs of the DEAg and PMRN, 2010 data

	DEAg	PMRN
Budget	30 000 million Gs/year	3 million Euros/5 years
Number of extensionists	800	45 to 90
Average number of families per extensionist	80	150
Number of beneficiary families	64 000	12 000
Cost of TA per family, Euros	72.12	50.00

Source: Project data, 2010.

It is worth noting that there was an intensive annual evaluation of the quality of the technical assistance based on the individual and collective evaluation of the documentation, data, and principally the work done in beneficiary farmers' plots. At the same time, the same work was assessed by the farmers with the aim of improving the services provided and giving feedback to correct errors and omissions, according to the need. In this evaluation, 31 percent of the technicians were awarded the highest qualification of 5, and 69 percent achieved 4. In the same way the technicians assessed the coordination, supervision and the technical administration in the central office in San Lorenzo. This kind of evaluation allowed reflection, correction and feedback with the aim of achieving individual and collective excellence.

1.5 MONITORING SYSTEM

Monitoring of the PMRN refers to the evaluation of the activities, results (products) and their use, as well as the direct and indirect impacts of the Project. The following is a presentation of a summary of the activities developed in the monitoring system at the different levels of the studies. Evaluation is necessary, on the one hand to control the achievements of the planned and agreed work, and above all it functions as feedback for the field technicians and the whole team in order to improve their field performance.

Control of activities is not emphasized, rather their impact at farm level. In other words: it is not important that a technician worked 40 or 200 hours per month, rather it is of interest to know if the technician managed to get the farmer to understand, apply and adopt the techniques being transferred.

In the monitoring of impact, Project beneficiary farmers were surveyed once a year, after harvest between the months of June to August. Approximately 10 percent of the committees were selected and in each one three farmers were interviewed as well as one woman who was not a direct beneficiary. The interviews were repeated with the same farmers each year to observe progress on various fronts. Base line data were collected by the PRODESAL project. With reference to farm income, surveys were conducted in 2005, 2007 and 2010 in Caazapá Department within the framework of the Good Governance Programme (PBG) of GIZ.

TABLE 1.7
Evaluation system

Levels of evaluation	Means of evaluation
Activities	Monthly reports of coordinators and supervisors.
	Monthly meetings of coordinators and supervisors.
	Three-monthly reports of coordinators and supervisors.
	Annual reports.
Results and their utilization	Technical reports of the committee and farmer on the field results (1-2 per year).
	Evaluation of the performance of the technicians (1 per year). - Quality of the reports and administrative work. - Evaluation of the plots. - Appraisal of the extensionists by the farmers. - Evaluation of the coordinators by the technicians, and of the supervisors by the coordinators and technicians.
	Annual, goals of the technicians with reference to the measurement of yields (soil and forestry). Soil: a minimum of one plot per committee.
Direct (and indirect) impact	Annual reports of the coordinators on results and impacts.
	Annual survey (~360 farmers).

Source: Control and Progress Report, 2010 (adapted).

The principal factors considered in the impact monitoring were:
- Evolution of production yields (productivity);
- Nurseries and GMs;
- Scaling up and multiplier effects;
- Introduction of new lines of production (diversification);
- Forestry aspects;
- Volumes and income from marketing (surplus production);
- Views on the participation of women and youth in the family farm;
- Group activities.

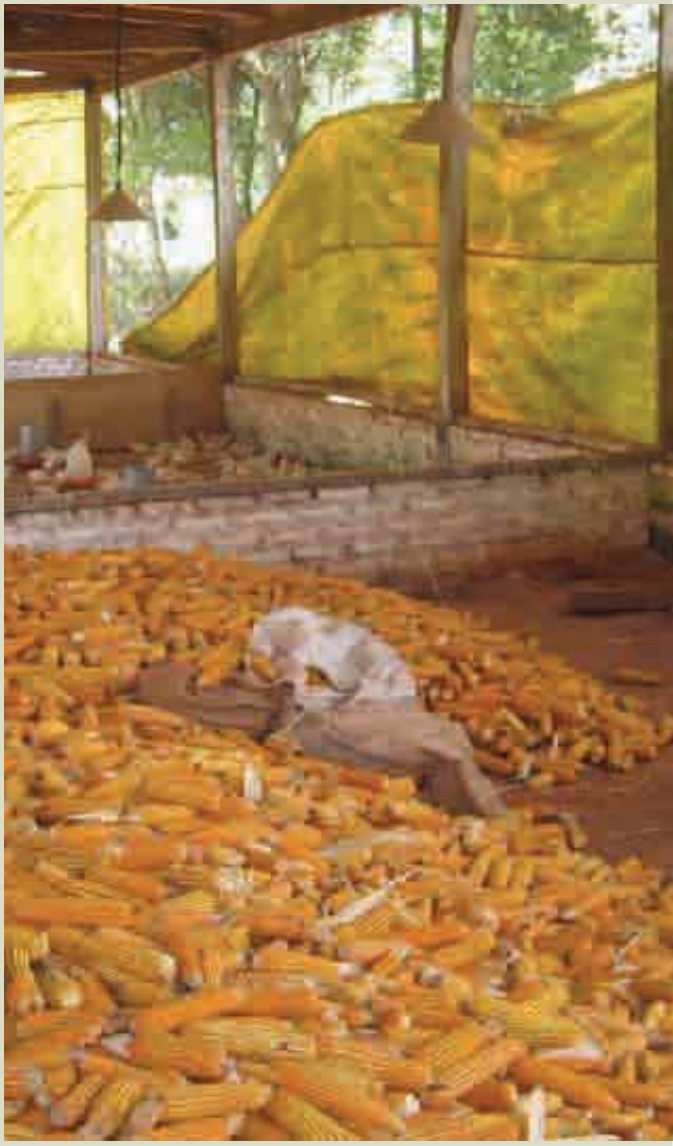
Survey results complemented the information from the data base; monthly three-monthly and annual reports of the DEAG and contracted technicians enabled the progress of the Project to be followed on an annual basis[2].

Apart from the impact monitoring, farmer surveys were conducted by means of consultancies on gender (Venus Caballero), forest impact (Markus Grulke), impact on soil management (Ademir Calegari), success factors (Fabio Nizz), and administrative audits via external audit companies and internally by DINCAP, MAG, by KfW and the Comptroller General of the Republic (CGR).

In Choré Experimental station scientific trials were conducted to answer specific questions with scientific rigour.

The results of the monitoring feature in the following chapters.

[2] See: Borsy, P. 2009. Informe de resultados e impactos del Proyecto Manejo Sostenible de Recursos Naturales, PMRN 2008. San Lorenzo, PY. Paraguay, MAG. 13 p.



CHAPTER 2

The farmer as a businessman: from the farm towards strategic alliances

The Paraguayan farmer, the same as farmers the world over, is an individualist and does not easily share or join groups. An organization or association only makes sense if it brings some benefit to the family. The Project has worked with organized farmers to facilitate the technical assistance, the transfer of funds, accounting and monitoring. On an individual basis it would have been a lot more difficult, and probably impossible.

At the beginning the Project promoted farm planning, taking into account the actual situation and visualizing the future of the individual farm. Nevertheless this planning was taken as an exercise to satisfy the formal requirements of the Project, and not as real planning.

In the first years of technical assistance it was focussed on financed plots for soil and forest recuperation and as a result lost the whole farm context. In many cases technicians and farmers spoke of the 'Project field'. Once the introduced practices were consolidated, the farmers took control of the plots and identified themselves with them. In this way the whole farm focus was regained, emphasizing diversification, marketing and alliances in the public and private sectors.

Case study 1: Group marketing in Vaquería

Mr Pablo Romero is a farmer who lives in the locality of Tekoja, 3rd line, in Vaquería District, Caaguazú Department. He has a 7.5 ha farm which he works with his wife and two children.

He produces and markets onions, cabbage, peas, watermelon and melon and crops for family consumption. His activities, as leader of an organization, were initiated with the formation of the committee on 8 December 2001, through technical assistance provided by technicians of PRODESAL/MAG. Later it was organized as a secondary grade association called the Associated Committee of Tekoja Farmers (CAAT) which functioned until 2005.

The following are some outstanding achievements of the organization:

- Marketing products for the first time in the wholesale market block of the Marketing Centre for Associated Farmers (CECO-PROA) where farmers negotiated their prices directly, without intermediaries.

- Access to credit authorized by the Farmers' Development Fund (FDC).
- Introduction to new cash crops such as onions, peas, etc.

PMRN technical assistance in soil management was initiated in 2006. At this time a series of works was commenced, strongly supported by the municipality with micro-projects, acquisition of GM seed, seeds of improved varieties of grains and the formation of the agricultural secretariat.

With the municipality agriculture secretariat, GIZ and other institutions started the process of forming an organization of secondary grade which involved eight women's committees and 28 farmers' committees. This was how the July 19 Farmers' Association was born and with that the process of documentation and training of its leaders was started.

Actually the Association was converted into the Multi-active Cooperative 19 of July, with Pablo Romero as its first president.

Amongst the achievements can be mentioned:

- Marketing cash crops in supermarkets: onions, chillies and pumpkin to a value of 120 million Guaraníes.
- Access to a 1 ha plot donated by the local municipality.
- Infrastructure for the manufacture of animal rations and *locro* maize storage with funds from the National Programme of Support for the Family Farm (PRONAF) to a value of 345 450 000 Gs.

Pablo Romero and members of his organization at work loading a truck to market their products

- Assistance from the Ministry of Finance and the UN Development Programme (UNDP) for the coalescence of micro projects into integrated committees of the association (2 machinery and 6 dairy farm projects).

2.1 CONCEPT OF THE COMMITTEE

Many of the committees were formed by DEAg technicians within the framework of PRODESAL; others were formed with the help of technicians contracted by PMRN. Their principal objective was always to organize to be able to receive technical assistance and/or some type of "project".

It is customary for farmers to ask of technicians what they can be given, thinking of tangible benefits like machinery, inputs or money and not intangible benefits like training or technical assistance. They are right as farmers do not like to waste their time listening to things in which they have no interest. It takes time to establish a good relationship of confidence between the farmers and the committee and the technician. PMRN's proposal was to work with committees to facilitate their administrative and organizational management and to work with individual farm families to strengthen them.

In Phase 1 of the Project there were many problems with the selection of farmers resulting in the desertion of committee members and a high percentage of non-achievement of programmed work. It was realized that it is very important to **differentiate between farmers and peasants (*campesinos*)**. With the former implementation and adoption of practices were achieved, whereas with others, implementation ceased with the withdrawal of the Project technician. With this lesson learnt during Phase 1, the selection of future beneficiary farmers for Phase 2 was much better, with better accomplishment and improved results with the selected people.

According to a study done in the framework of this Project (Nizz and Calegari, 2009), *"83 percent of those interviewed maintain that the PMRN cannot develop if it is not within a committee, at least at the outset; and 59 percent of the same interviewees equate the sustainability of the Project with strengthened committees…" "Achievement of objectives requires that the users desire to improve, have a minimum of self-estimation, and a wish for a better future for the family environment. Without these and other attributes, the Project leader can do little for them.*

The need exists for an adequate selection of the Project users and it can be seen that many do not have the necessary attributes to participate successfully".

Some of the **positive experiences** relating to the formation of outstanding committees are:

- The possibility of acquiring and using work implements;
- Permits the involvement of the municipal government in the organizations;
- Permits municipal funds to be channelled to the organizations;
- Support from state institutions;
- Increased participation of farmers;
- Active participation by women in the organization;
- Better marketing conditions;
- Better access to credit, confidence;
- Improvement in infrastructure for making and/or industrialization of products.

Other organizational advances could be detected according to monitoring data from 2010, where 53.3 percent of attended committees counted on their own centre, 76.6 percent had a shed to store the community machinery; 39.9 percent claimed to have attracted other types of project and 24.5 percent had invested in other group activities.

On the other hand it must be recognized that in many committees there is a **lack of confidence** and **disloyalty** between the members. There are members who are short-termist, not very participative, have a poor attendance record, have migration problems, have little understanding of the rules and regulations and a negative approach to policies (results of participatory workshops in Caazapá, 2010).

Case Study 2: An exemplary leader, Juan de Dios Monges, Caazapá District

Mr Juan de Dios Monges and his family have a 20 ha farm, considered to be a sustainable farm size for a family unit, where the last burn took place in 1993, 16 years ago. And the last ploughing was in July 2004.

The introduction of GMs on the farm was in 2001 via PRODESAL and GIZ. In the agricultural year 2004-2005 the rehabilitation of soils on 2 ha was started with maize and mucuna, of these 1 ha was with the PMRN.

Today the farm has 6 ha under no-till (NT), with a total of 12 species of GM, both summer and winter species. The productivity of the farm has increased considerably. To quote an example, the yield of *tupi pytá* maize increased from 1122 kg/ha to 2341 kg/ha and cotton from 1260 kg/ha to 2480 kg/ha. The farm also has auto-consumption crops such as several pulses, cassava, maize (*chipa, tupi pyta, locro, pichinga*), soya, groundnuts, various fruits and the production of sweetleaf (*ka´a he´ê* [Stevia rebaudiana]) under NT. Animal production includes milk cows, poultry, pigs and bee hives.

He also managed the woodlands within the farm and today has 2 ha of managed native forest, 1 ha agro-fruit forestry and 1.25 ha of reforestation with both native and exotic species.

The marketing of grains and cotton was done collectively via the farmer organization New Vision. The sale of GMs, suckling pigs and poultry as well as the sale of firewood and posts was done on an individual basis from the farm.

Juan de Dios Monges is a member of the Ko'e Rory committee which has 10 active members, the committee is part of the New Vision farmer organization, a second level organization with 300 family members and in which Juan is a member of the steering committee. He is also the representative of the organization within the District Coordination and the Departmental Coordination of Caazapá.

SUMMARY OF ANNUAL COSTS AND INCOME OF THE FARM

Description	Income Gs.	Costs Gs.	Balance Gs.
Agriculture	7 281 900	5 226 000	2 055 900
Forestrty	2 010 000	1 079 000	931 000
Pigs and poultry	2 700 000	720 000	1 980 000
GM	2 185 000	330 000	1 855 000
TOTAL	**14 176 900**	**7 355 000**	**6 821 900**

1 US$ = 4500 Gs.

Juan de Dios Monges with a citrus tree in production

2.2 PRECONDITIONS TO BECOME A BENEFICIARY OF THE PROJECT

Some basic requirements were established for the approval of requests from the committees. These are shown in the procedure manual of the Project. In addition to the documentation required by the MH, it is also required that the committee has **draught animals** for their NT planters; each farmer should have a **minimum of 5 ha** and should have a **GM nursery** to produce his own seed. This last condition was introduced in Phase 2 of the Project.

Farmers with less than 5 ha successfully demonstrated that it is feasible to produce GMs in small farms, nevertheless the majority did not demonstrate an entrepreneurial vision, rather they sought to cover their basic self-sufficiency needs without optimizing their production system. Non-adopting farmers often argued that they could not comply because of a 'lack of available land'. We know that this is not the case, but the decision was made to exclude them as beneficiaries with incentive contracts.

Juan de Dios Monges in a field of cassava associated with winter green manures

It would have been better to not deliver the inputs and machinery as a donation provided by the Project, but rather extend lines of credit. However, usually the farmers did not have sufficient funds available for investment and many had limitations on their credit worthiness because they did not have title to their land, a requirement that is usually needed to access credit.

2.3 LEGAL ARRANGEMENTS OF THE COMMITTEES

Over the years from the start of the Project until the present, there have been several legal requirements which the Project had to adapt to. Amongst them were the police and judicial background checks, the costly updated identity cards needed by all members of the committees and demanded by controlling authorities, and accounting forms demanded by the MH, among others. But without doubt, the biggest challenge for the project was in 2005 when Law 2421/04 on Administrative Restructuring and Fiscal Adaptation came into effect. This stipulated that all no-profit organizations must be inscribed in the tax register (RUC). Without doubt, inserting the committees in the RUC was a great challenge which was met with the help of the field technician team and the central PMRN office and 1500 organizations with 17 000 families were registered. The fiscal compliance of the committees implied much additional expenditure and effort for the field technicians who sacrificed and reduced their dedication to field visits.

For the committees there was also an additional cost in employing professionals for their inscription with the MH to obtain the RUC, printing

of invoices and receipts, VAT declaration and small scale income tax contributions (IRPC), the seal of a notary for the cash book, and payments for various negotiations. In cases of not fulfilling the paperwork requirements, the committee had to pay an annual fine of 150 000 Gs. Annually these requirements had a cost of approximately 520 000 Gs, without including any fines.

It is debateable whether this additional effort was worthwhile given that:

- The committees were probably never going to pay taxes to the state as they had no income;
- The majority of the citizens were amongst the poorest in Paraguay;
- Usually the members could hardly read or write, in may cases they are illiterate;
- They have no training or experience of these negotiations;
- In the zones and regions of action of the Project there were no Finance Ministry offices;
- They are committees which, after the close of the Project, are not going to be able to comply with the legal demands and the fines are probably going to increase.

In summary it can be asked if it is justifiable to demand of the poorest of Paraguay something that not even the most powerful in the country comply with (the Agricultural Activities tax – IMAGRO), only to participate in a support Project funded by donation from another country that is exonerated from payment of all taxes.

On the other hand the advantage is that the providers of inputs, seeds and machinery, who formerly had no legal documents, were formalized.

Case Study 3: The formation of the Carolina Cooperative with the help of COVESAP

COVESAP, located in the Itacurubí del Rosario district of San Pedro Department began life as a community help project in 1999 through the initiative of the Friesland Colony, and operated in some of its adjacent communities.

COVESAP operates in nine communities adjoining the Friesland Cooperative, working with 881 families, a total of approximately 3680 people and a geographic expansion in the district. From the outset the project received funding from the AVINA Foundation, the Friesland Cooperative, KfW, the International Mennonite Organization (IMO), the Paraguayan state initially, and some other institutions. COVESAP's vision focuses on ***improving the quality of life of the participants on the basis of integrated and sustainable development***.

To achieve this goal, COVESAP has a **work method** based on five action areas: cooperative administration, agricultural production technical assistance,

education, health, home economics and nutrition. The central plank of COVESAP is self management and initiative.

The programme's slogan: "Dignity of life for my neighbour"

COVESAP's responsibility:
General administration of the programme, technical assistance in the COVESAP zone, to the Carolina Cooperative Ltd. and in the zone of influence in the district of Itacurubí del Rosario, provide advice in the area of education and health.

Carolina Cooperative Ltd.
Presentation
The Carolina Cooperative Ltd. was founded on 7 February 2009 within the area of "self-administration of the project", as a result of an arduous process of training and formation in cooperativism undertaken by COVESAP with the help of other organizations responsible for this field. The cooperative is located in the Carolina colony in Itacurubí del Rosario district – San Pedro; it has operated in the same place as the administrative head quarters of COVESAP from its establishment.

Basis of the conformation of the cooperative
The cooperative was founded with the aim of addressing collectively the needs of its associates based on the pillars of cooperative principles. On the one hand was the need to promote the practice of self administration in the management of goods and resources of the family, the farm and the community. Also improvement in agricultural production through the adoption and scaling up of good practices, improvement of the marketing system of the associates' agricultural produce through more effective avenues such as communal marketing avoiding intermediaries. Attention was also given to improving the educational system and access to medical services for the associates and their families; and maintaining the rural road infrastructure through the formation of neighbourhood commissions to this end.

Actual responsibility of the Carolina Cooperative Ltd.
Administration of the cooperative, marketing agricultural produce, extension of credit lines and provision of support for education and health.

Some lessons learnt for the execution of development programmes:

1. The peace of a region or country can be achieved through rural development.
2. The long term development of a group is only possible if there is an integrated development of the entire region.
3. Everyone carries a certain responsibility for under-privileged groups in a given country.

4. A development project should always be integrally implemented, that is to say with the promotion of the practice of administration of the farm and the home and of the goods of communal organization, the improvement of agricultural production and marketing the output, improvement in the quality and ease of access to education and health, coordinated work to improve rural roads to facilitate the movement of people and produce to markets.
5. At the commencement of a rural development project, it is necessary to establish a basis of confidence between the participating sectors.
6. To wish for a change in mentality does not necessarily mean a change in culture amongst the participating groups.
7. One should never start a rural development project if funding is not secured in the medium and long terms. If the idea is just to start a project, it is better to leave it.
8. Work with neighbourhood cooperation should be characterized by its professionalism and seriousness in the execution of all the activities.
9. Based on mutual confidence, it is possible to delegate different responsibilities in the medium and long terms.
10. In the medium to long term the project should be institutionalized to avoid donor dependency.
11. Accompanying the beneficiaries directly and periodically is fundamental to guarantee the introduction of new production technologies such as crop rotation, GMs, NT, diversification, etc., effective authorization and repayments of credit, group marketing, and updating the farmers through training courses.
12. Forming new leaders is of great importance for integrated and sustainable rural development.
13. Work directed at training women is fundamental for the economic and social development of a region.
14. Promotion of self sufficiency crops to guarantee a balanced diet.
15. All types of gifts and subsidies should be avoided in the medium and long terms.
16. The people who show real interest in participation should be involved at a higher intensity in the various activities of the project.

2.4 PRODUCT DIVERSIFICATION AND COMMERCIALIZATION

With the consolidation and appropriation of agriculture and forestry conservation practices by the farmers, the process of increasing productivity and diversification was started.

For many farmers this situation, desired by the Project, was a problem given the difficulty that they had to harvest, thresh, store, use and market their produce whose yields had risen considerably. This "problem" was converted, bit by bit, into an opportunity. With the accompanying technical assistance,

farmers had started to use the excess production to raise lesser breed animals, for local sales, and to improve family food security. The numbers of animals (cattle, pigs, sheep, goats, chickens, turkeys and others) on the farm increased enormously.

There is no doubt that farm organization improved. With farm planning the uses of land and labour were optimized and through this means better use was made of the areas devoted to different enterprises (maize, cassava, sesame, cotton, etc.) and advantage was taken of the different crop, cycles (annual, bi-annual, perennial).

TABLE 2.1
Percentage of farmers claiming to have introduced new enterprises according to monitoring and impact data, 2005 to 2010

New enterprises	2005	2008 to 2009	2010
Fruit trees	13.4	32.1	31.3
Cash crops	19.2	40.1	19.9
Trees	15.6	30.6	31.3
Animals	5.6	25.1	33.8

Source: PMRN impact monitoring, 2010

The PMRN committees improved their administration and could insert their products in the marketing and supply chains, and received better payment for them. Previously these products were sold to intermediaries at lower prices than those now achieved.

Case Study 4: Sustainable agriculture and production diversification, keys to improving family farming, Gregorio López, Yhú

Gregorio López was born in 1957 in the city of Ybycu'i and, having few options to work the land in his home town, he migrated to Yhú district in 1979 where he bought the rights to a 7.5 ha property. One year later he returned to his home town to marry with Dominga Pereira with whom he later returned to Yhú. At the moment his family comprises 11 children, of which 10 live and work on the farm.

Since 1980 they started to work the land in the traditional way, with great sacrifice and obtained good profits. Later, owing to the inadequate soil management, the yield progressively declined. On hearing of the PMRN he decided, with the members of his committee, to present a request for the recuperation of soils within their limits. With this help, since 2007 he has been incorporating GMs (pigeon pea, mucuna, canavalia, oat and radish) associated with crops both for self-sufficiency and sale.

Today the farmer manages the whole farm with GMs and NT. He has diversified his income with the production of onions, sesame, reforestation and bee-keeping (producing bee honey); and, three or four times a year, markets the production communally for a better price.

He proudly commented: *"My children go to the farm looking for maize and my wife already has eggs, cheese, milk, honey, chicken meat in the house to prepare a delicious plate of food and we don't need to go to town to buy any of this".*

The farmer claims that the PMRN has allowed him to develop a sustainable and diversified agriculture with the incorporation of GMs and NT. On the other hand, he mentioned that he was facilitated with the knowledge and implements necessary to develop the system and urged his neighbours to introduce the practices as an alternative in order to improve farm incomes.

"Previously we were thinking of selling our property to look for better sites for production, but now we are learning how to improve the productivity of our own farm combining pigeon pea or mucuna with maize and castor bean, in addition this helps to improve honey production. By means of the community organization we are able to sell our produce at better prices and we are learning new production practices which do not damage the environment, seeing that we live on the farm".

Name and District	**Gregorio López Benítez, Yhú**
Technician	**Esteban Bernal**
Area of the farm	7.5 ha.
Family members	Wife and 10 children.
Principal activities	Agriculture: onion, sesame, maize with pigeon pea, cassava, bean, castor bean with mucuna, pea. Forestry: 1 ha of forest and 0.25 ha of reforestation with giant paraíso (*Melia* spp.). Fruit and vegetables: onion, lettuce, radish, beetroot, tomato, chilli, passion fruit, avocado, cabbage, pumpkin. Animal production: chicken, ducks, 2 milk cow, 2 oxen, 3 pigs. Production of milk, cheese, eggs and bee-honey, 60 rustic hives.
Marketing:	8000 kg of onions to the Stock supermarket in Asunción at an average price of 1000 Gs/kg. Sesame: 1600 kg a 3500 Gs/kg at the farm gate, castor bean 1000 kg a 1000 Gs/kg. Honey 800 kg at 10 000 Gs/kg. Giant paraíso 50 m^3 a 10 000 Gs. Pumpkin: 1856 kg. at 1100 Gs/kg.
Economy	25 141 600 Gs from produce sales without including family consumption.
Principal; impacts	Food security and group marketing, incorporation of sustainable production practices and soil management.

The markets for **joint marketing** of produce are a successful alternative for the sale of farm production for the organized committees, and above all for the women who participate actively in the **markets**, giving added value to their produce.

One advantage, emphasized by farmers, is that the Project helped them with **metal silos**. These have permitted the storage of grains and seeds of good quality to be sold on the market at convenient times. On the other hand, the lack of equipment or mini-industries to process primary products is a great limitation according to the farmers.

Gregorio López with his daughter in a plot of winter green manure (oat).

Gregorio López in a field of summer green manure (pigeon pea).

Case Study 5: Joint marketing, an alternative to improve farm family income. Bernardino Olmedo, Vaquería

Bernadino Olmedo lives in the community of San Pedro, Vaquería District together with his wife Julia Leguizamón and their two daughters Leticia and Adriana. He is president of the "**San Pedro II**" committee which was initially formed by 12 smallholder farmers who have grain and roots as cash crops, principally cassava. The committee receives assistance from PMRN technicians in agricultural production and CA, and in forestry practices (reforestation).

In 2004 work started on soil management, obtaining good results in maize production and introducing improved animals into the farm, such as ducks and hens that the members acquired with their own funds.

Later they introduced cassava as a NT enterprise and improved yields considerably compared with previous production methods. The increase was mainly a result of introducing mucuna, a summer GM, which supplies nitrogen and biomass, reduces weed competition and maintains soil humidity.

At the time of marketing, they came up against the problem of low prices offered by buyers. From 2009 they have organized, with the help of PMRN, the weekly supply of cassava to the wholesale market in Asunción, specifically in CECOPROA, with the aim of eliminating the intermediary, negotiating directly and obtaining better profits through joint marketing.

As a result of this good experience and management by the committee, other neighbouring farmers joined and participated in the joint marketing and as a result formed the San Pedro II Producers' Association. Today the Association has 72 members who send a truck three times a week to Asunción with cassava, chilli, beans, maize, cheese and pumpkin. The 72 farmers practice NT for their cassava, increasing yields by 35 to 40 percent from 18-20 000 kg/ha to 25-30 000 kg/ha. The local municipality occasionally helps with transport for the produce. The Association intends to buy a truck in the future to reduce freight costs and to have access to independent and opportune transport. Farmer Olmedo's net income from this process has improved by obtaining 40 percent higher final prices compared with that which could be obtained in the local market or through farm sales to intermediaries.

Apart from the cassava, the farmer has his plots of onion, lettuce, radish, beetroot, tomato, chilli, cabbage and as well has animal production: hens, ducks, 4 milk cows, 2 oxen, 9 pigs and produces milk, cheese and eggs. In total he manages to sell products to an annual value of 27 999 176 Gs.

Enterprise	kg	Gs
Cassava	30 250 kg/ha en 1.5 ha	11 764 500
Soya	1835 kg/ha en 1.5 ha	3 748 687
Cheese	800 kg	8 000 000
Pigs	5 animals	2 250 000
Beans	850 kg	2 125 000

According to Bernadino Olmedo, all his farm produce is negotiated in the Asunción market. In addition, with the work done in preparing the load for the market, extra income is earned for the members

Bernardino Olmedo and a member of the Association, loading cassava and onions to take to the Asuncion wholesale market.

Also the GM seeds proved to be an excellent business opportunity for the farmer and became an **alternative enterprise**. Today there is an important demand at national level for seed of GM species, the outstanding ones being mucuna, pigeon pea, lupin, crotalaria and canavalia.

In 2009 a total of 7500 families participated, with the help of technical assistance, in the commercialization of non-traditional products to the value of 12 850 million Gs, or 1.8 million Euros, equivalent to €287 additional income per family. In 2008 there were 6600 families with a value of 15 700 million Gs, or 2.37 million Euros, equivalent to €425 additional income per family. This difference in average income is due to the prolonged drought during the 2008/2009 season and the consequent scarcity of agricultural production during this period (Annual Reports, 2008 and 2009).

A noticeable aspect was the marketing of native forest wood, which respected all legal aspects, in a community of Repatriación, Caaguazú (See Case Study 28).

Case Study 6: NT vine tomato production, Silvero Rivas Mora, Loreto

Silvero Rivas's farm is located in the Jhugua Bonete company of Loreto District., Concepción Department. The area of the farm is 12 ha and agricultural enterprises include agricultural and vegetable crops, native forest management, cattle and small breed animal production, with family labour consisting of six members.

One of Mr Rivas's principal enterprises is tomato production which he does with NT with excellent yield results (70 000 kg/ha) and quality of produce.

Tomato was sown over mucuna residue which permits soil humidity to be maintained, adds additional nitrogen and reduces weed incidence and manual labour thanks to the mucuna cover.

Before starting with NT he had many difficulties in the productive process, such as a greater population of weeds which demanded manual labour for cleaning the plots. The amount of water required was greater so that, on occasions when rainfall was scarce, it was practically impossible to sow a crop. The advantages that the farmer attributes to this new production system are: better performance of the farm, reduction in manual labour for production, better weed control, more efficient use of water, better use of rainfall and greater crop yields which translate to higher income.

The help of the Project, which in addition to helping with inputs and equipment also gave quality technical assistance, helped the farmer to keep improving his production system which, according to the farmer himself, enabled him to make the greatest possible profit.

He sells the tomatoes in the regional market of Concepción and in the wholesale market in Asunción. Amongst the vegetable enterprises are chilli, onion, pumpkin, watermelon and melon. The farmer has an irrigation system. In the case of fruits, he has plantations of bananas and citrus for home consumption.

The farmer is convinced by the NT system because of the differences in quantity and quality of the production compared with the traditional system.

He is increasing the area of his plots and already has experience of different crops using this production system.

Mr Rivas has a forest reserve with important tree species such as pink ipê (*Tabebui* spp.), peterebey (*Cordia* spp.), cedro (*Cedrela* spp.), *Albizia* spp. amongst others. He himself manages the natural regeneration of trees and cutting back creepers to preserve the important species and the rational exploitation both for sale and home use.

The main impacts were particularly observed in the yields of the agricultural and vegetable crops, less use of manual labour for weeding because of reduced weed incidence, and improvement in soil productivity.

SUMMARY

Name and District	**Silvero Rivas Mora, Loreto**
Technician	**Ing. Agr. Rubén Aquino**
Area of the farm	12 ha.
Family	6 members.
Main activities	Production of home consumption crops: maize, beans, sweet potato, cassava, groundnut. Cash crops include: sesame and beans. Vegetable crops include: tomato, chilli, onion, pumpkin, watermelon and melon.
Marketing	Horticultural crops, sesame and beans.
Economy	Gross income of 140 million Gs from tomato sales leaving a net income of 90 million Gs.
Main impacts	Improved yields of agricultural and vegetable crops with less labour for weeding because of reduced weed incidence in the cropped fields. Improvement of soil productivity.

Silvero Rivas shows the root system of his vine tomato plants in his NT field

Silvero Rivas's son by the tomatoes harvested from the plot.

2.5 ALLIANCES AND INTERACTIONS WITH THE PUBLIC-PRIVATE SECTOR

With the help received in marketing, alliances from the public and private sectors were sought to ensure continuity, after the end of the Project, in the production and marketing processes of the farmers.

Private sector

In some cases the Project assisted the formalization of production by means of contracts and agreements with primary product purchasing and processing companies. Some examples are:

- Industrial Aceitera SA (IASA), production of coconut and maize for balanced rations in Paraguarí Department;
- Agreement with supermarkets and the Paraguayan Federation of Vegetable and Fruit Producers to market onions in Vaquería;
- Agreement with Soja Rica (Rich Soya) in Caaguazú Department for the production of maize for semolina and snacks;
- Agreement with The Primary Products Development and Industrialization Company (CODIPSA) for the production of cassava for starch in Repatriación, Guayaybi and Caaguazú;
- Production of orange, grapefruit and passion fruit in Caazapá between local government, Ministry of Agriculture, Capiibary and Frutika Cooperatives;
- Production of watermelon for export to Argentina with local government, Ministry of Industry and Marketing, Investment and Export Network (REDIEX), MAG, National Service of Vegetable Quality and Health, Agricultural Credit (CAH) and the Tekopyahu Cooperative;
- Sale of beans to Brazil with the HP Campo company.

These agreements served to establish permanent contact between the buyer and the marketing channels for the produce. In some cases the quality of the product demanded by the buyer is superior to the traditional, but with a preferential price premium. In the case of CODIPSA, family quotas were defined, with a premium if the delivery was of good quality and on time. The permanent and constant sale of produce, at a better price, has contributed considerably to the quality of life of the families participating in these agreements.

Case Study 7: Watermelon production with minimum tillage, Basilio Báez, Loreto

Basilio Báez Aguilera's farm is in the Torales San Roque company, Loreto District, Concepción Department. The total area is 10 ha of which 3 ha are under NT. He also has agricultural and horticultural enterprises, manages the native forest, raises cattle and smaller animal breeds all with family labour comprising five members.

One of the main enterprises of Mr Báez is watermelon production which, since 2009, has participated in the Programme for Export to Argentina with the assistance of local government, REDIEX and SENAVE through an agreement with these institutions. REDIEX facilitated the export of watermelon to Argentina; SENAVE has as its function within the Project the weekly monitoring of the crop with respect to pests and diseases with the placement of insect traps to maintain a record of incidences. Local government, through the agricultural secretariat, provides watermelon seeds and the PMRN gives technical assistance to the beneficiary farmers of this agreement.

For watermelon production, first there was an improvement of the plot with a maize crop associated with mucuna. Once the maize was harvested, the mucuna was left to develop to obtain a good cover to eliminate weeds and leave available biomass on the soil. Then the mucuna was rolled and water melon was sown through the residue with NT.

"With this system almost all my weeds were eliminated, I only had to weed once and during the dry spell soil humidity was better retained. That's how I got a good harvest and made a good profit", declared the farmer.

With this system the farmer obtained 1500 premium quality fruits (8 to 12 kg average per fruit) in 1 ha, selling at 6000 Gs per fruit this gives an income of around 9 million Gs. He also sold about 500 fruits, considered second quality, at 3000 Gs, and received 1.5 million Gs for those.

Implementing GMs in the farm through the PMRN Project implied less labour for weeding the fields due to reduced weed incidence, and the maintenance of soil humidity because of the cover. Further, the sale of GM seed, which actually he does, generated an additional income in a period without other cash enterprises and also permitted both animal and human consumption.

The farmer also has a forest reserve with important species such as kurupay (*Piptadenia* spp.), peterebey, pink ipê, amongst others. He manages the natural regeneration in order to conserve the valuable species as well as practising a rational harvest regime for home use and sale.

Public sector

One of the **reasons for failure** of the correct implementation of the promoted measures, mentioned by farmers and appearing in various reports, is the **lack of help from the state and contradictions in state policies**. Whilst MAG with the Project is promoting CA, local governments support the use of ploughing and harrowing, mainly during political campaigns, in the name of offering 'services' to the farmer. The same occurs with bi-national entities and in some cases farmer federations and organizations also demand these free or subsidized services from the state.

From the farmers' perspective the main challenges are:

- Lack of political good will;
- Poor procedures of both public and private institutions;

SUMMARY

Name and District	**Basilio Báez Aguilera, Loreto**
Technician	**Ing. Agr. Aldo Raúl Martínez Valiente**
Farm area	10 ha.
Family members	Wife and 4 children.
Main activities	The farmer produces beans, sweet potato, cassava, groundnut, banana, maize and sesame, as well as *habilla (Phaseolus vulgaris)* and castor bean. Horticultural crops include: tomato, chilli, onion, pumpkin (for home consumption) and min-till watermelon.
Marketing	1500 Premium fruits (8 to 12 kg average per fruit) per ha, selling at 6000 Gs each and generating a profit of around 9 million Gs. He also sold about 500 second grade fruits at 3000 Gs each and received 1.5 million Gs.
Economy	The sale of watermelon at the beginning of October generated a good farm income, bearing in mind that at this time there is no other saleable produce. With the money earned, the farmer could prepare his fields, buy seed to sow sesame and could pay back the debts to CAH. Also with the sale of GM seed, the family received an additional benefit as this was considered an extra income compared with the marketing of traditional cash crops.
Main impacts	The main impacts observed by the farmer is implementing GM (pigeon pea) in his farm via the PMRN, less manual labour for weeding and weeds are fewer, selling seeds of the GMs which generates an income at a time when there are no other sales, and their multiple uses for human and animal feed. Additionally the members of the committee are better organized and have greater opportunities.

Basilio Báez with his plot of watermelon associated with maize on an oat cover crop.

- Absence of adequate rural development policies;
- Lack of confidence between members of farmer organizations;
- Migration.[3]

[3] Results of a workshop on leadership and organization within a meeting of farmers of the PMRN in Caazapá, 2010

In the light of these worries, both the authorities and local leaders have recognized the need to revisit the traditional system of management of development by proposing the interaction of private and public sectors.

According to a study made by Fabio Nizz: "… it is noticeable that there is a lack of a general framework for the rural sector and objectives or goals for the country in the short, medium and long terms. It is here that the progress of projects becomes erratic because when they end nobody knows what actions to take in the affected communities, or for what additional time. The sustainability of a project cannot be viewed as isolated or self-sufficient. In addition to the central institutions there are also local and regional entities. What is needed is not only to abandon help for counter productive practices, but positively support the practices promoted by the PMRN."

The district and departmental coordination groups, promoted by PMRN and the Good Governance and De-centralization Programme (PBG) of the GIZ play a preponderant role in territorial development. They have involved local authorities in their clear objectives aimed at mitigating negative effects on soils and forests and in so doing releasing the potential to alleviate the present situation in the countryside.

In this sense, the strengthening of dialogue, coordination, consensus, planning, articulation of implemented activities, follow up, monitoring, control and evaluations are fundamental components to achieve success with the community initiatives. The Integrated Management System for Rural Agrarian Development (SIGEST) was created by executive power decree of the MAG to "*ensure the coherence of contents, the organic and effective implementation of the Sectorial Policies of Rural and Agricultural Development*". It is premature to evaluate the impact of SIGEST, but it is certainly a very positive initiative to overcome the lack of coherence of state policies at local level[4].

The PMRN had a utopian vision that the impact of such easy and simple practices, which at the same time as helping to conserve and rehabilitate natural resources, also helped to improve yields, would impact so positively on professionalized farmers to stabilize family incomes and assure the wellbeing of future generations.

Nevertheless, we would be disingenuous if we believed that the positive impacts on the rural population would be achieved only through the conservation and recuperation of soils and natural resources and with yield increases. In this sense it must be understood that strengthening product marketing chains constitutes a fundamental step for the consolidation of the expended effort.

So that to the extent that there is security in markets, research, extension, credit and marketing of the diverse enterprises present in the territory, added

[4] See: Gerencia de desarrollo territorial rural (management of rural development), Georg Birbaumer, 2009

to a solid, agreed and consolidated system, successful, results can be obtained from this type of project.

Research

The practices introduced were new and during their implementation it was necessary to adapt and adjust them. The principal client, the farmer, was who mostly invented, improved, adapted and adopted the technologies and it was the technicians who learnt from them. Also, the promotion of an excellent technology without its subsequent adoption by the farmers is not to be recommended.

To evaluate, document and improve the practices research units were used. Above all there was close cooperation with Ing. Miguel Florentín of the Choré experimental station of the Agrarian Research Directorate (DIA), today the Paraguayan Institute of Agricultural technology (IPTA), and with the Faculty of Agrarian Science of the UNA. Dissertations, theses, research, visits, exchanges, training in forestry and agriculture have all taken place on a grand scale which unfortunately cannot be presented in this book due to the large volume of accumulated information. The most outstanding results appear in the corresponding chapters. Also different trials were carried out, without scientific rigour, in the fields of the farmers with help from technicians. Nevertheless the results of these trials performed a fundamental role in the process of learning and adoption of practices transferred to the farmers.

Case Study 8: Comparison of bean yields, Luis Cantero, Yby Yau

Beans constitute the principal winter cash crop in Concepción Department for rural families whose yields in the conventional system were reduced with each cropping cycle.

The farm where demonstration plots were installed has 10 ha with 40 years of production under the traditional system. It has 3.5 ha managed with 4 species of GM in NT and 2 ha of 2-year old reforestation. It receives technical assistance from **PMRN**.

To improve bean production, the farmer together with technical assistance, had a trial which compared different treatments:

T1: Beans with 3-year mucuna cover, without fertilizer.
T2: Beans under the conventional system with fertilizer.
T3: Beans under the conventional system without fertilizer.

The bean plots were installed under the same conditions; the treatments are side by side separated by paths. They were sown on 25 May using 60 kg seed/ha with a distance of 60 cm between rows and 20 cm between plants, with 3 seeds per station. Treatment T2 was fertilized with 150 kg/ha of compound fertilizer, 10-20-10 at 30 days after germination. In plot T1 glyphosate was applied before sowing, without manual weeding. Plots T2 and T3 each received one weeding.

Bean crop on a third year mucuna cover, without fertilizer, at maturity.

Conventional bean crop with fertilizer.

Conventional bean crop without fertilizer (in the background) with samples from T1, T2 and T3 (left to right).

RESULTS

Treatment	Average height of plants, cm	Yield, kg/ha
T1, mucuna, without fertilizer	50	1400
T2 conventional with fertilizer	40	1200
T3 conventional without fertilizer	20	700

T1, T2 and T3 height development (10 plants per sample at random) from left to right.

With this trial on Luis Cantero's farm it was possible to see that the plot with beans on 3-year mucuna cover had the best yield and plant development compared with conventional plots with and without fertilizer.

"The yields of the crops increased progressively with the use of GMs on the farm" – Agronomist José Jiménez, Coordinator

CHAPTER 3

Conservation Agriculture

This chapter describes the principles of Conservation Agriculture (CA) and the advantages of its application in the framework of the Project.

The inadequate use of diverse exploited regions has contributed to a considerable decline in soil fertility leading to a situation of reduced crop productivity because of the degradation process of organic matter which causes the loss of some physical and biological soil properties, accelerated erosion and a reduced crop potential. In conventional systems, the temperature of the soil surface can rise to 60C[5] with a loss of 20 to 60 ton/ha/year of organic matter. CA aims to reverse the degradation process with a few basic principles:

- No ploughing the soil, using minimum soil disturbance;
- No burning on the farm;
- Always leaving cover on the soil;
- Using GMs;
- Rotation of crops;
- Direct planting (NT-no-till).

These principles should be applied permanently on the farm of whatever size, organic or not, large or small with whatever climate and with whatever crop. The principles of CA are being applied around the world on some 105 million hectares, with the greatest participation in the US, Canada, Latin America and Australia. With regard to the percentage of agricultural land under CA, Paraguay is the world champion with 95 percent of farmland under CA with some 40 000 smallholder farmers and 1000 mechanized farmers, the majority producing soya, wheat and maize.

The advantages of NT are:

- Less manual labour;
- Long term productivity increase;
- Reduction of erosion;
- More constant soil temperature;
- Better moisture retention;
- Increase in water infiltration into the soil;
- Reduction of soil compaction;
- Improvement in soil structure;
- Carbon sequestration and lower CO_2 emissions to the atmosphere.

[5] GIZ/MAG/2001. Abonos Verdes y rotación de cultivos en SD (Green manures and crop rotations in NT).

So it can be seen that CA is an ideal tool for climate change adaptation and contributes to mitigating impact of the greenhouse effect.

3.1 GREEN MANURES

It is possible to practise CA without GMs; nevertheless the addition of organic matter to tropical soils is a fundamental requirement to maintain soil fertility. It is estimated that, under the climatic and edaphic conditions of Paraguay there is a need to add 8 to 10 tonnes/ha/year of dry matter to the soil (CA Congress in Foz de Iguazú, 2010).

GMs supply nitrogen, reduce erosion, maintain soil temperature and humidity, reduce weed incidence and reduce diseases with the rotation. For the smallholder farmer the use of GMs is indispensable to achieve a sustainable agriculture with stable yields and no degradation.

With the package defined by the PMRN and the annual sowing of GMs, this objective can be achieved (See 1.1). Several trials have shown that the use of GMs is the most important factor in improving production.

TABLE 3.1

Maize production (kg/ha) as a function of tillage systems and fertilization with 60-40-40 kg/ha NPK, Choré Experimental Station

Management system	Agricultural cycles						Mean
	96/97	98/99	00/01	02/03	04/05	06/07	
	Without fertilizer						
1. NT on fallow	3377 b	3379 b	2151 bc	2317 b	2649 b	2775 a	**2776 c**
2.Minimum tillage on fallow	3328 b	2761 c	1974 c	2107 b	2347 b	2016 b	**2464 c**
3.Convention tillage with plough	3225 b	3600 b	2367 b	2345 b	2542 b	2141 b	**2703 c**
4. NT with GM	3789 b	3721 ab	3506 a	3485 a	3522 a	2731 ab	**3459 b**
5. Minimum tillage with GM	4731 a	4238 a	4587 a	4183 a	3702 a	2963 a	**4067 a**
Mean	**3693 B**	**3540 B**	**2917 B**	**2887 B**	**2952 B**	**2575 B**	**3094 B**
	With fertilizer						
1. NT on fallow	4904 b	4979 b	3165 bc	4518 b	4576 ab	3778 a	**4319 bc**
2. Minimum tillage on fallow	4773 b	4766 c	3092 c	4260 b	4118 b	3180 b	**4031 c**
3.Conventional tillage with plough	4508 b	4804 b	3635 b	4377 b	4229 ab	3450 b	**4083 c**
4. NT with GM	5079 b	5153 ab	5043 a	4869 a	4568 ab	3473 ab	**4602 ab**
5.Minimum tillage with GM	5468 a	5274 a	5064 a	4722 a	4658 a	3861 a	**4845 a**
Mean	**4881 A**	**4994 A**	**3951 A**	**4452 A**	**4430 A**	**3548 A**	**4376 A**

Source: Experimental Station, Miguel Florentín, 2008. Differences significant at 5% are indicated by different letters.

The yearly means verify that with maize production in agricultural systems without fertilizer, treatments with minimum tillage plus GM (treatment 5) and NT plus GM (treatment 4) were significantly better than the conventional system with ploughing and the minimum till and NT on fallow.

The most dramatic effect for farmers is the reduction in weed infestation under the GM cover crops and the humidity that is maintained under them. With mucuna and *Crotalaria juncea*, weed infestations were reduced by 95 and 93 percent respectively compared with the controls without GM (Choré Experimental Station, Florentin, M. 1997).

Case Study 9: Eliminating southern sandbur from the farm, pineapple grower Zacarías Lezcano, San Estanislao

Zacarías Lezcano is a farmer in San Estanislao District and has a 10 ha lot in joint family ownership. Five years ago the farm was infested with southern sandbur grass (*Cenchrus echinatus* L.) a weed which then seemed impossible to eliminate. Use of the plough and frequent burning favoured the multiplication of the weed without the farmer realizing. With highly degraded soils and low yields, he decided in 2005 to start a process of recuperation of the soils with the help of technicians from the PMRN. At that time he sowed 1 ha of maize with inorganic fertilizers and inter-row pigeon pea. That same year Zacarías acquired seeds of mucuna and installed a 0.5 ha nursery.

In the second year he had a satisfactory maize yield increase to 2500 kg/ha and he also saw that under the 2m high pigeon pea shade, the weed had practically disappeared. The preoccupation over what do with the pigeon pea stover, which in traditional agriculture is burnt, was transformed to optimism when he observed that the residues decomposed rapidly to organic matter and changed the colour of the soil.

Satisfied by the observed results, and on his own, he decided to use his own seed to sow pigeon pea in another plot between the rows of pineapple in association, and obtained excellent results. The half shade produced by the pigeon pea protected the pineapples from frost and reduced the labour required for weeding. The soil improved through the accumulation of stover and the cover of leaves and branches resulting from the pruning that he did twice a year. Fully convinced of this newly implemented system he incorporated the use of GMs of different species, associating them with other crops such as cassava and his home-consumption crops. He also decided to stop burning and using implements such as the plough, ridger and cultivator.

Five years later the landscape of the farm was notably different, the soils were more fertile with greater organic matter contents, southern sandbur had disappeared giving way to broad-leaved weeds, 100 percent of the area was sown with NT and yields had improved. In the case of pineapple, previously the harvest comprised 30 percent first quality fruits (9 fruits per box) and 70 percent second category (12-14 fruits per box). Now 60 percent of the crop is first quality and 40 percent second, at the same time labour use has declined from 30 to 10 labour-days. Today the farmer is using canavalia associated with cassava, mucuna with maize. He uses black oat and lupin in the winter, oats with banana, beans between citrus trees and pigeon pea, crotalaria and

Dolichos lablab between pineapple rows. He also sowed crotalaria between rows of pineapple giving very positive results.

With the increase in production the farmer was able to access his first formal credit through a local financial institution and has reduced his use of labour. "*Now I don't have to prepare food for the day labourers*", his wife tells us, "*all the labour is provided by our family.*"

Zacarías and his family now devote themselves to working on their own farm and do not have to work off-farm to improve income, given that they earn more than the minimum wage and so achieve a more dignified life.

Name and District	**Zacarías Lezcano, San Estanislao**
Technician	**Isabelino Portillo**
Area of the farm	10 ha.
Family members	Wife, 6 children and mother-in-law.
Main activities	Main enterprises: pineapple, cassava, sweet corn in 6 ha with CA. There is also 1 ha of natural forest which is being regenerated. There are vegetables and fruits, kitchen plot, citrus, ackee and others. 1 milk cow and lesser breeds (hens, dicks, pigs). For animal feed there is forage and pasture: *Brachiaria brizantha* and zero-feed pasture such as Cameron and sugarcane. The farm has *yerba mate* and *esencia de petit grain (Citrus aurantium).*
Marketing	Pineapple and corn cobs are marketed through local wholesalers and the cassava directly to consumers in the city of San Estanislao.
Economy	From the sale of produce, it is estimated that the annual income is: Pineapple: 5 million Gs. Cassava: 3 million Gs. *Esencia de petit grain:* 0.8 million Gs. Corn cobs: 4 million Gs. Citrus: 0.4 million Gs. *Yerba:* 0.5 million Gs. Cassava is often marketed in the local community as the farm has an animal-drawn cart in which 300-5000 kg are delivered each week at an average price of 700 Gs/kg.
Main impacts	Reduction of labour requirement in the pineapple crop, the use of GMs to eliminate weeds, more income without the need to hire day-labourers.

Zacarías Lezcano's son in a pineapple plot managed with pigeon pea.

Zacarías Lezcano preparing his pineapple crop for the market

TABLE 3.2
GM species evaluated by farmers in their nurseries

Common name	Scientific name	No of plots	Dry matter* kg/ha	Added Nitrogen* kg/ha	Germination	Cover
Rye grass	*Lolium multiflorum*	3	3-5000	400	Good to very good	Good
Forage oat	*Pisum sativum*	5	2-5000	40-100	Good	Good to OK
White oat	*Avena sativa*	1	3500-4500	150-200	Very good	Good
Black oat	*Avena strigosa*	5	3680	48	Very good to good	Good to very good
Calopo	*Calopogonium mucunoides*	1	4-5000	70-180	Good	Good
Canavalia	*Canavalia ensiformis*	10	7703	246	Very good to good	Good to very good
Safflower	*Carthamus tinctorius*	2	2-5000	90	Good	Good
Sunnhemp	*Crotalaria juncea*	90	7-8000	150	Without problem	Very good. some OK
Rye	*Secale cereale*	1	3500-4000	100	Very good	Good
Rattlebox	*Crotalaria espectabilis*	3	10 500-12 000	100-120	Without problem	Good
Dolichos	*Dolichos lablab*	12	4-6000	490	Good to very good	Good to very good
Stylo	*Stylosanthes* spp.	6	2500-4500	30	Very good to OK	Very good to OK
Corn Spurrey	*Spergula arvensis*	2	2-3000	10-20	Very good to OK	Good
Pigeon pea	*Cajanus cajan*	11	9153	240	Good to very good	Good to very good
Blue lupin	*Lupinus polyphyllus*	2	18 000	180	No germination to very good	Good to poor
White lupin	*Lupinus albus*	5	4012	75	Very good to good	OK to good

Source: Own data, 2010.
*Dry matter and N addition based on literature: IAPAR, 1995: Legumes for summer green manures in Paraná; & MAG/GIZ crop rotations in NT.

Table 3.2 (Cont.)

Height, cm	Seed production	Pests	Association	Apt for smallholders	Observations
50-60				No	Affected by climate.
15-60	Regular			With limitations	Without results. Most of the plots observed had little germination or cover. Needs fertile soil.
40-50				Good	Good weed control.
45-60	Good	Infestation		Good	Good germination and weed control. Affected by rain and hail.
Prostrate	Good			Very good	Good germination and weed control. Good seed production, easy to harvest.
40-60	Good	nematodes, beetles, lepidoptera		OK	Good germination, weed control and seed production. Easy to harvest, many pest problems.
100-200				No	Without results.
100-600	Excellent	Fungus in some cases	Millet, maize, pineapple, passion fruit, cassava	excellent	Seed very apt for smallholder. Good organic matter production also in the dry season. Reduces nematodes. Very good for tomatoes.
40-50				Good	Good weed control
100-200	Very good	Fungus in some cases loopers		Good	A good option. The advantage is its low height so it doesn't compete much with the crops.
30-80	OK	beetles, Diabrotica	maize	OK	Good weed control, germination and seed production. Rapid growth rate.
70-90	OK		Perennial fruits	OK	Good cover, nevertheless, frost killed the plants before seed production. Difficult to seed producing, but harvest is generally easy.
30	Good	OK		OK	Good cover, but difficult to produce seeds, easier in some cases, harvest is difficult.
110-250	OK			Very good	Good weed control, germination and seed production.
40-50				OK	Good weed control. Difficult to harvest and little germination.
60-80	OK			Very good	Good germination, weed control and seed production. Easy to harvest.

TABLE 3.2
GM species evaluated by farmers in their nurseries *(continued)*

Common name	Scientific name	No of plots	Dry matter* kg/ha	Added Nitrogen* kg/ha	Germination	Cover
Groundnut	*Arachis hypogaea*	7	976-8000	68-206	Good to no germination	Good to bad
Pearl millet	*Pennisteum amercanum*	28	10 000	200	Good to very good	OK to very good
Foxtail millet	*Setaria* spp.	8	7200	20-60	Very good to no germination	Good to OK
Foxtail brittle grass	*Setaria italica*	8	3-5000	400-900	No germination to very good	Good to poor
Mucuna	*Styzolobium* spp.	10	7500	192	Good to very good	Good to very good
Radish	*Raphanus sativus*	4	4771	86	Good	Good
Finger millet	*Eleusine coracana*	1	2-4000	140	Poor	Poor
Bean	*Phaseolus vulgaris*	3	4500	497	Good	Good to OK
Sesbania	*Sesbania* spp.	3	8500-9000	181	Poor	Poor
Sorghum	*Sorghum vulgare*	6	5-20 000	332	Good	Very good to OK
Tephrosia	*Tephrosia vogelii*	2	7-15 000	570	No germination	
Wheat	*Triticum aestivum*	3	10 000	125	No germination	No
Hairy vetch	*Vicia villosa*	14	2942	81	Very good to good	Good

Source: Own data, 2010
*Dry matter and N addition based on literature: IAPAR, 1995: Legumes for summer green manures in Paraná; & MAG/GIZ crop rotations in NT.

Table 3.2 (cont.)

Height, m	Seed production	Pests	Association	Apt for smallholders	Observations
		Leaf cutting ants, red spider mite		With limitations	Very apt for agroforestry systems, yerba mate, fruit trees. Difficult to reproduce. Once established grows well with good cover.
2-3.5	Very good	Birds	crotalaria	Good	Very good biomass production and weed control. Functions well in infertile soils and drought. Problems with birds. Difficult to harvest seeds. Allergic reaction with several farmers.
0.5	30%			OK	Good weed control; difficult to harvest and poor germination.
0.5	OK		cassava	Good	Good control of weeds, good seed production but difficult to harvest.
Good cover	Good			Very good	Good weed control, germination and seed production.
0.5-0.75	OK	Mites		OK	Good weed control average germination and seed production, usually easy to harvest.
0	No			No	A good plot was not achieved.
0.4	Good	Aphids		Good	Good germination and seed production.
0	No			No	A good plot was not achieved.
1.5-2.5	Very good			Very good	Good germination, weed control and seed production; rapid growth, easy to harvest but problems with birds.
				No	
0	No			With limitations	Used widely with large-scale farmers. Not so successful with smallholders.
0.15-0.5	little			OK	Failed to achieve good cover or seed production. Seem s best suited to fertile soils in cooler regions, 50% affected by drought.

To maintain the production of GMs, farmers should manage a plot for seed multiplication of at least 0.25 ha per species and a minimum of 3 species of GM each year. According to 2009 evaluation survey data, 72.2 percent of farmers had seed nurseries, whilst in 2007 there were just 42.6 percent. The majority of farmers keep individual plots for production, but there are also committees who have community nurseries.

The Project promoted the introduction of different GM species to study their behaviour and acceptance by farmers. Table 3.2 is a summary of the different species and their corresponding evaluation, according to their performance.

With the promotion of diverse GMs, it can be seen that today farmers have access to a greater variety of them (See Table 9.8).

It can be confirmed that the GMs cited below are the most recommendable for the smallholder farmer. This can change according to the climatic zone, soil and predisposition to use them by the farmer.

Mucuna ceniza *(Stizolobium niveum)*

Advantages: Very good biomass production, good cover, weed control, good seed production, fixes nitrogen, easy to manage with knife roller, killed by frost without the need to apply herbicides. Apt for all crops as a dead cover.
Disadvantages: If not managed on time (milk stage of seeds) it germinates and then needs much effort to control. As a climber, if it is associated with banana, fruit trees, cassava or others then it need special attention.

Pigeon pea

Advantages: Very good cover, biomass and weed control. Very robust, deep root system, fixes nitrogen, can be used for fuel wood. Can be used as food for humans and animals, good forage production. This GM should be used initially with degraded soils, and be left for two years if possible.
Disadvantages: Management can be difficult if the stems become too woody due to low planting density. In this case it needs much labour.

Canavalia

Advantages: Easy to sow and reproduce seed. Fixes nitrogen. Resists drought, biannual, not a creeper (according to variety), low height. Very appropriate for cassava, pineapple, yerba mate, fruits and others.
Disadvantages: Less cover than other species like mucuna and pigeon pea.

Dolichos lablab

There are three varieties with black, brown and white seeds.
Advantages: Good cover and germination, easy to manage, good seed production, especially in the northern zone (very successful in Concepción). Fixes nitrogen. Biannual. Used as food for humans, resists drought well. Good with maize, pineapple, cassava, banana and citrus.

Disadvantage: Susceptible to diseases. Less cover than mucuna or pigeon pea.

Crotalaria juncea

Advantages: Excellent germination, seed production, seed harvest, biomass, cover and weed control. Drought resistant. Easy to sow by broadcasting. Can be sown late in March after sesame, tobacco, cotton, watermelon, etc. Good for pasture renovation. Half shade for pineapple. Excellent for cleaning the soil after tomato. Ideal for rotation or succession with organic sugarcane. Intercropped with maize or cassava. Good in combination with millet. Reduces and/or controls nematodes.
Disadvantages: Rotate the planting site after two years to avoid diseases.
There is also Crotalaria espectabilis *with a shorter stature and more upright habit.*

Millet

Advantages: Very good cover, wed control and biomass. Resists drought well. Very good in combination with crotalaria.
Disadvantages: Suffers intense bird attack making seed collection difficult.

Black and white oats

Advantages: Winter GMs to be sown after the summer crops. Very good cover and weed control. Ideal for cleaning in rotation. Ideal in combination with forage radish and white lupin. Good between cassava rows. Natural regeneration in the subsequent year.
Disadvantages: Difficult to harvest because of their small seeds. Not appropriate for starting in degraded soil.

Ryegrass

Advantages: A winter GM to be sown after the summer crop. Very good cover and weed control. Ideal for cleaning in rotation. Natural regeneration in the subsequent year.
Disadvantages: Difficult to harvest the seed.

White lupin

Advantages: Very good in combination with oats in winter. Fixes nitrogen. Easy to harvest and sow by jab planter. Can be associated with cassava.
Disadvantages: Susceptible to diseases if grown alone. Do not associate with crops susceptible to nematodes in soils infested with this pest.

Forage radish

Advantages: Very good in combination with oats and lupin in winter. The roots facilitate water harvesting and bio-cultivation.
Disadvantages: Seed harvest is not easy, susceptible to diseases.

Case study 10: Experiences with the NT system in Yby Yaú, Mamerto Quevedo, Yby Yaú

The PMRN started work here in 2005 with all the difficulties implicit in the adoption of a new technology and above all the scarce availability of GM seed in Concepción Department.

The farm has 12 ha with 40 years of using traditional practices. Of these 6 ha are now managed with a conservationist system with 9 species of GM and NT, 1 ha of forest with 2 years of natural regeneration, 0.25 ha of agroforestry, forest nursery, kitchen plot and the rest for cattle, pigs and poultry, sources of food and income for the family. The farm receives technical assistance from the PMRN.

The farmer wanted a rotation to maintain the soil with cover throughout the summer cycle to reduce the risks of pests and diseases.

Sesame was sown over a cover of black oat with a yield of 1040 kg/ha followed by the late sowing of crotalaria associated with millet/sorghum with excellent results, even in conditions of drought.

Maize is the star product of the farm with historical yields of 400 kg/ha under the traditional system and now, especially in this third stage, yields of 2800 kg/ha are registered with NT. It is worth mentioning that in the whole production cycle, drought has been a constant factor, with only one rainfall event in the period.

Mamerto Quevedo in his plot of associated crotalaria and millet

The implementation of forestry practices assures the production of fuel wood, as a product of forest management, and the future production of timber. These results are important in the Department where the forests at farm level are increasingly scarce and oblige the population to seek firewood in distant places at high cost.

Mamerto Quevedo and his family pose by a NT plot

Another of the characteristics of the farm are the GM nurseries with 9 species including pigeon pea, crotalaria, canavalia, mucuna, Dolichos lablab, black oat, forage radish, lupin and millet that assure the sustainability of the system. It also represents a cash crop when seeds are sold to other committees of the region.

"*Previously agricultural work did not pay, now I can see the fruits of my labours and those of my family at the end of each production cycle*", Mr Quevedo tells us, content with the work of his farm.

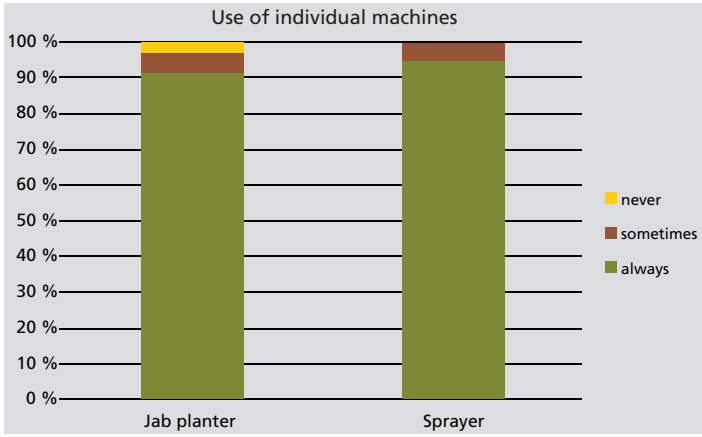
Name and District	**Mamerto Quevedo, Yby Yaú**
Technician	**Agronomist José Gimenez and Forester José Espínola**
Area of the farm	12 ha.
Family members	The farmer his wife and tour children.
Main activities	Maize sesame, beans, cassava, watermelon, tomato and home consumption crops.
Marketing	Maize, sesame, beans, watermelon and tomato.
Economy	Income of 15 million Gs for crop enterprises and 8 million Gs from the sale of pigs, chickens, cheese and starch in the agricultural cycle 2998/9.
Main impacts	Greater income, diversification of production, improved nutrition, less work, availability of firewood for home use.

3.2 USE OF TOOLS AND MACHINERY

The introduction of tools via the Project has contributed enormously to the development of family agriculture. The individual equipment (jab planters, 20 litre sprayers and 600 kg metallic silos) had a good reception from the start. According to farmer surveys conducted in 2010, more than 90 percent of farmers always use their tools.

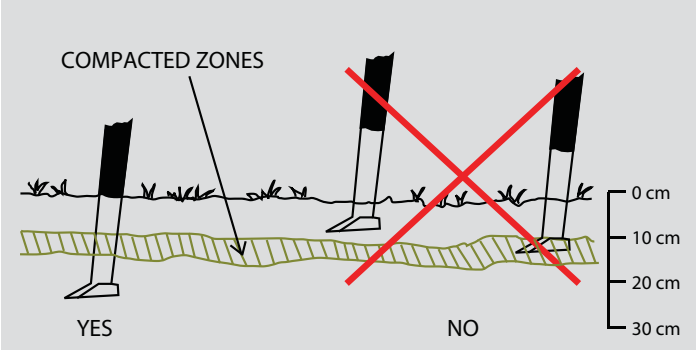
The Project requires the committee to establish an **internal regulation** for the use of group machines and a fund for their maintenance. The majority of committees have this fund, but there are still some problems with the repair of machinery due to the lack of specialized workshops in the work regions.

FIGURE 3.1
Use of individual machines, 2010 survey data



Source: Own data, 2010

FIGURE 3.2
Use of the subsoiler



Source: Carrasco, J. 1998. INIA. La Platina, Chile.

TABLE 3.3
Cotton yields as a function of evaluated tillage systems (kg/ha)

TILLAGE SISTEM	COTTON YIELD, kg/ha					
	Weeding system			MEAN		
	Hoeing	Hoeing + ridging	Herbicide + hand roguing	kg/ha	Duncan 5%	Relative %
1. Plough tillage	1.548	2.033	1.754	1.815	**AB**	**113**
2. Minimum tillage with ripper	1.550	1.729	1.523	1.600	**B**	**100**
3. Minimum tillage with subsoiler	2.095	2.096	2.025	2.072	**A**	**130**
4. NT without green manure	1.034	1.835	1.631	1.800	**AB**	**113**
5. NT with GM	2.186	1.925	1.699	1.937	**A**	**121**
Mean (Duncan 5%)	**1.883 a**	**1.924 a**	**728.728**			

Source: Choré Experimental Station, Miguel Florentín, 2008. Significant differences are indicated by different letters.

With reference to the group-owned equipment, the subsoiler/ripper at first encountered some resistance to its use. Farmers protested that it did not work well, it did not cut, it just was not suitable. After an intense campaign by the Project to promote its diffusion and use, it became a frequently used tool. The subsoiler is now used to de-compact the soil, improving the availability and flow of water and gases; and as a ripper in land preparation, mainly for planting sesame and cassava. It also helps in harvesting water and encouraging root development and plant vigour.

"*Cotton production was significantly improved in the minimum till systems with subsoiler and in the NT system with GM, in comparison to the minimum till treatment with ridger. Yield increases were 30 percent and 21 percent respectively*".

The **knife roller** is indispensable for the management of GMs and is widely accepted. A common practice observed amongst the farmers was the use of the knife roller for weed control. Before sowing the knife roller is passed over the weeds, with or without a subsequent application of herbicide, as a substitute for the traditional practice of burning.

One implement was given for 10 members, that is to say that from 11 members two knife rollers were given to the committee. In Phase 1 only one knife roller was delivered for each 20 members, which proved to be insufficient for a committee with that many members. The absence of more knife rollers in committees with large numbers of members made it difficult to organize their timely use, above all in zones where the farms were widely spaced.

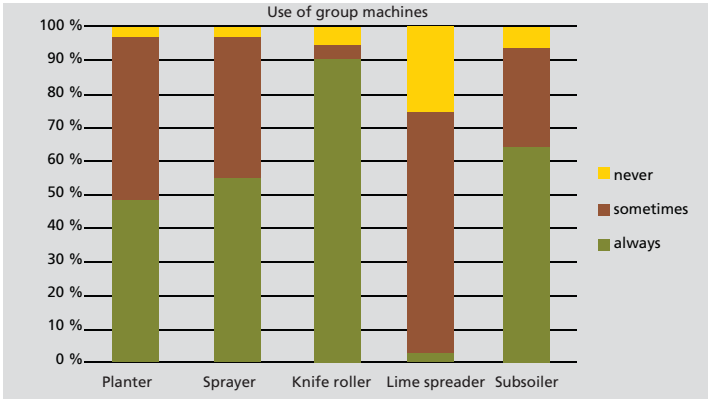
In the second final payments in Phase 1, the acquisition of a two-row draught animal powered (DAP) planter and 20 litre sprayers was stipulated (See 1.1 and 1.2).

According to surveys of farmers and technicians in 2010, in which the use of group owned machines was evaluated, of the 285 committees evaluated it was found that the knife roller and subsoiler were the machines most used, whilst the one or two row planters and the pedestrian or draught animal-pulled sprayers were used less frequently.

Farmers explained that the under use of these group machines was due to:

- The poor state of the fields, presence of stumps;
- The lack of draught animals;
- The topography of the roads and/or the fields;
- The weight of the planter and its difficulty of use;
- The shape and size of the fields which made turning difficult, and the lack of need of the machines;
- They didn't want to use them.

FIGURE 3.3
Acceptance of group machines, 2010 survey



Source: Own data, 2010

Due to the lack of use of these expensive machines, it was decided to give them only to those committees who satisfied a series of requirements, and were qualified as excellent (See 1.2).

With these changes incorporated into Phase 2, there were few organizations who managed to achieve the requirements to gain access to the machines offered as prizes. But in those places where the machines are being used, they are considered by the farmers as being fundamental to speed up the work and increase the area sown, and for the application of phytosanitary agrochemicals in both self sufficiency and cash crop enterprises (maize, beans, soya, etc.). By these means they were able to incorporate crop rotations and the use of GMs, simplify field work and so reduce unnecessary physical effort that the farmers were normally accustomed to expending. The use of two-row planters was notable in those places where smallholder farmers had neighbours who practised mechanized farming, such as Vaquería, Yhú and Repatriación.

Several committees opted to change the two-row planter for two or three one-row planters. Apparently the individual machines, light and with few mechanical complications, are better accepted by the majority of farmers. At the same time there are those committees who asked to change two or three 20-litre sprayers for a 50, 120 or 200 litre animal traction sprayer. The experience of these cases is positive.

The **lime spreader** was used practically only at the start of the Project, in Phase 1, to spread agricultural lime in 1 ha. Later there were very few farmers who gave this machine other uses. Farmers are not used to buying agricultural lime and neither are they willing to pay for it themselves. Consequently the Project decided not to subsidize purchase of the lime spreader. (See 1.2).

In the case of the **silos**, farmers asked to change the group silos of 2000 kg (as established in Phase 1) for individual ones of 600 kg capacity. These are

used by the beneficiaries to store all kinds of grain, both for home consumption and sale, so contributing to food security.

Based on these experiences we can conclude that the machines should be simple, robust, require little maintenance, without complications and, where possible, individually owned. More sophisticated machines, such as the DAP planter and sprayer, are not suitable for all farmers, but rather only those who have demonstrated their ability and interest.

Adaptation of machinery

Over the years improvements have been made to several machines:
To the two-row planter a third wheel was added at the front with the aim of distributing the machine's weight better and make lighter work for both oxen and horses. This modification was mostly found in the San Pedro region where horses are the principal draught animals used.

The attack angle of the subsoiler tine was changed in order to reduce friction and resistance to soil penetration as happened previously with chisel points at right angles. Many farmers have modified their old ploughs, changing mouldboards or wings for chisel points.

The cutting discs of the subsoiler were increased in diameter and made of stronger material so that they cut straw better without a tendency or need to pull it or bury it. It should be noted that the performance of the subsoiler depends very much on soil conditions at the moment of working.

Case Study 11: The process of soil recuperation and use of technology, Eligio Villalba, San Estanislao

Eligio Villalba lives in San Estanislao District. He tells us: "*I remember well one of the first training sessions of the PMRN when a technician said, poor soils, poor families. That day I took the decision to change my soil preparation methods. For some time I had not burnt and incorporated weeds into the soil with a harrow, but even so my yields were low. Lately when I started to use GMs, I noticed changes in many aspects such as the colour of my soils, its structure, the improved water infiltration and less erosion*".

Three years ago Mr Villalba started to use GMs, rotation of crops and permanent soil cover and quickly noticed improvements in maize yields. It was then that he decided to extend these practices to the other fields on his farm. Today he has 50 percent of the farm under GMs of different varieties sown at different times of the year.

Initially Mr Villalba used a ridger (*carancho*) to clean the furrows between crop rows and had little knowledge of the subsoiler. After participating in demonstrations organized by PMRN for committee members, seeing the importance of the tool he took the initiative to use it on his own farm proving that the implement was lighter in work for his animal and that the slot that it left in the soil was sufficient to sow seeds. He also confirmed that it reduced soil compaction when it burst the plough pan (compaction beneath the soil-

surface) permitting maize roots to develop better and reducing crop lodging by the wind. Today he uses the subsoiler to de-compact soils in his fields in the first year of soil recuperation, he understands that the plough is not necessary for sowing crops and for that reason has stopped using it.

When the committee received a two row animal traction planter from the Project, he was able to reduce the time taken to sow maize, reducing from two entire days per hectare to just four hours per hectare. The good soil cover achieved with GMs allowed him to grow crops to harvest with no weeding whilst achieving increases in maize production from 1500 to 4500 kg/ha. This was when the maize enterprise, previously considered only for home consumption, was converted into a cash crop.

The change of production model from traditional agriculture afforded this farmer, and many others, the opportunity to improve his standard of living for him and his family, changing from extractive and subsistence farming to sustainable agriculture which maximizes the use of the farm's resources, and taking on an entrepreneurial vision which allowed him to generate greater income without neglecting the home consumption crops.

Rolling crop residues and weeds after the application of herbicide

No-till maize sowing with a two-row planter

Name and District	**Eligio Villalba, San Estanislao**
Technician	**Aurelio Notario**
Area of the farm	15 ha.
Family members	Father, mother, two brothers with their respective families.
Main activities	Crops and livestock.
Marketing	Sesame, maize and cassava on his own. 2 bull calves.
Economy	Income: Sesame 12 150 000 Gs. (3 ha, yield 900 kg/ha, price 4500 Gs./kg). Maize 7 million Gs. (4 ha., yield 3500 kg/ha, price 500 Gs./kg). Cassava 14.4 million Gs. (3 ha., yield 20 000 kg/ha., price 240 Gs./kg). Cattle 2 million Gs.
Main impacts	Use of technology like the two-row planter, the subsoiler and GMs to economize on hand labour. Achieved better yields and greater income from agriculture.

Quality of machinery and inputs, honesty and corruption

At the beginning, with technical assistance from PRODESAL, the Project had many problems related to the quality of the machinery and inputs. **Providers delivered low quality machines** for the price of high quality ones. Out-of date fertilizers were encountered as well as being adulterated with whatever type of substance, falsified in re-made bags. Agricultural lime which was simply ground rock, out-of-date herbicides, sprayers without nozzles, lances, protectors, and many other things.

It is suspected that both some technicians as well as some farmers were bribed by some supply companies, with the objective of having these products in these conditions accepted, so that quality was sacrificed.

The Project had to take measures and intervened with the suspension of several companies as providers owing to non conformity with the established standards. Now there are several companies who are producing according to the required standards.

In a similar vein, it was proven on more than one occasion that farmers sold their inputs to unscrupulous persons who thereby acquired these inputs at a lower cost and re-sold them to other committees at market prices. There were also cases of companies who falsified NT machinery which has never worked and technicians who have falsified receipts, signatures and deliveries for their personal gain.

There were also farmers and/or committees who withdrew and auto-distributed Project funds destined for the purchase of inputs, without performing the planned work.

In all cases the Project took the decision to intervene, discuss and in some cases denounce to the public prosecutor.

Owing to the number of dishonest situations presented in the course of Project execution, the ameliorating measure was taken of **including coordinators and local supervisors as co-signatories to the committee**

accounts. By these means, and since adopting these measures, the responsible representatives of each committee and each account could not withdraw cash to pay suppliers without previous control by the coordinator and/or the supervisor of the Project.

It should be pointed out that the support necessary from the authorities was not always forthcoming to clarify and solve these sorts of problems.

3.3 AGRICULTURAL LIME

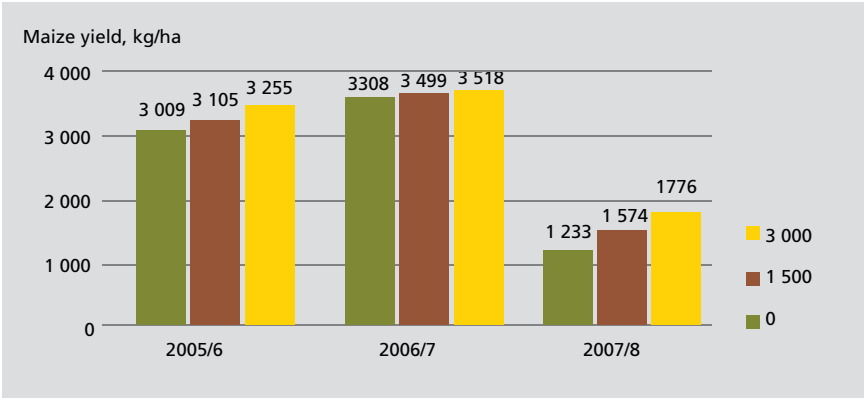
There are three classes of lime: calcitic, magnesian and dolomitic of which only the first has a high calcium content in its composition and almost no magnesium. The second, apart from calcium also contains magnesium (5-12 percent MgO); and the third contains calcium and magnesium (>12 percent MgO). Agricultural lime is a powder which can be of different grain sizes on which precisely depends its total relative neutralizing power (TRNP). The finer the powder grains the higher the TRNP.

Within the technology packet promoted by the Project, specifically for degraded soils, the application of agricultural lime was established as one of the first measures for their recuperation with the aim of correcting soil acidity. An acid soil generally has a low content of calcium and magnesium, (low pH) and high aluminium which is toxic for most plants. Lime application neutralizes the negative effects of the aluminium and magnesium and increases the availability of phosphorous and micro nutrients. Lime is also a nutritive element and permits the multiplication of beneficial micro-organisms which accelerate the decomposition of organic matter.

Although no soil analysis was carried out on the plots where lime was applied, the recommendation was for 1500 kg/ha, based on results obtained by similar work during a pilot project in Paraguarí Department. This application was divided into two stages, the first in the first year when 1000 kg/ha were applied, and the second in the following year when 500 kg/ha were applied. This task was facilitated by the employment of an animal traction lime spreader provided by the Project.

With the passage of time it was decided to apply the 1500 kg/ha in one go. This was determined by the interest of the farmers who wanted to apply the lime in one application because of fluctuation in both price and availability. On the other hand, the field results demonstrated that in very poor and acid soils the split application did not have a determining impact, compared with application of the whole amount in one dose which optimised fertilizer use efficiency.

FIGURE 3.4
Maize yield in relation to the amount of lime applied (0, 1500 and 3000 kg/ha)



According to trial results from Choré Experimental Station: "*The use of agricultural lime, independent of the application rate, did not affect maize production in the first years following its application*".

Other studies show that the use of agricultural lime does not have a differential effect on sesame yields in the three years of duration of the experiment (Table 3.4).

TABLE 3.4
Sesame yields according to agricultural lime application rate (kg/ha)

Lime application, kg/ha	SESAME YIELD								
	Year 1 (2005/6)		Year 2 (2006/7)		Year 3 (2007/0)		Mean		
	kg/ha	Duncan 5%	kg/ha	Duncan 5%	kg/ha	Duncan 5%	kg/ha	Duncan 5%	Relative %
0	**824**	A	889	A	1170	A	961	A	100
1000	**781**	A	930	A	1154	A	955	A	99

Source: Choré Experimental Station, 2008

After the evaluation of these experiences, and following several debates and technical discussions, it was decided to eliminate the agricultural lime and the lime spreader from the technology package for the degraded soil measures. The main reasons for this decision were: 1) the high cost of the product which increased year after year; 2) it was not feasible to generalize applications in fields of medium to high fertility, given the results of the trials cited above; and 3) there was no defined use for the applicator after lime spreading.

For the smallholder farmers the incorporation of organic matter is considered to be of greater importance than lime application. Furthermore, it is within his reach and has a positive impact in the short, medium and

long terms. In all the trials undertaken, the GMs had a positive effect on the development of crops. Independently from this decision, the possibility was considered of seeking to buy agricultural lime and the spreader for those regions where there were biological indicators of acid soils (indicator plants such as *Andropogon* spp., *Baccharis isabelae*, *Psidium* spp., and others).

Lastly it is worth mentioning that agricultural lime is, and will continue to be, the most useful product for correcting soil acidity, and there are regions where its use is a necessity. However in many cases for the practicalities of the Project which works with a large number of farmers with farms having a wide range of soils and, above all, uses of the soil, the scaling out of lime application is not to be recommended given the variable responses to be expected.

3.4 CROP ROTATIONS

The lack of crop rotations is one of the main problems in the field, as much for smallholders as larger scale farmers. Usually farmers sow year after year the crop that gives them the highest returns, or that they have more technical knowledge about, and the crop is sown each year in the same plot. As a consequence there is a disease build up in the soil, resulting in attacks by pests and diseases of the crop and a rapid reduction in soil fertility.

Independently from the crop cultivated, crop rotation is an indispensable requirement for the sustainability of the fields and of the farm. An alternation or association of grasses and legumes should be considered as a possibility.

Rotation comprises a planned alternation of different crops to obtain and maintain the diversification of the system, break the cycles of weed, pests and diseases, reduce climatic and market risks and to exploit, to the best extent possible, the soil and water resources. This is achieved through the differential capacity of different plants to explore the soil and improve its physical and chemical properties and by so doing establishing an improved water balance for the crops. It is of the utmost importance not to confuse rotation with crop succession, they are not the same thing and the latter is a practice often promoted by agricultural technicians.

The crop rotation established in the PMRN packet is based on maize production, and crops considered to be cash crops by the farmer, associated with summer and winter GMs. The rotation should be adjusted to take into account factors such as: the main crop, season, availability of GM seeds, implements and the predisposition of the farmer. The following are some examples of rotations.

TABLE 3.5
Crop rotation options

Option 1: Sesame, cassava				
Year	**Spring**	**Summer**	**Autumn**	**Winter**
1	Sesame	Sesame/*Crotalaria juncea*[*]	Black oat	Black oat
2	Cassava	Cassava	Cassava/forage radish	Cassava/radish
3	Sesame	Sesame	Forage pea	Forage pea

[*]The *Crotalaria* is sown immediately after the sesame harvest.

Option 2: Sesame, maize				
Year	**Spring**	**Summer**	**Autumn**	**Winter**
1	-	-	GM mixture (oat, lupin and radish)	GM mixture (oat, lupin and radish)
2	Sesame	Sesame – canavalia**	Canavalia	Maize
3	Maize/mucuna	Maize/mucuna	Mucuna	Mucuna
4	Sesame	Sesame/dwarf mucuna	Dwarf mucuna	Dwarf mucuna

**When canavalia is sown in association with the sesame crop it should be sown 30 to 40 days after sowing the sesame.

Option 3: Sesame, cassava				
Year	**Spring**	**Summer**	**Autumn**	**Winter**
1	Sesame	Sesame	GM mixture (oat, lupin and radish)	GM mixture (oat, lupin and radish)
2	Maize/pigeon pea or mucuna	Maize/pigeon pea or mucuna	Pigeon pea or mucuna	Pigeon pea or mucuna
3	Cassava	Cassava/canavalia	Cassava/canavalia	Cassava

Option 4: Sesame, maize				
Year	**Spring**	**Summer**	**Autumn**	**Winter**
1	-	-	GM mixture (oat, lupin and radish)	GM mixture (oat, lupin and radish)
2	Sesame	Sesame Sesame/ crotalaria	Crotalaria	Maize
3	Maize/mucuna	Maize mucuna	Mucuna/ GM mixture (oat, lupin and radish)	GM mixture (oat, lupin and radish)
4	Sesame	Sesame	Short cycle maize	Short cycle maize/ pea

Option 5 Cotton				
Year	**Spring**	**Summer**	**Autumn**	**Winter**
1	Maize	Maize/pigeon pea or mucuna	Pigeon pea or mucuna	Pigeon pea or mucuna
2	Pigeon pea or mucuna	Cotton	Oat/lupin/radish	Oat/lupin/radish
3	Cassava	Cassava/Canavalia	Cassava/Canavalia	Oat/lupin/radish
4	Oat/lupin/radish	Cotton	Crotalaria	Crotalaria

Option 6: Soya				
Year	**Spring**	**Summer**	**Autumn**	**Winter**
1		Maize/pigeon pea or mucuna	Pigeon pea or mucuna	Pigeon pea or mucuna
2	Pigeon pea or mucuna	Maize	Late soya	Oat/lupin/radish
3	Oat/lupin/radish	Maize	Crotalaria	Wheat
4	Wheat	Soya	Oat/lupin/radish	Oat/lupin/radish

TABLE 3.6
Proposed crop rotation for a smallholder soya producer with 10 ha of agricultural land

Area, ha	Year 1		Year 2		Year 3		Year 4	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
4	Soya.	Oat, lupin (2 ha) Oat, radish (2 ha)	Cotton (2 ha) Maize (2 ha) 2nd crop maize	Oat, radish, Oat, Lupin	Maize (2 ha) 2nd crop maize Cotton (2 ha)	Oat, Lupin (1 ha) Oat (3ha)	Cassava (1 ha) Groundnut, bean (1 ha) Soya (2 ha.)	Ryegrass (4 ha)
4	Cotton (2 ha) Maize (2 ha) 2nd crop maize	Oat (4 ha)	Soya (4 ha)	Oat, Lupin (1 ha) Oat (3 ha)	Cassava (1 ha) Groundnut, Bean (1 ha) Soya (2 ha)	Oat (2 ha) Oat, Lupin (2 ha)	Soya (2 ha) Cotton (2 ha)	Ryegrass (2 ha) Oat, Radish (2 ha)
2	Cassava (1 ha) Groundnut, Bean (1 ha)	Oat, Oat, Lupin	Groundnut, Bean (1 ha) Cassava (1ha)	Oat (2 ha)	Soya (2 ha)	Oat, Radish (2 ha)	Maize (2 ha) 2nd crop maize	Oat, Lupin (2 ha)

Source: Own data, 2010

Case Study 12: Cassava yields in traditional and NT systems, Cecilio Fiore, Choré

Cecilio Fiore belongs to the Ka Aguy Poty committee in 15 August community, Choré District, San Pedro Department. He started to introduce measures for managing fertile soil with the project in 2006. He has 7.5 ha of land with 25 years of management with the plough and cultivator.

With the help of the Project's technical assistance he started to plant maize and mucuna in the first year on 2 ha. One hectare had the complete packet offered by the PMRN which included the use of chemical fertilizers. The development of the maize associated with mucuna was impressive. The mucuna achieved excellent cover and the maize harvest was a clear signal of improvement for the farmer. From 1500 kg/ha he achieved 3500 kg/ha. The plot was rolled in May and 15 days later cassava was planted at a high density.

The farmer decided to plant cassava with NT on the cover of mucuna and another plot with the conventional system, without the mucuna cover. At that time he had:

- 1 ha of NT cassava on mucuna cover with fertilizer;
- 1 ha of cassava on mucuna cover without fertilizer;
- 1 ha of cassava without cover and without fertilizer in the traditional system.

The optimum yield of cassava varies between 10 000 and 12 000 kg/ha in the region. Planting in the three cases took place on 22 June 2007 at a density of 1m x 60 cm giving 16 600 plants/ha. The variety used was *Tacuara Sa yju* and the time to harvest was 11 months. The price per kg was 300 Gs.

1. COSTS, Gs/ha

	Conventional	Mucuna with fertilizer	Mucuna without fertilizer
Cutting and seed storage	140 000	140 000	140 000
SOIL PREPARATION			
Rolling	0	85 000	85 000
Glyphosate + labour	0	100 000	100 000
Weeding	210 000	0	0
Ploughing	140 000	0	0
Harrowing	140 000	0	0
PLANTING			
Furrow opening	70 000	105 000	105 000
Seed cutting	70 000	70 000	70 000
Planting and covering stakes	210 000	210 000	210 000
Fertilizer 200 kg of 10.20.20	0	960 000	0
Urea100 kg.	0	550 000	0
Labour	0	60 000	0
GM	0	315 000	315 000
Ridging	140 000	0	0
Weed control	630 000	70 000	105 000
Harvest	350 000	210 000	210 000
Total costs	**2 100 000**	**2 875 000**	**1 340 000**

2. YIELD

Variable	Conventional	Mucuna with fertilizer	Mucuna without fertilizer
Weight of whole root, kg/ha	13 330	36 400	25 930
Height, m	1.8	2.22	2.1
Commercial root, kg/ha	11 660	31 220	18 670
Non-commercial root, kg/ha	1670	5180	7260

3. ECONOMIC ANALYSIS (per ha)

	Conventional	Mucuna with fertilizer	Mucuna without fertilizer
TOTAL COST, Gs	2 100 000	2 875 000	1 340 000
GROSS INCOME, Gs	3 832 000	10 402 000	7 053 000
NET INCOME, Gs	1 732 000	7 527 000	5 713 000

Calculated on the basis of 300 Gs per kg.

SUMMARY

Name and District	**Cecilio Fiore, Choré**
Technicians	**Agronomist Manuel Galeano, Elvio Garcete**
Area of the farm	7.5 ha.
Family members	Wife, 1 son, 2 daughters and 2 granddaughters.
Main activities	Maize, sesame, cassava. Forest: 1 ha of giant *paraíso* (*Melia* spp.) in an agroforestry system and 1 ha of manage forest - natural regeneration. Vegetables and fruits of different species. Animal production: small breeds such as: hens and pigs. Draught animals; 2 horses. Forage, pasture: has a plot for cut grass, sweet cane and Cameroon grass.
Marketing	Cassava and sesame.
Economy	The farmer's gross annual income was approximately 20 million Gs. Annual costs were 6 million Gs, giving a net annual income of 14 million Gs.
Main impacts	For production, before the start of the PMRN it was around 9 million Gs per year, since the technical assistance of the Project this has risen to 20 million Gs per year with much less work.

3.5 ORGANIC PRODUCTION

Agriculture in general and NT are strongly linked to the supposed indiscriminate use of herbicides and other agro-chemicals. During the execution of this Project, several committees were helped who are dedicated to producing organically grown crops. This obliged the Project to seek valid alternatives to satisfy the demand for permitted inputs and appropriate practices that are compliant with the demands of international and local certifying agencies.

This need was a priority in the regions of San Pedro and Caaguazú. In San Pedro, farmers of Guayayví work with the Arasy organic company with crops such as sesame, black beans and lately with cedron (*Simaba cedron*). In the District of San José de los Arroyos, farmers work with the Paraguayan Sugar Company (AZPA S.A.) with organic sugarcane.

Over time it has been shown that organic agriculture can be practised under NT when the following points are borne in mind: 1) Understand the adequate management of crop rotations; 2) Know how to associate cash crops with GMs; and 3) Practise the gradual suppression of weeds (avoiding the production of viable seeds).

Another important aspect of organic agriculture with NT is, above all to understand the qualities of GMs with respect to their:

- Capacity to delay the germination of, or suppress, weeds.
- Appropriate date and method of establishment.
- Density of population of the GMs to control the development of weeds.
- The opportune time and management of the GMs.

The farmers needs knowledge, ability and, fundamentally, courage, to produce organically on their farms under NT.

Some of the modifications needed included changing chemical fertilizer for organic products such as animal manures, especially that of turkeys which was sold through input distribution companies. Others, such as from cows or chickens had less commercial distribution due to the difficulties in acquiring sufficient quantities as recommended by the companies giving advice to the farmers. Another product used was earthworm humus which was produced by the farmers themselves, but it was required in large quantities and the production costs were very high. Also excluded was the use of systemic herbicides, specifically glyphosate.

For those farmers who did not use wide-spectrum or specific herbicides, the alternatives for on-farm management were; manual weeding and the use of the knife roller to crush and dry the GMs. The lime spreader was sometimes used for the distribution of animal manure.

Trials in Choré Experimental Station showed that maize yields were significantly increased with the application of organic manures, independently of the type and dose rates used. At low application rates 5000 kg/ha of animal manure; 5000 kg/ha of essential crop residues; 500 kg/ha of Ferticel; and 65-40-40 kg/ha NPK. The medium dose rate was 10 000 kg/ha of the first two, 1000 kg/ha Ferticel and 65-40-40 NPK kg/ha plus 1000 kg/ha Ferticel.

TABLE 3.7
Effect on maize yields of using natural organic manures to recuperate degraded soils

MANURE SOURCE	MAIZE YIELD								
	MANURE APPLICATION						MEAN		
	0 kg/ha		Low		Medium				
	kg/ha	Relative %	kg/ha	Relative %	kg/ha	Relative %	kg/ha	Duncan 5%	Relative increase %
1. Cattle manure	4002	100	4728	118	5159	129	4630	a	124
2. Essential oil crop residues	4002	100	4537	113	4995	125	4511	a	119
3. Ferticel	4002	100	4361	110	4462	111	4275	b	111
4. Chemical fertilizer	4002	100	4698	117	4510	113	4403	ab	115
Mean	**4002**	**100**	**4581**	**114**	**4782**	**119**			
Duncan 5%	**b**		**a**		**a**				

Source: Choré Experimental Station, Miguel Florentín, 2008

TABLE 3.8
Effect on maize yields of using natural phosphates to recuperate degraded soils (kg/ha)

MANURE SOURCE	MAIZE YIELD			
	Doe rate of natural phosphate			
	0 kg/ha		50 kg/ha P_2O_5	
	kg/ha	Relative %	kg/ha	Relative %
1. Cattle manure	4525	100	4734	105
2. Essential oil crop residues	4468	100	4554	104
3. Ferticel	4279	100	4270	100
4. Chemical fertilizer + Ferticel	4398	100	4409	100
MEAN	**4418**	**100**	**4492**	**102**
Duncan 5%	**a**		**a**	

Lowercase letters in rows are statistically the same according to Duncan's test at 5%
Source: Choré Experimental Station, Miguel Florentín, 2008

There was no significant response of maize yield to the use of natural phosphate under the conditions of the experiment.

In total there are 20 committees who asked for management measures for organic soils. Some of the advantages or benefits of organic measures in the field were the gradual adoption of CA in the whole farm, whereas in other cases this was not completely achieved. There was a reduction in use of chemical products and the introduction of alternative homemade products for the control of pests and diseases. There were also increases, often significant, in the yields of cash crops without the use of chemical fertilizers.

On the other hand a negative aspect was the rejection by many farmers of this production system, due principally to the failure of the companies to honour their established agreements on the final price of the products and the heavy demands of the certifying companies. This had a decided impact on the number of farmers who adopted this alternative production modality, but on the other hand it favoured the solidarity of those farmers convinced of the principles of the production practices.

The use of GMs is again fundamental in organic production. Some general recommendations are:

TABLE 3.9
Options for organic production with NT

Organic crop	Green Manure	Application
Sugarcane	Crotalaria	Between rows or for the recuperation of the plot.
Cotton	Crotalaria, black oat	Each 10 rows of cotton, 2 rows of crotalaria. Plot free of cotton for 3 years. Sow oat, radish and lupin after cotton harvest.
Maize	Mucuna or pigeon pea	Between maize rows.
Sweet herb (*Stevia* spp.)	Mucuna	Sweet herb on mucuna residues
Sesame	Oat, crotalaria	Sow sesame on oat residue, sow oat or crotalaria after sesame.
Mulberry	Dwarf mucuna, canavalia, pigeon pea in rotation, forrage groundnut, oat, radish, lupin.	Associated with the mulberry or in rotation.
Cítrus, banana and Yerba Mate	Forage groundnut, pigeon pea, *Crotalaria espectabilis*, dwarf mucuna canavalia.	Associated with the crop. *Stizolobium niveum* needs to be managed to stop it climbing.
Passion fruit	Canavalia, *Crotalaria espectabilis*, pigeon pea, forage roundnut,*Crotalaria juncea*, oat, radish, lupin.	Associated. Manage the pigeon pea and crotalaria so that they do not shade the passion fruit.
Soya	Maize and crotalaria	After soya harvest, sow Maize and crotalaria together at high density.

Source: Own data, 2010

Case Study 13: Sesame production in a plot rehabilitated with 3 years of GM, Celestino Martínez, Horqueta

"In the past yields were insignificant, but with NT the yield rose again". According to farmer Celestino Martínez soil management is the most important factor in agriculture, underlining NT and GMs.

"Before, I produced 500 to 600 kg of sesame per hectare. This year I sowed sesame over the residues of mucuna in a plot rehabilitated with three years of GMs. Yields rose to 1100 kg/ha. This motivated me to once more want to work the farm. In addition I only weeded once which greatly reduced my costs of production".

The farmer used a subsoiler to open a furrow in the mucuna cover. Then he sowed the sesame seed in a trickle into the furrow. After a time he thinned the crop. The mucuna cover maintained the humidity in the soil and also avoided erosion and the consequent loss of the sown seeds as happens in the conventional system. "My neighbours sowed two or up to three times, I only once", commented the farmer. It is important to note that the farmer does not have anybody to help with the farm work because his daughters are students and only help out with vegetable production.

Thanks to the new system installed, according to the farmer, there was greater crop diversification and at the same time there was more time to work with the vegetables to increase production.

It is also important to mention that Mr Martínez, together with the members of the committee, have experience of joint marketing of sesame with

local traders. The marketed crops are sesame, castor bean, maize, watermelon, and principally tomato and chilli. From the sale of chilli and tomato he obtained an income of 6 million Gs and the sale of sesame generated an income of 3.5 million Gs.

Name and District	**Celestino Martínez, Horqueta**
Technician	**Ever Almada**
Area of the farm	5 ha.
Family members	The farmer with his wife and two daughters.
Main activities	Production of maize, beans, cassava, groundnut and principally horticultural crops such as tomato, watermelon, onion, carrot, beetroot, garlic, parsley, etc. He has lesser breed livestock such as hens, pigs, ducks and guinea fowl which are used for home consumption with the excess sold. He also has cows for milk production and cheese making on the farm.
Marketing	Mainly sells maize, sesame, watermelon and beans.
Economy	Watermelon 2.5 million Gs, sesame 3.5 million Gs, black beans 1.6 million Gs, beans 0.4 million Gs, and maize 1.2 million Gs. Sales of chilli and tomato produce an income of 6 million Gs. And the total annual income is 15.2 million Gs. Costs: 1 million Gs for labour; education 2 million Gs; inputs 1.5 million Gs; food 6.5 million Gs; recreation 1 million Gs; and the remainder for diverse purchases. Total costs: 12 million Gs.
Main impacts	The increase of sesame yield with mucuna cover with less use of labour, and joint marketing.

Celestino Martínez with his plot of sesame on a green manure cover

CHAPTER 4

Animal production

4.1 SMALL ANIMALS

The production of lesser breed animals (hens, pigs, rabbits and goats) within the family unit constitutes an interesting alternative for family nutrition and as a source of additional income. To undertake this livestock raising the farm must have enough raw material for their feed and so reduce the costs of production. Within the PMRN we have used maize associated with summer GMs.

The production of small animals, above all in the quantity and quality of hens and pigs, increased considerably among the beneficiary families. This was due to the increase in grain production on the farms, principally of maize and GM seeds. The periods when market prices did not justify the commercialization of maize and GMs obliged (mainly the female) farmers to increase the numbers of lesser breed animals and by so doing add value to the maize by converting it to meat, eggs or fat. Marketing these products generates income in periods when there is no sale of agricultural products.

In this way the small breeds function as a savings bank for the family, generating income in times of need, and at the same time improving the family nutrition.

GM seeds are used for animal feeding, as a source of protein. Crops that can be used are pigeon pea, mucuna, canavalia which can be made into balanced rations according to the age and nutritional needs of the species to be fed. They can also be combined with maize and oats as sources of carbohydrate. These home-produced balanced rations are low cost and good quality. It is recommended that 30 percent of pigeon pea is mixed with other ingredients such as maize, grass, sugarcane, or others, to avoid the negative effects of tannin.

It should be mentioned that some grains contain toxic substances and so need to be treated with heat or washed with water before being eaten. When used dry they should be toasted in the oven, otherwise they can cause problems with pigs, poultry and cattle. The common varieties of bitter lupin have high contents of alkaloids which are toxic when consumed by humans or animals. To eliminate these alkaloids, the seeds should be allowed to soak in water for two days, changing the water four or five times to dissolve the poisons which are only found in the shells. The grains free of alkaloids can be ground and used as flour, and mixed with flour of wheat, maize, rye, etc. to enrich the protein content.

Mucunas must be pre-treated with heat (two hours boiling or roasting) to inactivate the L-dopa, a substance which can be dangerous for organisms. There is good experience with rations containing 25 percent boiled mucuna mixed with maize and cassava as pig feed.

Canavalia also needs cooking for several hours with two or three changes of water to eliminate the effects of the toxin canavalina. Seeds of this species, once treated, can be used for animal and human food (MAG, 2006).

The following are some recipes for balanced feeds (Caballero, 2008):

1. 10 kg pigeon pea with 20 kg maize, add mineral salt, bone meal and vitamins for hens, turkeys, ducks. Increases egg production and weight.
2. 30 percent pigeon pea with cassava and maize for pigs and cattle.
3. Leaves of pigeon pea and Cameroon grass or sugarcane or elephant grass. Chop the mixture. For milk cows, calves and goats. If it is available, add Leucaena at no more than 30 percent.
4. Pigeon pea seeds toasted or boiled for 10 minutes with milled maize, wheat bran 1 or 2 kg salt per 100 kg. For pigs, cows and hens.
5. 6 parts maize or cassava, 3 parts pigeon pea or coconut, 1 part minerals. For 30 day old chicks.
6. Mucuna or canavalia boiled or toasted for pig feed.

Case Study 14: Improving animal production, Manuel Giménez Brítez, Caaguazú

Manuel Giménez Brítez lives in Caaguazú District in Company 1, Línea Balanza. The farmer emphasized that his soil type is sandy and degraded so that under normal weather conditions he will get an average of 250 to 300 kg maize per hectare. By means of field days and radio programmes he heard that the Project was helping the rehabilitation of degraded soils. With this information and considering the poor state of his soils, he asked for help to improve them.

In the first year the farmers received 300 kg of compound fertilizer 10-20-10 and 100 kg urea 45-0-0 which he applied to his maize crop at the right time and at the right application rate. By these means he obtained 1520 kg of maize. The same year he planted, for the first time, the GM pigeon pea between his lines of maize, this was later used as feed for dairy cattle. The pigeon pea seed was used as raw material for the preparation of balanced feed, as a source of protein, and also for sale. In the second year he planted maize associated with mucuna and obtained a yield maize of 1980 kg/ha. With the employment of the GMs, yields increased and weed populations declined significantly.

Today the farmer has 2.5 ha with GMs and sows 0.5 ha pigeon pea as forage for his animals. For animal feed he uses pigeon pea at flowering stage and with seed at the milk stage. Plants are cut at soil height and chopped in a forage chopper. This chopped forage can be mixed with other types of traditional forage such as Cameroon grass, sugarcane and others. It can also be mixed with a little balanced ration for the milk cows. Pigeon pea seed is used as well

for the preparation of balanced feed for pigs and poultry. The nutritional requirements of the animals are taken into account as well as the nutrients that can be supplied by the seeds of this GM, so that when the different ingredients are mixed they result in a truly balanced ration.

With the additional feed the family had 60 hens, 20 ducks and 5 cocks. There were also 5 suckling pigs, 2 pregnant sows, 2 milking cows, 3 calves and one heifer.

"Now I can increase my stock of animals because I have assured their feed and balanced rations through the adoption of NT and GMs".

FARM INCOME

Products	Annual units	Value, Gs
Sale of poultry, hens and ducks	40	1 000 000
Sale of eggs	300 dozen.	1 800 000
Sale of cheese	200 kg	2 000 000
Sale of piglets	5	900 000
Sale of pigeon pea seed	450 kg	900 000
Other income		1 000 000
Total		**7 600 000**
Total production costs		**5 000 000**

SUMMARY

Name and District	**Manuel Giménez Brítez, Caaguazú**
Technician	**Cristóbal Alderete**
Farm area	5 ha.
Family members	Farmer, his wife and three sons.
Main activities	Maize, cassava and squash, animal production, 1 ha house plot, fruit trees, vegetable production. 1ha paddock/pasture and 3 ha for agricultural production.
Marketing	Sale of animals and animal products 7.6 million Gs/year.
Economy	Sale of animals, hens, eggs, cheese, piglets, pigeon pea seed.
Main impacts	Improvement in maize yield, production of forage and feed for the animals, and increase in numbers of animals.

Manuel Giménez Brítez with his grandson in his pigeon pea plot and by his milk cows.

4.2 CATTLE

Experience with the association of grasses and legumes has shown it to be a valid option for the recuperation of degraded pastures. The benefits can be short, medium or long term, depending on the species to be planted in the system. The system is viable in both small and large areas. The best experiences with smallholder farmers have been gained in San Pedro with the assistance of COVESAP.

The main factor in the degradation of pastures is their over-grazing and the lack of nitrogen in the system which leads to pasture of low quality, weed infested and producing a low yield of kg of meat per hectare. The values of crude protein in different species of legumes contribute to improving the quality of the forage consumed by the animals. Legumes are also a constant source of nitrogen in the production system. **It is a technology of low production cost, easily accessible by the smallholder farmer**.

Management

In general grasses have different growth habits compared with legumes, this complicates a little their association, but it can be regulated with the subsequent management of their rotation (rotation - rest). On implementing the system on a farm, this factor must be considered to avoid a possible failure in the initial and subsequent phases of the legume cultivation where the human factor plays a crucial role.

Criteria for species selection

For the selection of appropriate species, it must be observed whether there are similar species or subspecies occurring naturally (e.g. *Crotalaria*, *Desmodium*, *Stylosanthes*, etc.).

Bushy legumes for quality soils

Crotalaria juncea (short term, one year) is very effective in the control of nematodes (in agriculture). For its installation in pasture one pass of a harrow is required, the seed is broadcast (10-20 kg/ha) and then one pass of a light disc harrow. It fixes 50-150 kg N/ha/year.

***Cajanus cajan* – pigeon pea** (medium term, one to two years). It is more demanding in terms of soil preparation and the seed should be sown (at 30-40 kg/ha) with a planter. It fixes between 200 to 250 kg N/ha/year. It is an excellent forage species which can be used as a strategic reserve for winter use.

Leucaena leucephala (long term, 20 years). It is very demanding, needing a thorough preparation of the soil. It does not tolerate competition from weeds or grasses, especially at the start. It is the most delicate species to establish. It is recommended to sow at a depth of 2-3 cm in strips 4 m apart (at 3-4 kg/ha). It is slow to develop at first. Once sown a herbicide (Imazetaphyr) is applied immediately with an insecticide (Fipronil) to protect the plants from weeds and leaf-cutting ants. Once it reaches 2 m in height a grass can be incorporated (it doesn't tolerate competition). It can fix more than 400 kg of N/ha/year, depending on its height. Leucaena fixes nitrogen in the system and produces excellent forage and, if it is allowed to grow, will produce good quality firewood for the farm. It should be mentioned that in the region of Itacurubí del Rosario caterpillars specific to leucaena appear and they can cause crop damage, but they can be controlled. Results of browsing with leucaena show that animals can increase body weight by 800 to 1200 grams per day and a grazing load of 2-3 animal units per hectare per year can be achieved. Toxicity caused by the mimosine of leucaena is not a problem today. There is available on the market a bacterium to combat the toxicity caused by continuous consumption for more than four months.

Legumes for short stature grasses and intensive grazing

(These are legumes that can supply 100 or more kg of N/ha/year and contribute to an increase of 30 percent in production).

Alysicarpus vaginalis (Alyce clover). It is excellent at adapting to different soil types and systems. If it is accompanied by a grass, which could be *Paspalum notatum*, it is not difficult to sow, it can be broadcast (at 1 kg/ha) and covered with a light disc harrowing. If sown into a *brachiaria* pasture, because of the allelopathic effects, it requires a more thorough soil preparation. It has good potential for natural re-sowing.

Stylosanthes hippocampoides (Oxley fine-stemmed stylo) 2 to 3 kg/ha, the same process as Alyce clover).

Stylosanthes 3 kg/ha, requires a sandy soil.

Arachis pintoi (forage groundnut) functions in lowlands.

Desmodium heterocarpon* ssp *ovalifolium will tolerate temporary flooding.

Aeschynomene americana (shyleaf) for swamps, tolerates flooding.

The best time to sow legumes is in the first days of October.

In summary we can conclude that it is very important to maintain a **source of nitrogen** (legumes) in the system and that these contribute to the maintenance of pasture with **acceptable protein levels** and so achieve a good meat production per hectare. **The use of legumes in pastures is ecologically correct and economically sustainable. Nitrogen is protein, protein is meat and meat is money.**

Case Study 15: Increase in lesser breed animals through recuperation of a degraded soil, Dario Martínez, Dr Juan Manuel Frutos

The introduction of new production practices, specifically in degraded soils, had a tangible short-term impact. With reference to measurements taken by the farmer, maize yield increased from 805 kg to 2605 kg. In a short time the farmer noticed a difference, not only in yield but also in the quality of his produce, obtaining these benefits with less effort. With the incorporation of GMs he could see a reduction in weed infestation and finally could use the green manure as a sub-product for both human and animal consumption.

The farmer increased dramatically his production of poultry and other small animals owing to the increased availability of feed resources for them.

No-till, the use of pigeon pea and mucuna, contributed greatly to the improvement of the soils. The GMs facilitated soil cover, reduced weeds, retained humidity and resulted in an increase in the productivity of the crops.

Income increased through the increase in yields of both cash and home-consumption crops. Now, thanks to NT, the excess production which previously was only sufficient to feed the family, is sold.

Also an increase in the numbers of lesser breed animals was observed on the farm. This has contributed to a better quality of life and a better use of family labour. With the sale of the animals, and their sub-products, the farmer earned approximately 3 million Gs/year.

Type of animals	Number of animals	
	Before	After
Poultry	13	67
Pigs	1	7
Milk cows	-	1

Name and District	**Darío Martínez ,Dr. Juan Manuel Frutos**
Technician	**Romoaldo González**
Area of the farm	5 ha.
Family members	Farmer, wife and one son.
Main activities	Agriculture: Maize and cassava. Animal raising: poultry, pigs, cattle for home consumption and sale respectively. Vegetables for home consumption.
Marketing	The harvest of cash crops is sold in the wholesale market and in the case of livestock; they are sold within the District.
Economy	Sale of agricultural products: 3.2 million Gs (Maize chipá 400 kg x 2000 Gs/kg, maize tupí 500 kg x 800 Gs/kg, cassava 10 000 kg x 200 Gs/kg). Sale of animals and sub-products: 3 million Gs. (calves hens, pigs, eggs and cheese). Costs are approximately 3.1 million Gs and profits are 3.1 million Gs/year.
Main impacts	Increase on crop yields, marketing of production, raising small animal breeds, also his participation in different activities within the community has increased.

Dario Martínez with his wife feeding their poultry

CHAPTER 5

Forestry plantations

5.1 FORESTRY NURSERY

The Project assisted with the implementation of forestry measures such as reforestation and agroforestry which meant the acquisition of forest species seedlings by the beneficiary committees. One of the options was the purchase of seedlings from private nurseries with the funds received from the Project. The other option was the presentation of micro-projects by the committee for the installation of a forestry nursery, bearing in mind the requirements of plants for the areas to be reforested by the committee. The nurseries installed for seedling production were first dimensioned and designed according to the physical characteristics of the area of location, such as the distance from the future plantation, accessibility and availability of irrigation water, as well as the production plan for the plants, this was the work of the Project technicians.

The **cost of the nursery** was approximately between 6 and 13 million Gs for the production of 20-40 000 seedlings in 2-3 years. The cost per plant was estimated at 300-350 Gs. This cost is lower than the market price which was a requirement of the Project for the approval of a nursery. The committee contributed with labour and local materials. In most cases the nurseries had plastic netting for half shade, tables for potting, seedbeds and hardening-off areas. The irrigation system was through tubes from a raised tank and the nursery had a perimeter fence for protection. It was also equipped with all the manual tools needed for the production of quality seedlings.

During the execution of the Project, approximately **88 nurseries** were installed with a production capacity of between 5000 and 20 000 plants per year. On average each nursery produced around 20 000 plants in two years of production. By these means **1.8 million plants** were produced by the nurseries and were planted.

Some committees, continued to produce seedlings once the reforestation programme was concluded. These were for sale to other committees, for individual farmers, organizations, municipalities, etc.

It is important to emphasize that many committees had acquired seeds of native species by selecting from specimens in the forests of the region. For species such as eucalyptus, most seeds were acquired from the seed laboratory of the National Forestry Institute (INFONA) which has plantations of various species and guarantees the quality of the seeds.

To date some 45 nurseries have remained active and they achieve production of 541 626 seedlings of different species between natives: pink ipê,

Cedrela spp., Patagonian rosewood (*Anadenanthera* spp.), *Cordia* spp., and exotic species: eucalyptus, *Toona* spp., grevillea. Paraíso (*Melia* spp.), and others.

As the country does not have **certification of forest species seeds** it would be important to select **seed bearing trees or seed production plantations 'plus'** to ensure the good quality of the mother tree and consequently the genetic quality of the seeds and seedlings. This is most important for native species as there does not exist any quality control for these.

The seed tree should have characteristics such as a straight trunk, free of disease, good canopy formation, good growth, little branching and good fruit production. For exotic species, today there is a market in nurseries which produce seedlings of high genetic quality, including clones.

Case Study 16: Forestry nursery and forestry activities, an option to earn money, Tranquilino Britos Cuenca, Yasy Cañy District.

Farmer Tranquilino Britos Cuenca says that he started reforestation before the arrival of the PMRN, but he was able to increase the activity on his farm with the help received from the Project. "*Before there was forest in the entire District, but bit by bit it was cleared and burnt by both large scale producers and smallholders for their crops and livestock. My neighbours laughed at me when I started to produce seedlings and plant trees*".

Later he increased seedling production in his nursery to supply plants to various committees or associations in other districts. "*Now they are also interested in this activity, because of the need for firewood and for the income that reforestation will produce in the future*".

In 2008 Tranquilino Britas sold 100 000 plants of eucalyptus, paraíso and some native species and received around 30 million Gs in income. Four years ago he started the harvest of eucalyptus trees from his reforestation established on 2 ha in 1997, this produced an income of some 45 million Gs. The farmer's statements indicate his conviction and enthusiasm to continue to produce seedlings of different species with the aim of promoting and increasing the area of reforestation, and by so doing diversifying his income streams.

Last year, 2009, he also sold 100 000 pots of different species such as eucalyptus, natives and others, generating an income of 50 million Gs, from which has to be subtracted the production costs which include materials, inputs, labour, transport, forest management plan and others, giving a total of around 20 million Gs of net income. This implies production costs of 30 million Gs. He also sold eucalyptus logs which generated a net income of 30 million Gs. from the 2 ha, given that the costs of sawing and processing were the responsibility of the purchaser. These two activities have been done since April 2009. Annually the farmer has outgoings of between 12 and 15 million Gs. In this are included costs of education, health, food, work, amusements and incidentals.

According to the farmer he transplanted eucalyptus in his 2 ha at a density of 3 m x 3 m, to give a population of 1 111 plants per hectare. He comments that from the eighth year he realized the first harvest of about 10 percent of the plantation, generating a notable improvement in relation to the price of the product. The first harvest was in 2006 when he obtained 600 m^3 AP (Alto Paraná) and received 5000 Gs/m^3 AP. The second important harvest was in 2008 when he produced 1200 m^3 AP and received 10 000 Gs/m^3 AP, and in the last harvest, which took place in 2009 he obtained 2500 m^3 AP of wood, receiving 12 000 Gs/ m^3 AP sold. This income was generated in the 2 ha already mentioned. It is very important to mention that the price of wood doubled in two years.

According to these calculations, the farmer affirmed that with 10 ha (these data from the farmer were calculated as an example, given that his actual experience is based on his 2 ha) planted at a density of 3 m x 3 m, from the 8^{th} year it would be possible to generate an income of 15 million Gs/ha from the first harvest. The period of harvesting covers 18 years, foreseeing annual harvests. In exceptional circumstances it is possible to cut twice per year.

Similarly the farmer related that of 2500 m^3 sold as logs there remained a useful by-product, mostly branches, from which he produced 9000 kg of charcoal which he sold at 250 Gs/kg generating an additional income of 2.5 million Gs.

The farmer mentioned that there is interest from a company (named MADECOR) producing wooden sheets which suggested that at 6 years of development of the eucalyptus the first cut could be made to produce charcoal generating about 98 000 kg of charcoal which would be bought in its entirety by the company. There are also companies interested in producing eucalyptus essence.

Neither of these forms of production are in the interests of the farmer given that he devotes most of his time to the nursery. It is very important to note that the farmer also does contract planting of seedlings for others. For this he receives 1.2 million Gs/ha, on the condition that at least 80 percent of the seedlings prosper. The jobs of soil preparation and control of pests such as leaf cutting ants is the responsibility of the land owner.

It is important to emphasize the economic impact of this activity in the region. Today the neighbours show a great deal of interest in reforestation as an alternative enterprise. In 2009 he distributed 75 000 seedlings to 45 farmers, who were not members of the PMRN, for energy purposes (firewood and charcoal). For this year he has programmed 50 000 more seedlings for an additional 55 farmers.

The farmer relates that the costs of production for the installation of reforestation in 1 ha reach about 2 million Gs. This includes land preparation, transplanting, weeding and ant control. 1.2 million Gs are for the work of transplanting in the required place, without including land preparation. In

the case of the contractor doing the complete job, from land preparation to establishment of 80 percent of the plants and the control of ants, the charge is 2 million Guaraníes per hectare.

To date the farmer has reforested about 130 ha for third parties, which has generated an income of approximately 156 million Gs. On this point it is clear that the farmer, because of the experience acquired in forestry activities, was no longer a simple farmer but has been converted into a forest establishment business with a vision towards the future given his multiple forestry activities at district and departmental level. The nursery and the establishment of forest plots as a private operator is an important source of income for the family.

Tranquilino Britos demonstrating part of his seedling production.

5.2 REFORESTATION

Within the forestry component of the PMRN, one of the measures promoted is reforestation. This has been implemented on 3500 ha and directly involves some 5500 producers.

Case Study 17: "NT saved my property", Silvano Enciso, Repatriación, Caaguazú

"Nda japoi rire la SD ahejama ramoa la che kokué". "If it wasn't for NT I would no longer be on my property". Was the expression of farmer Silvano Enciso, when in the Guarany language he initiated his commentary on a difficult situation. As a director member of a second tier farmer association

he was responsible for a debt of 18 million Gs for inputs and seeds received by members of the association, with a legal threat from the cotton input supply company. He continued commenting that he could beat the obstacles and economic problems with the knowledge and technical assistance that he received from the PMRN, achieving an improvement in productivity and minimizing his production costs.

Silvano commented proudly, together with his family, that by applying CA, the permanent use of different types of summer and winter GMs, they were able to substantially improve the volume and quality of their crops, at less cost and with a reduction in the use of labour and inputs they improved their income.

Silvano's main enterprise is cassava whose yield increase was from 18 000 kg/ha to 42 000 kg/ha representing more than a 100 percent increase in yield, through the technology diffused by the PMRN. Because of the quality and volume of the produce the farmer assured its sale to the CODIPSA starch factory.

Through this way of working, the farmer and his family overcame all their economic problems. They served as an example to the community, infecting and transmitting the benefits of NT which he denominated a "**sustainable guarantee**". The practices with the soil coupled with the forestry activities worked together perfectly and he is receiving the first benefits by means of the sub-products of reforestation (firewood) with the management of thinning. In the thinning of 0.5 ha of 4-year old *Eucalyptus grandis* he harvested 1911 kg of firewood which he sold at 90 Gs/kg giving an income of almost 1 million Gs. The actual value of the reforested plot is 15 million Gs according to the local demand. For the second thinning the farmer estimates an income of 5.6 million Gs, and for the final cut, in the 12th year, an income of 37 million Gs.

SUMMARY

Name and District	**Silvano Enciso, Repatriación**
Technicians	**Marcelino Prieto, Javier Saavedra**
Are of the farm	12.5 ha.
Family members	Wife and four children.
Crops and animals raised	Cassava, maize sugarcane, animals, reforestation and yerba mate.

Marketing of agricultural products, 2007/8

Crop	Area, ha	Weight sold, kg	Gs/kg	Production costs, Gs	Profit
Cassava	5	210 000	230	80/kg	31 500 000
Cotton	2	3200	2300	1 800 000/ha	3 760 000
beans	2	1800	2000	1 300 000/ha	1 000 000
Maize (*tupi locro*)	0.75	2317	1400	745 000	2 500 000
Yerba mate	1	3200	600	300 000	1 620 000
Total					**40 380 000**

Marketing of agricultural products, 2008/9 to date, July 2009

Crop	Area, ha	Weight sold, kg	Gs/kg	Production costs, Gs	Profit
Cassava	4	120 000	230	80/kg.	18 000 000
Beans	1	400	2000	500 000	300 000
Maize (*tupi locro*)	0.5	1300	1600	745 000	1 335 000
Yerba mate	1	5200	600	300 000	2 820 000
Total					**22 455 000**

Note: during the agricultural cycle 2007/8 the farmer obtained good yields in the majority of his crops, but not in 2008/9 when the prolonged drought reduced yields.

Projection of marketing for forestry products in 0.5 ha

Activity	Age, years	Quantity of firewood, kg	Quantity of timber logs, m^3	Income from firewood, Gs	Income from timber, Gs	Net income, Gs
1st Thinning	4	19 111	-----	955 000	------	955 000
2nd Thinning	6	6420	35.7	321 000	5 301 450	5 622 450
Final cut	12	42 360	176.4	2 118 000	34 927 200	37 045 200
TOTAL	**------**	**67 891**	**212.1**	**3 394 000**	**40 228 650**	**43 622 650**

Sale of firewood to CODIPSA from 0.5 ha of reforestation with 4-year old *E. grandis*, 2.009.

Concept	Quantity, kg	Price, Gs/kg	TOTAL, Gs
Firewood	19 111	90	1 719 990
labour			764 440
profit			955 550

Silvano Enciso's son carrying thinnings cut from the eucalyptus plot

5.3 SPECIES, SITES AND SPACING

Species

The species utilized and both native and exotic. It is the producer who decides the species that he is going to use. Amongst the exotic species used are: eucalyptus of the species *E. grandis* and *E. maldulensis*, paraíso (*Melia* spp.), raisin tree (*Hovenia dulcis*), *Toona* spp., grevillea and teak (few trees). Native species used include: *Cordia* spp., *Cedrela* spp., pink ipê, *Peltophorum* spp., Patagonian rosewood (*Anadenanthera* spp.), *Albizia* spp., *Amburana ceraensis*, *Patagonula americana*, *Balfourodendron* spp. and others.

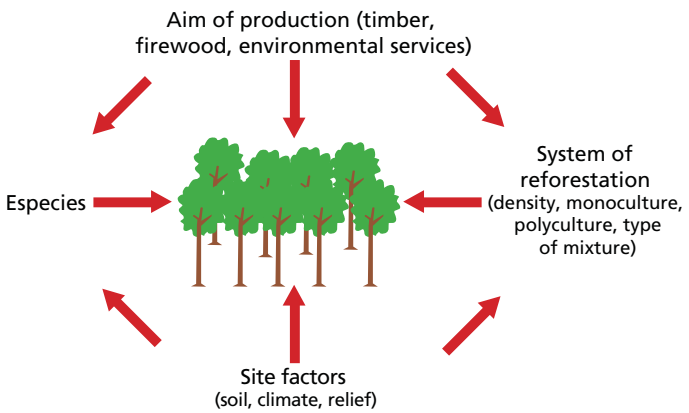
The PMRN recommends to its users to mix species in reforestation, at least two or three and in this way diversify production and reduce possible problems due to attacks of pests or diseases. On the ground there is:

- Monoculture reforestation (mainly eucalyptus and paraíso).
- Mixed reforestation, with at least two exotic species.
- Mixed reforestation with native and exotic species.
- Mixed reforestation with at least two native species.

The native species are used in about 30 percent of all the plots, and exotics in 70 percent, of these 50 percent of species are eucalyptus. The reasons why the majority of producers have opted for exotic species are: a) the rapid growth of these species; b) the economic return; c) the need for firewood; d) the scarcity of native species seeds in the market.

The decision over the species to be reforested depends on the aim of the plantation and the quality of the site, the density of the plantation will also depend on these two factors. That is to say that the producer needs to decide if he wants short term firewood or valuable timber in the medium and long terms. That is the decision which will determine the species. Another important factor to consider is the site.

FIGURE 5.1
Factors that influence the choice of forestry species



Source: Grulke, 2005

Sites

The sites where reforestation has been implemented are:

- **Natural areas**, which can be: a) **lowlands**: soils prone to flooding, hydromorphic, the species most used in this type of conditions is *Eucalyptus camuldulensis,* Inga; b) **highlands**: deep soils, sometimes compacted, species most used are: *Eucalyptus grandis*, paraíso, *Hovenia,* grevillea, *Peltophorum* spp., etc.
- **Agricultural soils**, generally deep of medium fertility, species used are the exotics and natives in general.

Spacing

The spacings used are 2 m x 2 m (2500 plants/ha); 3 m x 2 m (1667 plants/ha); 3 m x 3 m (1111 plants/ha); 4 m x 2 m (1250 plants/ha); 4 m x 3 m (833 plants/ha); 3.5 m x 3.5 m (816 plants/ha); 4 m x 4 m (625 plants/ha). The most frequently used are 3 m x 3 m (1111 plants/ha) and 4 m x 4 m (625 plants/ha). **High density spacings are used mostly for the production of firewood** with densities that vary between 1500 and 2000 plants per ha. In this case *Eucalyptus camuldulensis* can be used with a rotation of 7 years without thinning or pruning and it is clear felled. After felling the shoots can be used (leaving one per stump) for a new cycle of production.

The lowest densities are used for the production of high quality timber, with appropriate management which consists of pruning and thinning. In agroforestry systems, with fruit trees, agricultural crops and cattle, spacings are from 3 m x 3 m to 10 m x 10 m.

For native species it is recommended to use higher densities (3 x 3 or 2 m x 3 m) to promote the production of straight trunks and natural pruning (through lateral competition).

Case Study 18: Production of Trébol (*Amburana cearensis*) associated with grapefruit, Fernando Duarte, Loreto

Farmer Fernando Duarte from the 1 March committee in the locality of Jhugua Guazú, Loreto District planted trébol in 0.75 ha in September 2003 with the aim of associating the trees with home consumption crops. Planting density was 10 m between rows and 4 m between plants.

At first he was not successful with the development of the plantation due to a lack of knowledge about the management of the plot and a lack of an appropriate technician. At that time Fernando Duarte was not part of any committee and worked independently. In the first year (2004) the plantation was associated with cotton where he obtained the first harvest of produce for sale. In the second year (2005) he planted cassava for home consumption, obtaining another good harvest for the family to eat. After the cassava harvest the farmer did not know how to proceed with the management of the trébol plantation. The plot, when it ceased to be cultivated, was invaded by weeds

and was converted to a fallow area with the trébol trees over branched and poorly developed.

In 2007 the 1 March committee was founded and with it the technical assistance of the PMRN. From this time the farmer started to manage his plot more appropriately. The first task of management was to clear the weeds and prune to form the trébol trees which had too many branches. After that beans were sown in the plantation avenues. Subsequently, through the management of the technical assistance and with help from the local government and the NGO Aldea SOS, he obtained plants of grafted grapefruit supplied to the committee. These were associated with the plantation of trébol. Also, GMs such as crotalaria, mucuna and forage groundnuts were sown in the plantation.

5.4 PLANTING AND MANAGEMENT

Generally, before planting, the land is cleared with hand tools, then the preparation of the holes where the trees will be planted and sometimes organic matter may be added if it is available on the farm.

Fernando Duarte with his grapefruit trees associated with trébol (*Amburana cearensis*)

With regard to planting itself, Project beneficiaries use seedlings whose size varies from 20-50 cm in height. Normally they should be hardened, that is to say they are removed from the half shade of the nursery to be gradually exposed to the sun before taking them to their final location. Seedlings should be healthy and vigorous with good root development.

Planting can be done in almost any month of the year, after a good rainfall or fresh weather with drizzle, months of excessive heat (January and February) should be avoided, as should months of hard frosts (July and August). On planting take care that the roots go straight into the holes, to avoid being bent

and becoming curled which will make it difficult for the plants to grow well subsequently.

The **maintenance** of plantations is started in the first few months, with weeding and crowning (hoeing around the trees) which helps the initial growth of the seedlings. Afterwards, when the plantations are older, lateral branches are pruned.

Generally reforestation plantations are used for agricultural production between the tree rows in the first 3 or 4 years. This eases the weeding and exploits the available area.

Several farmers introduced GMs between the reforestation rows, mainly mucuna, pigeon pea, crotalaria and canavalia with the aim of producing seeds, increasing soil fertility, and reducing manual labour for weeding. This practice, created by the farmers, can be considered successful; nevertheless there are no scientific data to show that the use of GMs helps the growth of the forest species. But it is probable that they do, especially in times of drought as a result of the maintenance of humidity in the soil, and the supply of nitrogen in the case of legumes.

One practice that is accepted and recommended is 'reforestation' by means of the management of natural regeneration (technically speaking this would be the management of natural establishment which appears spontaneously on the farm). In this case the farmer should create conditions on the farm favourable for the regeneration: no burning, keep clear of weeds, liberate the saplings, do not introduce animals in the area. Naturally the tees occupy space and the farmer must select the most desirable species or plant those that are needed.

Another practice is to remove the naturally regenerated trees (clean rooted), after a good rainfall, and replant in a new location. The biggest problems arise when farmers extract the trees inappropriately (damaging the roots, without rain, in times of great heat, bending the roots on replanting, etc.) and on being relocated there are many losses. Normally the losses of plants, with this practice, are higher compared to plants produced in pots. Also such losses must be replaced. Depending on the situation of the farmer and his aims, it continues to be a valid option.

In the forestry training given to technicians and farmers, it is recommended to **give a root pruning with the spade without extracting the plant**. A prudent moment is awaited, after a good rainfall, to extract the plant and take it to its final location. The place should be prepared with holes and incorporated organic matter, manure, etc. With this technique root breakage can be avoided and losses are minimized at the time of planting.

5.5 PRUNING AND THINNING

Pruning

To obtain the best quality timber and trunks free of branches to 8 m high, it is **recommended** to prune in plantations, especially with paraíso, pine,

eucalyptus and Toona species. Paraíso needs a first pruning before it reaches 1 year in the plantation, after that it is pruned according to need.

To optimize the use of labour, it is best to prune after thinning, that is to say, only prune the best specimens. Through PMRN technical assistance, it was possible to raise awareness of the importance of pruning with many beneficiary producers and in the majority of the silvo-cultural properties it was practised. The lack of appropriate tools in many cases is a limitation for achieving good pruning. The appropriate tools are the pruning saw and pruning shears (secateurs). Pruning with the machete should be avoided wherever possible. Branches should be cut flush with the tree trunk, avoiding leaving stumps. Excessive pruning should be avoided and it is recommended to **leave a canopy for at least 30-40 percent of the total height of the tree**.

Pruning can be realized almost throughout the year, but the ideal period is between April and August because this is the period when there is little physiological activity in the trees. Pruning is accepted and implemented by the farmers once they have access to appropriate tools.

Thinning

This operation comprises the elimination of some of the trees in the plantation. It favours the development of the diameter of the trunks of the main trees. It is also important for hygiene in case of disease. It is possible to do 1 to 3 thinnings during the cycle depending on the species used, the density and the objectives of the plantation.

As a general rule it can be said that a thinning is needed when there is competition between the canopies of the best specimens. The number of trees at the end of a plantation is approximately 245-400 specimens of good diameter, trunks free of branches to 8 m and a good canopy.

The first thinning should be done at 3-4 years, depending on the growth and the density of planting, approximately 30 percent of the planted trees will be thinned out. The thinned trees can be used for firewood, posts and charcoal. The second thinning can be done at 6-7 years, again removing about 30 percent of the total. This product can be used for firewood, posts, charcoal and timber. The third and last thinning is done only if needed which will depend on the species, density and felling cycle.

Types of thinning

Selective thinning: This can be of two types: **thinning tall trees**, the biggest-trees are selected; b) **thinning low trees**, the least developed trees are selected (thin, split, crowded).

Thinning tall trees is recommended when the aim is to produce good timber of good diameter and high value. Usually it is done after the plantation has reached several years of age, that is when there are specimens of harvestable dimensions. With this type of plantation it is hoped to accelerate a little the rate of growth of the trees remaining in the forestry plot.

On the other hand **thinning low trees** is usually done in the first years of the plantation, for example in **energy production** plantations where the aim is that the remaining trees are the best specimens and will continue to grow in volume so that, at the final felling, all the trees are in condition to produce the maximum volume of good quality timber. This type of thinning can also be done in more mature plantations. The product of the thinning, in younger plantations, can be used for energy (firewood, charcoal). The product of thinning in older plantations can be used for energy, posts, columns and timber, etc.

Systematic thinning: In this type of thinning trees of good size are extracted at the same time as the elimination of poor growers. The extraction can be systematic, every other tree as well as every other row of trees.

The PMRN has given on-farm training on pruning and thinning, but it has been noticed that the majority of farmers are loath to thin for the fear of losing trees, without realizing the future economic damage that this causes. Nevertheless, there are regions in the Repatriación District where there are several plots of PMRN farmers where thinning trials have been carried out with positive results and the products were sold to make vegetable boxes, posts, firewood and charcoal.

Generally farmers sell their trees early (with 15-25 cm diameter at breast height -DBH) without reaching the optimum age and diameter to attract the best price, so they lose much money by not waiting at least 3 to 5 years longer. The temptation at the moment is very great when a buyer offers cash to the owner of the plantation.

Economic valuation of a plantation

At the smallholder level the net income with exotic species is approximately US$800 to 1000 per hectare per year. The final felling is at 10 to 15 years, depending on the growth rate, species, site, etc. It is recommended to do this when the chest-high diameter is 40-45 cm.

Below are presented tables with data from plantations with different types of management with both exotic and native species where the gross income is given. In plantations on smallholder farms, labour is provided by the owner and there are few additional costs (use of the chainsaw and purchase of seedlings).

TABLE 5.1
Gross income per hectare and type of plantation, with and without management

Species	Management type	Years	Total gross income, Gs	Annual gross income, Gs/year
Exotic	With thinning and with pruning	12	69 652 000	5 804 333
Exotic	UIT thinning , without pruning	12	51 480 265	4 290 022
Exotic	Without pruning, without thinning	12	30 460 011	2 538 334
Native	With thinning and with pruning	40	129 990 000	3 249 750

Source: Own data, 2010

TABLE 5.2

Gross income from 1 ha reforestation plots with exotic species, with and without management; and native species with management

WITH THINNING AND WITH PRUNING

Activity	Age (years)	No. of trees (%)	Trees to extract (%)	Av. Diameter at chest ht. (cm)	Commercial ht. average (m)	Firewood (m^3)	Vol. timber in log (m^3 real)	Firewood income (Gs)	Timber income (Gs)	Total income (Gs)
1st thinning	3	625 (100%)	187 (30%)	10	3	6.9	-----	207 000	-----	207 000
2nd thinning	7	438 (70%)	187 (30%)	25	6	26.4	41.3	792 000	8 260 000	9 052 000
Final cut	12	251 (40%)	251 (40%)	40	8	121.1	189.2	3.633 000	56 760 000	60 393 000
TOTAL	----	-----	625 (100%)	-----	-----	154.4	230.5	4 632 000	65 020 000	69 652 000
Mean Gs/year										5 804 333

WITH THINNING, WITHOUT PRUNING

Activity	Age (years)	No. of trees (%)	Trees to extract (%)	Av. Diameter at chest ht. (cm)	Commercial ht. average (m)	Firewood (m^3)	Vol. timber in log (m^3real)	Firewood income (Gs)	Timber income (Gs)	Total income (Gs)
1st thinning	3	625 (100%)	187 (30%)	10	2	4.6	-----	137 470	-----	137 470
2nd thinning	7	438 (70%)	187 (30%)	25	4	17.6	27.5	528 731	5 507 617	6 036 348
Final cut	12	251 (40%)	251 (40%)	40	6	90.8	141.9	2 725 199	42 581 246	45 306 446
TOTAL	----	-----	625 (100%)	-----	-----	113.0	169.5	3 391 401	48 088 863	51 480 265
Mean Gs/year										4 290 022

The details of the calculations are given in the following Tables 5.2 and 5.3:

TABLE 5.2 (cont.)

Gross income from 1 ha reforestation plots with exotic species, with and without management; and native species with management (continued)

WITHOUT PRUNING AND THINNING

Activity	Age (years)	No of trees (%)	Trees to extract (%)	Av dia. at chest ht. (cm)	Av. Commercial height (m)	Firewood (m^3)	Vol. timber in log (m^3real[6])	Firewood income (Gs)	Timber income (Gs)	Total income (Gs)
1st thinning	3	625 (100%)	-----	10	2	-----	-----	-----	-----	-----
2nd thinning	7	550 (88%)	-----	20	3	-----	-----	------	-----	-----
Final cut	12	450 (72%)	-----	30	4	61.1	95.4	1 832 181	28 627 830	30 460 011
TOTAL	**----**	**-----**	**-----**	**-----**	**-----**	**6.,1**	**95.4**	**1 832 181**	**28 627 830**	**30 460 011**
Mean Gs/year										**2 538 334**

Source: Own data, 2010

TABLE 5.3

Gross income for 1 ha reforestation plots with native species with management

NATIVE WITH THINNING AND PRUNING

Activity	Age (years)	No of trees (%)	Trees to extract (%)	Av dia. at chest ht. (cm)	Av. Commercial height (m)	Firewood (m^3)	Vol. timber in log (m^3real)	Firewood income (Gs)	Timber income (Gs)	Total income (Gs)
1st thinning	5	833 (100%)	208 (25%)	10	2	5.4	-----	162 000	-----	162 000
2nd thinning	15	625 (75%)	208 (25%)	20	4	10.1	20.9	303 000	4 180 000	4 483 000
3er.Raleo	25	417 (50%)	167 (20%)	30	6	36.3	56.7	1 089 000	19 845 000	20 934 000
Final cut	40	250 (30%)	250 (30%)	40	8	128.7	201.1	3 861 000	100 550 000	104 411 000
TOTAL	**-----**	**-----**	**833 (100%)**	**-----**	**-----**	**180.5**	**278.7**	**5 415 000**	**124 575 000**	**129 990 000**
Mean Gs/year										**3 249 750**

Source: Own data, 2010

[6] See Figure 8.1

For native species a price of 30 000 Gs is assumed per cubic metre of stacked firewood, 200 000 Gs per real cubic metre of timber for the second thinning, 350 000 Gs per real cubic meter of timber from the third thinning, and 500 000 Gs per real cubic metre of timber from the final cut.

For exotic species the following prices are assumed: 30 000 Gs/m^3 firewood; 200 000 Gs/m^3 real timber from the second thinning and; 300 000 Gs/m^3 timber from the final cut.

5.6 GROWTH

Within the framework of the Project some reforestation plots were analyzed. Forestry measurements were initiated as training for the technicians so that they would learn the methodology, afterwards each technician followed up with at least one medium sized plot. As a minimum, two rows were measured in the middle of the plot. Also measurements were initiated in the plots of the beneficiaries of the PMRN with the assistance of the FCA, Forestry Faculty (CIF) with the idea that students practise and that the FCA/CIF would follow up on the plots with the objective of getting data from different zones of the Eastern Region that are needed at national level.

Very summarized results of these measurements are presented below. It should be noted that the majority the plots are to be found on poor quality soils and that the techniques of planting are not the most sophisticated, that is to say without access to certified seeds, without good quality control of the seedlings, without application of inorganic or organic fertilizers, often with bare root plants coming from the forest, and plots with little management. We can confirm that the technology applied by the farmers was rustic and the growth achieved does not represent the potential at national level. These figures can be considered as the minimum potential for growth of the measured species.

TABLE 5.4
Results of measurements taken on approximately 200 ha of reforestation plots

Ecoregion San Pedro / Concepción		Increase in diameter (cm/year)			Increase in commercial height (m/year)			Increase in total height (m/year)		
		Increase in the measured plots			Increase in the measured plots			Increase in the measured plots		
Species	**N° of plots**	**min.**	**max.**	**average**	**min.**	**max.**	**average**	**min.**	**max.**	**average**
Cedrela spp.	4	1.1	2.6	1.83	0.0	0.0	0.0	0.5	1.9	1.2
Anadenanthera spp.	1	-	-	1.00	-	-	0.0	-	0.0	1.2
Tabebuia spp.	2	0.9	1.7	1.30	-	-	0.0	0.7	1.7	1.2
Mixed natives Natives	3	2.3	2.8	2.55	-	-	0.0	0.9	1.7	1.3
Cordia spp.	3	1.5	6.7	4.10	-	-	0.0	1.1	2.0	1.5
Amburana spp.	1	-	-	1.23	-	-	0.2	-	-	0.6
Peltophorum spp.	7	2.2	3.3	2.75	0.0	0.0	0.8	1.6	2.5	2.1
Pterogyne spp.	2	1.1	2.2	1.65	0.0	0.0	0.0	1.1	1.5	1.3
Eucalyptus camaldulensis	1	-	-	4.80	-	-	0.0	0.0	0.0	3.7
Eucalyptus grandis	1	-	-	3.60	-	-	2.2	-	-	1.2
Eucalyptus spp.	6	1.2	5.3	3.25	0.7	1.3	0.5	1.7	5.0	3.4
Grevillea spp	3	1.6	4.2	2.31	0.0	0.0	0.0	1.2	3.4	1.7
Hovenia spp.	3	1.3	3.5	2.40			0.0	1.6	4.5	3.5
Melia azedarach	13	3.1	7.1	4.09	1.1	2.3	1.5	1.1	5.1	3.1
Tectona grandis	1	-	-	1.53	-	-	0.0	-	-	1.7
Balfourodendron spp.	3	1.3	2.8	2.0	0.7	0.9	0.8	0.7	1.6	1.12
Tabebuia spp.	7	1.2	2.8	1.9	0.5	1.2	0.9	1.0	3.9	1.5
Mixed natives	10	1.1	6.8	3.0	0.5	10.0	2.04	0.5	1.8	1.09
Cordia spp.	1	-	-	1.1	-	-	-	-	-	0.8
Myracodruon spp.	1	-	-	-	-	-	1.1	-	-	1.7
Astronomium spp	1	-	-	4.3	-	-	-	-	-	1.0
Peltophorum spp.	7	1.3	9.1	3.82	0.6	1.3	0.95	0.7	2.7	1.6
Eucalyptus camaldulensis	6	2.7	4.1	3.28	2.3	3.1	2.6	1.6	3.8	3.1
Eucalyptus grandis	20	1.9	7.3	3.93	1.3	6.0	2.7	1.69	7.0	3.73
Eucalyptus spp.	9	1.3	7.8	4.32	1.2	2.3	1.4	1.0	4.2	2.5
Grevillea spp	5	0.1	5.4	3.28	1.0	1.6	1.1	1.3	1.9	1.5
Hovenia spp.	2	2.1	6.6	4.35	0.4	0.9	0.6	1.1	1.8	1.5
Melia azedarach	23	2.6	7.8	4.07	0.8	2.7	1.47	1.2	3.9	2.5
Pinus spp.	1	-	-	1.30	-	-	1.1	-	-	1.3
Pinus eliotii	1	-	-	-	-	-	-	-	-	1.1
Toona spp.	1	-	-	-	-	-	-	-	-	3.3

TABLE 5.4 (Cont.)
Results of measurements taken on approximately 200 ha of reforestation plots (continued)

Ecoregion Caazapá		Increase in diameter (cm/year)			Increase in commercial height (m/year)			Increase in total height (m/year)		
		Increase in the measured plots			Increase in the measured plots			Increase in the measured plots		
Species	**N° of plots**	**min.**	**max.**	**average**	**min.**	**max.**	**average**	**min.**	**max.**	**average**
Eucalyptus spp.	14	1.2	6.9	3.52	-	-	0.0	1.8	4.4	2.9
Grevillea spp.	4	1.7	3.8	3.22	0.0	0.0	1.3	0.5	2.2	1.5
Melia azedarach	5	2.5	4.9	4.26	0.8	1.9	1.0	1.0	3.0	2.3

Source: Own data, 2010

CHAPTER 6

Management of native forest

6.1 INTRODUCTION

The management of native forest is an activity little known by the farmer. 'Traditional management' comprises a dramatic intervention, eliminating all the useful trees at once, leaving a forest very open which allows the development of weeds in general, bamboos, lianas, etc. and low quality trees. Another management concept known by the term, 'environmentalist' is where there is no intervention in the forest which is allowed to grow and offer environmental services.

The management concept applied by the PMRN is the forest as a source of income which at the same time produces environmental services. The central idea of the concept is to work with and not against the natural dynamic of the forest. Interventions are made from time to time to ensure the appearance and growth of desirable tree species (trees with a future use) and to harvest mature trees that have reached their peak. In this way the quality of the forest is gradually improved and so is its productive potential, without affecting its diversity and other environmental services.

Case Study 19: "Conscience capital", Juan de Díos Ojeda, Repatriación, Caaguazú

"*Before, Caaguazú was called the timber capital, in the same way that Yhú was known as the cotton capital. Today there is practically no more forest in our district. When we arrived at this place with our families, there was forest, wild animals and clean water. Today we do not value the forest, quite the reverse we fell it and burn everything to cultivate cotton, maize and cassava. Agriculture prospered, one now has a better income and perhaps better perspectives, but by any analysis you will see that this growth has been achieved at the cost of a resource that is absolutely vital. The Forest*".

This is what Juan Ojeda told us, he lives in the neighbourhood of Culantrillo in Repatriación District, Caaguazú Department. This farmer by profession decided in 2005 to change his attitude towards the forest remnant on his property, and with the help of technical assistance from PMRN decided to apply practices of forest management with the view of conserving this area. Through training he understood that the objective was not to keep the forest as it was, but to exploit it sustainably and foreseeing its permanency for future generations.

In the forest, the first thing that he did was to make an inventory to know how much and what species there were, the total and harvestable volumes, competition and sources of seed. He also identified trees for the future, desirable species. Later he proceeded to liberate these by cutting back lianas and eliminating competing trees.

The results are surprising, related the farmer, "*I have my forest still almost intact, but I also obtained these benefits: I extended my house, I sold timber to a value of 2.6 million Gs and the most important thing was that I sold the timber legally without intermediaries with guides and all the documentation required*".

It is estimated that there was growth of approximately 3 to 6 m^3/ha/year which would be the annual rate for a forest managed sustainably. Furthermore, the activities in the forest are compatible with the agricultural activities with respect to period, labour and time.

The happiness is clear on Juan's 62-year old face, he knows that he is leaving an incomparable legacy for his family.

SUMMARY

Name and District	**Juan de Dios Ojeda, Repatriación**
Technician	**Alcides Brítez**
Area of the farm	12 ha.
Family members	Wife and 9 children.
Main activities	Tomato, chilli, onion, animals, citrus and forest, maize, cassava, beans.
Main impact	Forest management as a source of additional income.

Use of a mobile sawmill to produce planks from logs of timber from the farm of Juan de Díos Ojeda

For the management of the native forest a simple technique was applied which the farmers have quickly understood and have easily adopted, these were the activities realized:

1. Logging and extraction paths
2. Rapid inventory
3. Marking future trees and competitors
4. Cutting lianas
5. Liberation of future trees
6. Exploitation of mature trees
7. Care of nature regeneration
8. Tree pruning
9. Enrichment, according to need.

With the experience gained in different areas, it was observed that, at the start, the farmers cut back the lianas, opened up for logging and marked the trees of the future as their principal management activities. A forest with the lianas cut and trees marked with tapes was considered to be a managed forest by both farmers and technicians. With time, and through many training sessions, it was possible to make farmers understand that good management is not simply performing these tasks; but rather only through the implementation of all the other activities are the desired results achieved.

6.2 LOGGING AND EXTRACTION PATHS

To be able to reach all parts of the forest and to work everywhere, it is necessary to open up logging trails with machete every 20 to 25 m. It is important not to damage natural regeneration trees during this process. At the same time, each 40 to 50 m a strip needs to be opened up for the transport of logs, firewood and timber with the aim of minimizing the impact on the rest of the forest. The trails and extraction paths should be kept clear at all times.

6.3 FOREST INVENTORY

To know the composition of the forest, a rapid inventory is required. It is recommended to open a path 100 m long in the middle of the forest and measure the trees that are to be found in a strip of 5 m to the right and 5 m to the left of the cleared path. In this way a plot of 1000 m^2 is established where the diameters at breast height (DBH) are measured and the commercial height of the trunks of all the trees, of over 10 cm in diameter, can be estimated.

The trees should be classified as: future trees; seed producers; indifferent; and competitors. Future trees are considered to be those species that, for the farmer and owner of the forest, have a high value and they are considered thus from 2 m in height. The results of the rapid inventory in 1000 m^2 are projected to 1 ha (that is to say the results are multiplied by a factor of 10). Also all the natural regeneration trees should be counted, including those of less than 10 cm DBH.

If, in the rapid inventory, fewer than 150 trees of the future per hectare are found, and/or very little natural regeneration, the forest can be considered degraded and will need to be enriched with valuable native species in the required locations.

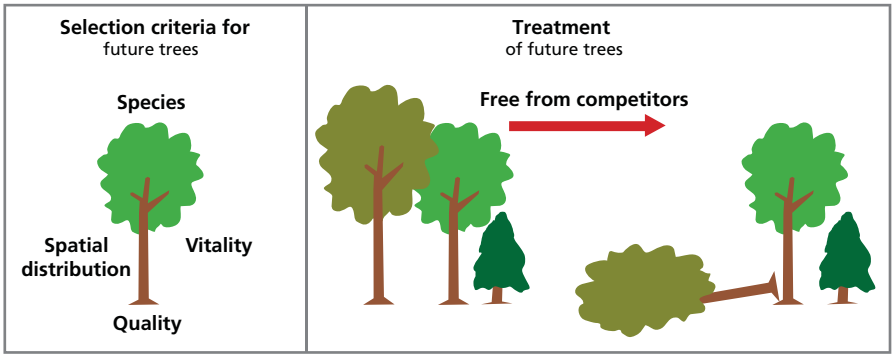
6.4 TREES OF THE FUTURE AND THEIR LIBERATION

The concept of a tree of the future is very important for the management of the forest, especially for the farmer. Not only valuable timber species like *Tabebuia* spp., *Cedrela* spp. and *Pterogyne* spp. are considered as future trees, but whatever other species that may be of benefit and exploitable by the farmer.

A future tree is defined as one of a species valuable to the farmer, with a well formed trunk, good canopy development, without damage or disease and a minimum of 2 m in height. It is recommended that these trees are marked as future trees with a high-visibility tape (red, orange or yellow) to be able to find them easily, look after them and keep them free of lianas and competitor trees.

FIGURE 6.1
Management of future trees

Selection criteria for future trees	**Treatment of future trees**
Species	**Free from competitors**
Spatial distribution	
Vitality	
Quality	



During the implementation of the Project, one important step was to get the farmers to eliminate competitor trees. Due to an erroneous concept that they had from the beginning, they did not consider this to be part of management of the forest.

Even today there still exists a negative approach on the part of farmers to eliminate a competitor tree that is impeding the good development of a future tree. There is much resistance to this practice owing to a belief by farmers that this would decrease the value of the forest. In addition they are unwilling to invest in a chain saw or contract an operator to do the job.

With the passage of time, the measure has mainly been accepted, above all because of the introduction of **ring barking** which consists in removing the bark around the circumference of the tree with a machete, inhibiting the circulation of sap and bringing about the death of the standing tree. This technique was successful for the farmers.

A negative experience at the start of the Project was that farmers invested a great deal of time and energy in clearing their plots leaving them **like parks**, and eliminating the incipient natural regeneration. This activity was never recommended by the Project.

Liana cutting

It is important to free the trunk and the canopy of a future tree from lianas. Lianas are cut both high up and flush with the soil. Lianas should be cut the number of times that may be necessary, and especially around 6 months before the harvest of the mature tree so that they die and dry out and not cause problems for the neighbouring trees at the time of felling of the mature tree.

The exploitation of harvestable trees, the elimination of competitors for use as firewood or poles can be considered to be the most sustainable method of forest management. In other words, the producer can receive an annual income from the harvest of some mature trees and not only in one period which occurs with clear felling of the forest.

6.5 LOW IMPACT EXPLOITATION

With low impact exploitation one wants to achieve a harvest of mature trees with a minimum of damage to the future trees and the natural regeneration. It is very important to make an exploitation plan, that is to say maintain the extraction paths and fell a tree towards them and not at right angles, to facilitate the extraction of the log and cause the least possible damage to the other trees in the forest. Also work should not proceed after heavy rains, but should wait until the area dries out.

To minimize the negative impacts of the process of harvesting mature trees and competitors, the practice of **directed felling** should be employed. That is to say that the tree should fall in the direction where it causes least damage to the natural regeneration and the future trees. Those that are severely damaged in their trunk or canopy should also be felled for their exploitation. The same care should be taken in the process of extraction.

After the harvest it is important to perform post harvest management which consists in exploiting all the branches possible for firewood, then cut down all the remains of the canopy so that it comes into contact with the soil and so accelerates its decomposition. Also the natural regeneration should be cleared of the remains of the canopy. This work is usually done by machete. If there is no natural regeneration it is recommended to plant seedlings in those sites where they are needed.

Case Study 20: The native forest, my savings account, Julian Díaz, General Aquino

Julián Díaz and his family produce sesame for sale in the region of General Aquino. In the past, the management of native forest was not considered amongst the economic activities of the farm. From 2006, he started forest management on one hectare of his farm. The plot under management is secondary forest regenerated in an 18 year old fallow. It has an abundance of *Cedrela* spp. which is predominant in the plot. "*Before I didn't know what to do with my forest, I only used it to extract firewood and medicinal plants*", commented Julián. "*Then the technicians explained how to manage the forest so that it would produce more and of better quality.*"

The first step was to do an inventory, noting and recording in a plan all the trees of over 10 cm DBH. In the plan he noted the future trees, seed producers and harvestable trees. Harvestable trees were those over 40 cm DBH, seed producing trees were those of good size and healthy, future trees were from 2 m high and above, valuable timber species of good proportions and healthy.

Later he marked with different coloured tapes the future tress (red tapes), seed producers (yellow tapes) and trees for harvest (white tapes). In the 1 ha plot there were 360 future trees of 7 different species: *Cedrela*, *Piptadenia*, *Peltophorum*, *Albizia*, *Pterogyne*, *Cordia* and *Myrocarpus*.

The next step was clearing the future trees, cutting the lianas by machete and eliminating the competitors. With this work the desirable species with good economic potential were identified, it also allowed more light to enter which allows the trees to grow more rapidly and induces the appearance and growth of natural regeneration species.

In 2008, when the forest was 16 years old, trees with a big enough diameter were harvested for sale. "*I harvested 25 trees, all* cedro [Cedrela *spp.*] *which produced 7000 inches of planks and beams in total.*" In the local market he sold at 600 Gs per inch. The income generated was 4.2 million Gs, "*which is more than I made from the 2009 sesame harvest*" commented the farmer.

With these results the farmer is even more convinced that it is worth while managing the forest. "*The advantage is that it is little work, furthermore I can do it when there is no other work on the farm, and so I have my savings*

SUMMARY

Name, location, District and Department	**Julián Díaz, Hugua Rey, General Aquino, San Pedro**
Technician	**Ever Rebey**
Area of the farm	10 ha.
Family members	5 members in total.
Main activities	Production of maize, cassava, groundnut, beans and sesame.
Marketing	3 million Gs from the sale of sesame; 4.2 million Gs from the sale of timber in 2009.
Economy	Principally sesame.
Main impacts	The management of the native forest as an additional source of income.

Julián Díaz marking trees on his farm

account on my farm and I can use it whenever I wish", explained the farmer with a smile.

Experience has shown that with this practice it is possible to increase the yield of a native forest plot from approximately 3.2 m^3 to 5.3 m^3 per hectare per year. The increase in volume of the trunks of the future trees can increase by 270 percent (data from Unique Wood, Golondrina).

6.6 MANAGEMENT OF NATURAL REGENERATION

At this point it is important to point out that the process of development of a managed forest is very slow and the results will not be apparent immediately.

The care of natural regeneration was a very important learning process. Many farmers and technicians considered certain forests to be much degraded, even so when they started to identify the natural regeneration and the future trees they realized that the majority of forests have a high potential for production and regeneration.

To contribute to the appearance of natural regeneration it is important to identify the **seed trees**, clear weeds which compete with natural regeneration and keep the desirable trees clear of growth. In the case of a very closed canopy where little light can enter, it is possible to start a selective thinning to improve light penetration and so stimulate the germination of seeds.

An important fact to mention is that during the process of identification of the management concepts for natural regeneration, on the part of the farmers, they also analyzed the low cost of taking these measures. It is not necessary to acquire seedlings from nurseries, everything can be provided by the forest itself.

6.7 PRUNING

The native forest is not as demanding of manual pruning as the reforestation. In the forest there is natural pruning provided by the competition of the

neighbouring trees. Nevertheless it is a practice that can be employed to improve the value of the future trees. With a pruning up to 8 m high the harvested log will be free of branches and produce more high value timber. A pruning saw should always be used, avoid this pruning by machete, with the aim of not damaging the bark of the trees.

6.8 ENRICHMENT

Enrichment is an activity that is foreseen in more highly degraded forests, taking into consideration the availability of future trees and natural regeneration.

The experience of the PMRN indicates that the majority of forests do not need enrichment, they already have a large potential for natural regeneration (more than 90 percent of the forests that received management in the PMRN framework). This is to say that the majority have at least 150 future trees per hectare and/or a good natural regeneration.

For this reason the Project took the decision to not continue further with this activity as a component of the Native Forest Management measure. In specific cases where it was required, enrichment was combined with management of natural regeneration.

It is possible that cases of forests occur where there is the minimum required number of future trees but the variety of species is low. In this case it is also justified to enrich the forest with species that it does not have, be they high value species or species of use to the owner of the forest.

The best way to enrich is by **strip plantations**. This way it is easier to place and care for the trees. The strips are opened in an **east to west** direction so that the plants receive many hours of sun. Before planting, the strips must be well weeded for a width of 3 to 4 metres. The recommended distance between saplings is 4 metres.

Another possibility for enrichment is to plant the seedlings of high value species in an unsystematic way, that is to say only in those clearings and places where there is no natural regeneration. In this case it is advisable to place very visible stakes at the side of each plant in order to find them and to keep them free of weeds.

This practice is highly appreciated by those farmers who implemented it, for the good development and the ease of care. The species most appreciated in this activity were: *Tabebuia*, *Cedrela*, *Astronium*, *Torresea*, *Peltophorum*, *Pterogyne*, *Balfourodendron*, amongst others.

Species to plant in dry places: *Tabebuia, Anadenanthera, Cedrela, Peltophorum, Pterogyne, Cabralea, Copaifera, Balfourodendron, Cordia*, etc. Species to plant in wet places: *Cabralea, Enterolobium,* amongst others. The plants should have a height of approximately 50 cm, with a well developed root system and without damage or disease.

Experiences with the Project demonstrated that the majority of seedlings planted in the enrichment strips grow slowly, and in many cases more slowly than the natural regeneration. Also it was observed that the mean mortality

rate of the plants is 30 percent, in some cases up to 50 percent and in extreme cases 100 percent (Schrepel, 2010)[7]. The reason for this high seedling mortality could be due to their poor quality, poorly developed roots, damage during transplanting, too little light, wrong time of year, and a lack of cultural care.

It is important in enrichment to eliminate weeds and to maintain the planting strip open to permit the entry of sufficient light.

Case Study 21: Forest enrichment: savings account for my family, Mario Ocampos, Juan Manuel Frutos

The managed native forest is a permanent source of income for the family economy, it takes into account the conservation of the environment and functions like a savings account accumulating capital in the form of tree logs, delivering timber, firewood, charcoal, posts and serving as an environment for honey production and a refuge for wild animals.

The farmer claimed that a way of improving the family economy is the rational use of native forests by sustainable exploitation. For this reason Mario Ocampos opted for the enrichment of the forest with native species (*Balfourodendron*, *Astronium*, *Cedrela*, *Tabebuia* and *Cordia*) in addition to the existent natural regeneration which will serve as capital for future generations of the family.

With this system of management it was possible to identify the riches of the forest and, with a small amount of effort such as cutting lianas, opening and reopening of trails, marking trees and making an inventory, he gives an added value in the short term.

SUMMARY

Name and District	**Mario Ocampos, Juan Manuel Frutos, Guaviju**
Technician	**Agronomist Romoaldo González**
Area of the farm	15 ha: 1.5 ha for the house, fruit trees and garden plot; 8.5 ha forest; and 3 ha agricultural production.
Family members	The farmer and his wife.
Main activities	Agriculture and livestock raising.
Marketing	Sale of poultry (40): 1 million Gs in the local market. Sale of eggs, 300 dozen: 1.8 million Gs. Sale of cheese, 605 kg: 7.26 million Gs. Sale of piglets (10): 2.5 million Gs. Other income: 1.5 million Gs. Total income: 14.06 million Gs. (Without forest management or calves). Production costs: 7.2 million Gs.
Economy	Agricultural crops for family and animal consumption: Maize, cassava and pumpkin. For home consumption: beans, groundnut, and watermelon. Source of income: sale of small breed animals: hens, eggs, cheese, piglets and the sale of large animals is foreseen for April and May in 2011.
Main impacts	Forest enrichment, small-breed animals.

[7] Schrepel, J. 2010. Analysis of enrichment plantings in native forests of small-scale farmers in eastern Paraguay. Bachelor Thesis, Tharandt, Germany. 44 p.

Through a re-evaluation of the forestry systems, the heightened interest in them and the increase in forested area, a nursery was established through the committee where exotic species seedlings were produced which allowed a hectare of reforestation per member in order to enrich their farms and generate income in the short and long terms.

Availability of animals:

Poultry:	50 hens
	5 cocks
Pigs:	8 suckling pigs,1 pregnant sow
Cattle:	5 milking cows in production
	15 fattening calves
	1 bull

Mario Ocampos in this plot of forest enrichment

6.9 ACTUAL SITUATION OF THE FORESTS AND THEIR MANAGEMENT OPTIONS

To estimate the level of degradation, the following parameters can be used:

TABLE 6.1
Level of degradation of native forest

Parameter	Unit	Low	Intermediate	High
Base area	m^2/ha	>30	20 - 30	< 20
Standing volume	m^3/ha	> 200	100 - 200	< 100

Source: Grulke Markus, 2005

A study of farmer-plot forest inventories was made within the Project, the following are the mean results:

TABLE 6.2
Rapid inventory results

Department	Nº species	Average basal area and range, m^2/ha	Average volume and range, m^3/ha	Average harvestable volume, m^3 /ha
San Pedro 2 plots	19	16 (14.4 – 18.5)	74 (61.2 – 86.5)	31
Caazapá 35 plots	80	17 (5.9 – 62.2)	76 (21.4 – 281.7)	35
Caaguazú 8 plots	60	4 (1.2 – 6.7)	27 (6.9 – 72.2)	17

Source: Own data, 2010

It can be seen that the plots suffer a strong degree of degradation. Nevertheless, with adequate management the farmers can obtain large benefits, as can future generations. The values vary widely from one plot to another, which indicates the different levels of degradation.

6.10 FIRES AND OTHER FOREST DAMAGE

One outstanding negative experience was the burning of plots by third parties. The custom to clean fields with fire is strongly rooted in some farmers. This had a negative impact on the work and development of the managed plots.

In 2007, under extreme drought conditions, above all in the Departments of San Pedro, Amambay, Canindeyú and Concepción, there were huge losses of forest biomass occasioned by forest fires which were started spontaneously or intentionally and resulted in great damage to the forest plots.

At the smallholder level a reduction in burning in agricultural areas has been noted. "Controlled" burns can still be seen in regions of extensive cattle production which in most cases join areas the of forest remnants of the smallholders. This requires greater care on the part of farmers in order to avoid new damage in the areas of forest recuperation.

To avoid damage from fire, the farmer should not burn crop residues on the farm, especially in periods of drought. Neighbours should organize themselves to avoid burning and also to teach the lesson in schools. Also they should:

- Establish firebreaks 4 m wide and free of vegetation;
- Establish live barriers perpendicular to the direction of prevailing winds;
- Avoid the accumulation of organic residues near to the forest;
- Do not burn on the farm;
- Be alert to fires in the burning season.

In the case of forest fires they should be combated in an organized fashion.

In spite of the damage caused by fires, the forest has a high recuperative capacity. In a thesis study by a student of the FCA/CIF/UNA in forestry lots

of the PMRN beneficiaries in San Pedro Department, the following parameters were measured: physical damage to trees over 10 cm DBH; reduction in base area and; reduction in volume[8].

The native species of natural regeneration most affected were: *Cordia, Machaerium, Albiza*, and *Cedrela* and the species with the best regeneration after fire were species of the family Fabaceae (Leguminosae): *Albiza, Peltophorum, Pterogyne, Piptadenia*, amongst others.

It was found that trees of commercial species in burnt plots had a power of regeneration 6.5 times that of un-burnt plots.

The species most resistant to burning is *Balfourodendron*, whereas the most affected and vulnerable are; *Peltophorum* and *Astronium*.

To manage a forest after a fire, it is recommended to do **several weedings** to liberate the natural regeneration trees. Burnt or semi-burnt trees should be left standing until the forest recuperation is under way and the canopy is closing as this allows the natural regeneration to out compete the weeds.

In cases where the natural regeneration is not sufficient, the forest can be enriched by planting seedlings in strips.

6.11 GROWTH RATE AND ECONOMIC ANALYSIS

Field experience has demonstrated that the growth of a native forest without management is approximately 3 m^3 real/ha/year. With management this can rise to 5 m^3 real/ha/year. Also more high value species are obtained by selection and an increase in the growth rate of the future trees of 76 percent compared to future trees without management. In this way the value of the forest can be increased with only 15-20 days work a year (data from Unique Wood, Golondrina, Caazapá).

A sustainable harvest of 4 m^3 or 40 m^3 AP/ha/year at an average price of 50 000 Gs/m^3 AP will give an income of 2 million Gs/ha/year. In addition, if the economic value is calculated of the firewood that the farmer can sustainably remove from the forest for his own use throughout the year, this would round out at 80 000 Gs/year. This is approximately 4 "loads" of firewood, each "load" has about 1.3 m^3 and costs about 20 000. Adding together the annual yield of the forest means that the farmer "receives" from the native forest an economic benefit of 2.08 million Gs/year, or approximately US$250-300.

Compared to the income from agricultural enterprises per day of work, management of native forest represents an economically interesting activity. The farmer does not normally cultivate all his land and that forestry work can take place in slack periods for agriculture in winter.

[8] Echeverría Medina, CG. 2009. Definición de la distribución espacio temporal de incendios forestales e impacto del fuego en bosques manejados de pequeñas fincas en el Departamento de San Pedro. Tesis Ing. Forestal, San Lorenzo, Paraguay, FCA. 74 p. (Definition of the distribution of forest fires in space and time and the impact of fire on forests managed by smallholder farmers in San Pedro Department)

TABLE 6.3
Comparison of the net daily income for work in agricultural crops and forestry

Crop	Suppositions	Net income US$/ha/year	Work days/ ha/year	Net income US$/work day
Cotton	1 harvest/year	250	50	5
Sesame	1 harvest/year	800	70	11
Agroforestry (Cítrus)	20 year projection	1100	60	18
Reforestry	15 year projection	1000	15	67
Management of native forest	Average4 m^3/ha/year	250	15	16

Source: Borsy, Paul; 2009

CHAPTER 7

Agroforestry management

Agroforestry is a fundamental part of the integrated process of conservation and improvement of the soil. It is a strategy whose objective is to reinforce and establish sustainability in the fields of smallholder farmers through the promotion of productive diversification and training in the management of multi-storey systems. It is a system which combines trees with annual or perennial crops.

The advantage is that the same area produces timber, firewood, annual and/or perennial crops at the same time. Additionally the soil moisture is maintained, it affords protection against winds, gives shade, protection and food for animals, increases biodiversity on the farm and can function as a barrier against pests and diseases. The half shade can favour some crops, but on the other hand can reduce the yield of others.

The demand for firewood of a smallholder family is approximately 22 m^3/year, which is very high. Other energy alternatives are little disseminated. Incorporating tees in the farm allows the family to meet the energy demands of the household.

In the Project framework the requirement for this measure is a density of at least 100 trees/ha and the following agroforestry systems can be identified:

- Agro-fruit-forestry
- Agricultural crops with forest trees
- Yerba mate associated with forest trees
- Coconut, agricultural crops and trees
- Mixed kitchen plot
- Silvo-pastoral systems
- Windbreaks
- Living fences.

The systems with the greatest adoption are the **agro-fruit-forestry system in Caazapá,** annual crops with forest trees in the majority of the PMRN zones, **silvo-pasture in Repatriación** and **forest trees with coconut in Paraguarí.**

According to interviews conducted by the Project[9], the majority of farmers consider that agroforestry is important for the production of timber and firewood, with a projection towards retirement or for their children. Eighty seven percent of those interviewed do not see any disadvantage of the agroforestry system and few (5 percent) mentioned a reduction in yield of the agricultural crop. However, several indicated that the management of the annual crop is more complicated with trees. The increase in soil moisture (87 percent) and the increase in soil fertility (95 percent) are considered to be advantages. The interest of the family and young people in the system is also considered to be important. Many have already increased their area under the agroforestry system. Thirty seven percent of farmers interviewed believe that the forestry part will play an important role in the future of the farm.

7.1 THE AGROFORESTRY SYSTEM

To include timber trees on the farm it is recommended to plant about 100 trees per hectare of exotic, native or a mixture of species. Spacing will depend much on the planned association. Different spacings are used, for example: 10 m x 10 m, 8 m x 8 m, 8 m x 6 m, 10 m x 5 m, etc.

If the objective is reforestation, the density should reach at least 625 trees/ha (4 m x 4m). In this case, agricultural crops can be cultivated for the first 3 or 4 years. This density permits the farmer to sow his annual crops between the rows of trees. As the trees grow, the shade can affect the yield of the annual crops, but on the other hand there is a profit from the timber, firewood and half shade. There are several crops which grow better or at least withstand the half shade produced by the trees. Amongst them are pineapple, yerba mate, coffee, citrus, banana, etc. There are farmers who have very good experience of *Stevia rebaudiana* in half shade.

7.2 AGRO-FRUIT-FORESTRY

A system that has been well worked out, proven and recommend by the Fruitika Company is the combination of timber tees with citrus. Plants of lemon, orange and grapefruit must be free of diseases and seedlings should be acquired from a qualified nursery.

A wide range of forest species can be planted with the citrus, such as: *Cordia* spp., *Peltophorum* spp., *Cedrela* spp., *Balfourodendron* spp., *Hovenia* spp., *Toona* spp., *Albizia* spp., *Eucalyptus* spp., *Gossypiospermum* spp., *Grevillea* spp., etc.

[9] Albrecht, V. 2010. Posibilidades y límites de la realización de la agroforestería como forma sostenible del uso de la tierra – mostrado al ejemplo de los pequeños productores en el oriente paraguayo. Tesis de Geología, Münster, AL. Universidad Münster. 153 p. (Possibilities and limits of agroforestry as a sustainable form of land use – the example of smallholder farmers in eastern Paraguay. Geology thesis, University of Münster, Germany).

With the citrus and forest species in at least the first three years it is possible to grow annual crops such as: maize, cotton, cassava, sesame, beans, groundnut, etc. cultivated between the rows of citrus and forest trees to achieve an integrated use of the space.

In the case of **orange** it should be planted at a spacing of 7 m x 5 m. Forest species are placed every 2 orange plants, that is to say at a spacing of 7 m x 15 m.

Associated with grapefruit, the forest species should be planted at a spacing of 8 m x 8 m, the grapefruit between the rows of forest species, also at a spacing of 8 m x 8 m.

Case Study 22: "From deception to optimism via conviction", Carlos Bogado, Caazapá District

In Loma Hovy company, 10 km before arriving at the city of Caazapá and 5 km from the black-top road, lives Carlos Bogado with his family: his wife and 4 children (3 boys and one girl), where he devotes himself to agriculture with the help of his oldest son.

Don Carlos commented that back then before 1999 he was de-motivated and totally disillusioned by agriculture as can be understood from his own words, "*Nda hupivei mba´eve kokuégui, cada año hetave hembiapo, vicho ha ñana avei, amba`aporei, ahekatamante otro tembiapo" (I don't harvest anything from the farm, each year gives more work, there are more pests and many weeds. I work without reward and I am going to have to look for another job).*

In the same year he received a visit from a technician of DEAg, Mario Arévalos. After a pleasant chat they agreed to form a farmers' committee and receive guidance from the technician. In 2003 they presented a request to the PMRN for help with soil management, reforestation and agro-fruit-forestry. It was accepted and they started to work with their CA system.

At the outset they received much criticism from their neighbours: "*koâva atey rembiapo, la abono verde ko ñanaicha ojagarrapata kokue ha ndaipu´aka moaveitama hese, ho´upata ikogakuera*" (this work is for idlers, the GMs are like weeds, they are going to cover the whole farm and you are not going to be able to control them, they will drown out all the crops).

In spite of the numerous difficulties, drawbacks and so much uncertainty, Don Carlos continued ahead with a strong conviction and today, a little more than 5 years after having started his conservationist system, he completely covers his 8 ha with annual agricultural crops, fruit trees and forest species and in addition has a large number of farm animals. He has managed to increase the yield of his crops: in white maize from 600 kg/ha to over 1300 kg/ha; cassava from 9 to 15 ton/ha; and giving sugarcane the biggest boost in yield from 45 to 120 ton/ha. This was after 4 years of soil recuperation with GMs which caused satisfaction from the technician and surprised the farmer, the members of the committee and the neighbours who had formerly criticised

Carlos. Also he has incorporated other good cash crops on his farm which he did not have before, such as: orange, sesame, forestry species, all this working with only his son to help.

Today he is starting to sell his oranges, in the first harvest of 0.75 ha at 4 years he sold 6000 fruits for Gs 480 000, sold to buyers at the farm gate.

With the sugarcane, in spite of the strong increase in yield achieved, they came up against a problem with the market due to the distance from farm to mill leading to the well known losses in marketing costs, yield and quality. Even so, with his greatly improved management skills, together with other neighbouring farmers, they have managed to form a sugarcane producers' association and they are engaged in installing a cane juice extractor and a small factory to produce molasses and brown sugar.

Don Carlos commented that one of the things that gave him most satisfaction was that his brother, Victoriano Bogado, whose farm adjoins his own, after 5 years of criticism and permanent hostility asked him one day, "*may I harvest GM seeds from your farm to sow them in mine and start CA?* Today Carlos Bogado lives as a community leader, satisfied with his achievements and with an optimistic outlook for the future of his family.

Another possibility is to plant forest species as a windbreak around the agricultural fields, associated with citrus or other fruit trees and other shorter species. The spacings most used are: 3 m x 3 m and 3 m x 2 m.

In the case of **banana**, forest trees are planted at a spacing of 10 m x 5 m and in between the lines, two rows of banana are planted at a spacing of 3 m x 3 m. An estimated average net income of 4 million Gs (or US$890) is expected per ha per year for agroforestry systems with orange, and US$1100 with grapefruit.

Yerba mate and coffee are associated in the same way as fruit trees, with a spacing of 9 m x 6 m for the forest trees and 3 rows of yerba mate or coffee at a spacing of 3 m x 3 m between their lines. The experience of one farmer who associated yerba mate with mucuna was to increase his yield of yerba mate from 5000 kg/ha to 8500 kg/ha. In addition, the work of weeding was reduced because so few weeds emerge.

Case Study 23: Yerba mate associated with GM, Asdrúbal González, 3 of February District.

Asdrúbal's main enterprise is yerba mate which he previously managed conventionally with manual weeding (plough and hoe). In most years the plots were left weed infested as a result of economic problems (he did not have cash to pay the day labourers) and increasingly the plots were invaded by couch grass (*Cynodon dactylon*) and *Killingia odorata*. With this production system the yield was 2543 kg/ha. At one point he thought to sell his farm to the Brazilians.

One day he participated in a field day in the area of influence of the PMRN. From that moment he changed his opinion and appreciation, leaving to one side the desire to sell his farm. He started implementing conservation measures through the use of pigeon pea and canavalia in the inter-row spaces between yerba mate, which gave immediate good results. These activities also helped to conserve water in the soil, reduce erosion, gave good soil cover, better development of the leaves of the yerba mate and good weed control. Adoption of these measures resulted in a yield increase to 4772 kg/ha. He marketed the crop through wholesalers in the region at a price of 550 Gs/kg.

The farmer observed that with the use of GMs and with a minimum of effort he is improving his soils and his yerba mate production. He will always continue sowing summer and winter GMs in his fields, as well as practising crop rotations. With this new technology incorporated, the farmer increased considerably his income with less work on the farm.

Impacts: The farmer observed that the incorporation of GMs in his farm, and their association with yerba mate, favoured his land in many ways. Actually he is no longer worried by the *Cynodon* and *Killingia*, which used to be a headache for him. Through the employment of pigeon pea, canavalia and black oat in his fields, the farmer actually has more time to do other things. As a result this allows him to generate more income and improve the quality of life of his family.

SUMMARY

Name and District	**Asdrúbal González, 3 de Febrero District, San Pedro Company**
Technician	**Environmentalist. Gustavo Giménez**
Area of the farm	10 ha of which 1 ha is for the house and fruit trees, garden and natural regeneration; 4 ha is pasture; 5 ha of agricultural production, of which 4 ha are cropped with yerba mate; beans, maize, groundnut, GM; and animal production (cattle, poultry and pigs).
Family members	Farmer, his wife and 3 children.
Main activities	Agriculture (cassava, yerba mate) and animals.
Marketing:	Production of yerba mate, 4 ha:19 088 kg, 10 498 400 Gs. Cattle, 2 units: 5 million Gs. Cassava: 28 000 kg, 8.4 million Gs. Pigs, 3 units: 1.35 million Gs. Other income; 1.5 million Gs. **Total income: 26 748 400 Gs.** **Cost of production: 12 780 000 including family costs.**
Main impacts	Improved production of yerba mate with GMs: fewer weeds, more moisture, higher yield and income.

Asdrúbal González's yerba mate plot associated with black oat.

Pineapple can be planted for the first six years between the tree rows. According to farmers' experiences, the half shade delays the maturity of the fruits and allows later entry into the market, with a higher price. Other farmers combine pineapple with crotalaria or pigeon pea for half shade.

In Paraguarí and Horqueta they are practising the system of **coconut,** at 6 m x 6 m, associated with timber trees at a spacing of 12 m x 6 m. The coconut competes very little with agricultural, forestry or livestock production and gives an additional income to the farmer.

One can expect a yield of 1 to 1.5 boxes per year for each pair of trees, or 25-35 kg per coconut palm. Experience in Paraguarí demonstrates that in plots recuperated with the PMRN package, coconut production was increased from 1 box per 3 palms to 1 box per 2 palms[10].

In the first years, beans of various types, cassava, maize and other crops can be planted between the palms.

In all cases it is recommended to sow GMs as a natural fertilizer, to maintain soil moisture, help to control weeds and so reduce manual labour.

Forage groundnut will maintain a very good cover in perennial crops, canavalia and mucuna add nitrogen, crotalaria is good for nematode control in banana and pigeon pea will add nitrogen and eliminate weeds when sown at appropriate densities.

Case Study 24: Production and marketing of coconut, Paraguarí Department

Paraguarí is one of the Departments that has most worked with coconut, considered as the cash crop of greatest importance to smallholder farmers,

[10] Borsy, P. 2010. Agroforestry systems of the IASA company (interview). Paraguarí, Paraguay

after vegetable production. In the Department there are several processing companies and wholesalers of coconut, amongst them IASA works exclusively with smallholder farmers in Pirayú and Yaguarón Districts where it has its collection centre.

For better production and marketing an agreement was signed between DEAg, GIZ and the IASA Company. By means of this agreement the delivery of raw material to the company was improved as can be seen in the following table:

Marketing of coconut from the smallholder committees to IASA

Year	Number of boxes	Price per box, Gs	Total Gs
2008	3200	12 000	38 400 000
2009	32 500	14 500	471 250 000
2010*	**60 000**	14 000	84 .000 000

* estimated

IASA and DEAg installed four GM seed production plots, the most important being *Cajanus cajan*, *Crotalaria juncea* and *C. espectabilis*. The seeds were distributed to 25 farmers in the region of Zambonini and Guayaibity.

In addition to this, the farmers also had access to a truck to transport the coconuts at 50 percent of the normal cost, and this helped the supply of coconuts from the smallholder farmers. Additionally a collection point was established in Yaguarón to facilitate the delivery of coconuts brought by producers in their own carts, this largely avoided the use of intermediaries.

To compare the yield of coconut in plots with degraded and improved soils (with the PMRN packet), coconut palms were marked and observed with one of the PMRN beneficiaries of the Oñondivepa committee, Guajayvity Company. The results showed a good response of the coconut to GMs like pigeon pea and mucuna.

	Control plot	Plot with improved soil
Production	1 box per 3 palms.	1 box per 2 palms.
Bunches per palm	3 bunches per palm where leaves are used for fodder. 8 bunches per palm without leaf pruning.	14 bunches.

Hernán Solalinde, the technician of the region related that the majority of farmers, through ignorance, used the leaves of the coconut palms as forage for their animals (cattle and horses) and as a result the production of nuts fell considerably. Now farmers sow sugarcane and Cameroon grass as forage and so have eliminated cutting the palm fronds for this purpose.

Coconut production in recuperated plots.

Farmer Zacarías Estigarríbia mentioned that his main enterprises are groundnut and beans, and his secondary enterprise is coconut. With this income he maintains 4 people (his wife and children).

Crop	kg/box	Gs/kg/box	Total Gs
Groundnut	2000	2800	5 600 000
Beans	3000	2000	6 000 000
Coconut	60 (boxes)	14 000	840 000

At the moment there is a plan to develop the plantation of coconut on the farm with the aim of increasing to 1200 plants/ha. At this density the farmer will earn approximately 5.4 million Gs/ha/year, whilst with the 100 plants, which most farmers actually have, the income is 300 000 Gs/ha/year and the time for harvest is much greater.

7.3 AGRO-SILVO-PASTORAL

The incorporation of trees for cattle has the advantage that the trees **protect the animals against frost**, wind, sun and rain. In the winter of 2010, many animals died in Paraguay apparently from the combination of cold, rain and wind, which could have been avoided with the incorporation of trees in the farm. Also the trees produce an additional income or they can be used by the family for firewood and timber.

Principally there are two possibilities for combining the forest with livestock. The first is the incorporation of the animals in the **native forest**;

and the other is the incorporation of the animals in **plantations**. The native forest needs a weeding and a heavy thinning (leaving approximately 150 trees/ha) to be able to incorporate grass in the forest. The animals do not let the natural regeneration grow. If it is required to introduce saplings, these must be protected against the animals or the animals must be removed for a considerable period.

In the case of **plantations**, 100 to 200 plants/ha can be planted and after thinning these can be reduced to 150 trees/ha, which is considered to be the optimum density. To lower the costs of production it is recommended to start the reforestation together with an annual crop such as cassava or maize for the first 2 to3 years. From the third year grass can be established between the rows of trees. The grass can be *Panicum* spp., *Axonopus compressus*, *Brachiaria brizanta*, *Panicum maximum*, etc. The trees should be native species or exotics or a mixture of the two (*Grevillea, Eucalyptus, Pinus, Hovenia, Melia, Peltophorum, Balfourodendron*, etc.).

Leucaena is a very good legume for animals (See 3.2) and can be incorporated into the agro-silvo-pastoral system by planting, for example, two rows of leucaena between the tree rows. With this the animals' weight will be considerably increased and can achieve approximately 800 g/day/head.

Another system practised is reforestation at a higher density (250 to 370 trees/ha) from 9 m x 3 m to 10 m x 4 m with eucalyptus, plant an agricultural crop for the first three years (cassava, maize, soya) and then sow grass between the trees. From the fourth year the animals can be grazed at a density of approximately 1.5 animals/ha/year and at the same time the farmer can obtain 20 to 30 m^3 of timber per hectare per year. The timber is harvested every 10 to 15 years after which the re-growth is managed in the case of eucalyptus.

Case Study 25: Agro-silvo-pastoral production system, José Zaracho, Guajayvi District

"*My short, medium and long term savings account is the combination of agro-silvo pastoral enterprises*".

José Zaracho is a farmer who started to work with the PMRN Project in 2005 and he agreed to reforest 1 ha at a density of 4 m x 4 m, for which he opted to work with the following native species*: Peltophorum, Piptadenia, Tabebuia*, and exotic species such as *Melia azedarach* and *Grevillea robusta*.

It should be pointed out that this farmer only has 5 ha of land in which he is successfully implementing this practice, in contrast to many other farmers in the region who allege lack of land or the small size of their farms as an excuse to not introduce new working practices.

In the reforestation plot, from the time that he started with the first seedlings, he has continued to practise his normal agricultural production, sowing traditional crops for sale and home consumption and associating them with GMs for his own use and for sale.

José Zaracho with a pruning saw in his hand explains to other farmers his management of an agroforestry plot

Mr Zaracho plans, in the medium term, to devote his reforestation plot to fattening cattle. From the fifth year he can graze three animals of 200 kg each, or a total of 600 kg/ha/year. For each animal he hopes to generate an annual income of 324 kg or 972 kg of gain/ha/year. In Asunción he would be earning 6 804 000 Gs, plus the income generated by the reforestation, through the production of firewood and timber from thinning and prunings.

The following table shows the income generated in the short term by different agricultural crops (maize, cassava, groundnut, sesame, sweet potato and beans). This income comes from production on less than 1 ha, whilst the products of reforestation generate income in the future.

Years	Enterprises	Income
2005/2006	Agricultural cash crops	2 479 500
2006/2007	Agricultural cash crops + GMs	4 231 500
2007/2008	Agricultural cash crops + GMs	892 500
2008/2009	Agricultural cash crops + GMs	499 250
2009/2010	Agricultural cash crops + GMs	6 549 250
Total gross income		**14 652 000**

Projection beyond five years

Years	Enterprises	Quantity	Price	Income, Gs
6 to 8	Animals	972 kg	7000 Gs./ kg /LW	6 804 000
8 to 10	Animals Firewood Timber	1944 kg 11 m^3 323 m^3/AP	7000 Gs./ kg/LW 25 000 Gs./m^3 25 000 Gs. m^3/AP	13 608 000 275 000 8 075 000
10 to 12	Animals	1944 kg	7000 Gs./ kg /LW	1 608 000
12 to 14	Animals	1944 kg	7000 Gs./ kg /LW	13 608 000
14 to 20	Animals Timber	5832 kg 3300 m^3/AP	7000 Gs./ kg /LW 25 000 Gs./m^3 AP	40 824 000 82 500 000
Total approximate gross income in 20 years				**193 954 000**

LW: live weight; AP: Alto Paraná

Annual income would be 9 697 700 Gs.

Note: The costs and expenses need to be subtracted to calculate the net income in the case of the crops, the production costs; in the case of animals, the purchase price, health care and management; in the forestry part the costs of pruning, thinning and marketing.

Comparison of annual gross income by enterprise for the plot

Enterprise	Gross income/years	Income/year
Agricultural	14 652 000/5 years	2 930 400 Gs/year
Cattle	13 608 000/2 years	6 804 000 Gs/year
Forestry	91 337 500/20 years	4 566 875 Gs/year
Combining the 3 enterprises over 20 years gives a greater income is obtained than with any one alone		9 697 700 Gs/year

SUMMARY

Name and District	**José Zaracho, Guajaybi District**
Technician	**Osmar Aquino**
Area of the farm	5 ha.
Family members	His wife and 9 children.
Main activities	Agriculture: mainly pumpkin, squash and GMs combined with small-breed animals.
Marketing	The agricultural production is sold in the wholesale market of Asunción in coordination with other farmers of the region.
Economy	The economy of the family is sustained by the agricultural production of the farm, combined with occasional off-farm work with an estimated total for the farm of 12.8 million Gs from which there are costs for the children's education, light, health which amounts to some 9.54 million Gs per year. **Income: 12 000 000 Gs.** **Costs: 9 540 000 Gs.** **Net income: 2 460 000 Gs.**
Main impacts	Increase in income/ha as a result of combining the 3 enterprises: agriculture, livestock and forestry, because they complement each other. Reduction in maintenance work in the forestry plot as a result of working in it all the time. Reduction in weed pressure because of the use of GMs and trees. The trees protect the agricultural crops and the animals creating a microclimate to protect from frosts and solar radiation. The practice of using GMs and forestry has been copied by neighbours to whom the farmer provided GM seeds, which became an additional source of income for the farm.

7.4 MIXED FARMING, WINDBREAKS AND LIVING FENCES

The idea of the **mixed vegetable plot** is to maintain the maximum diversity in the plot nearest to the house, of timber trees for shade and firewood, fruit trees for food, medicinal plants and a vegetable plot for home consumption or sale. The are no recipes for this combination, but 50 timber trees and 20 fruit trees around the house can be recommended for the system.

Windbreaks are to protect annual and perennial crops as well as animals, against wind, frost and pests. They should comprise three strata; high, medium and low. For example *Grevillea*, *Eucalyptus*, *Cordia, Samanea*, etc., as the high stratum; *Inga*, orange and star fruit (*Averrhoa carambola*) as the middle stratum; and elephant grass, sugarcane, pigeon pea, *Alysia triphylla* and *Pogostemon cablin*, as the lower stratum.

Living fences are trees or bushes which form a barrier, they can be pigeon pea, *Aloysia triphylla*, *Pogostemon cablin,* Cameroon grass, bamboo (*Chusquea* spp.), *Poecilanthe parviflora* and *Mimosa* spp. amongst others.

CHAPTER 8

Forest products

8.1 FIREWOOD AND CHARCOAL

Firewood continues to be the principal source of energy in the country (74 percent of the total consumption). In rural homes the annual demand for firewood by a farm family is approximately 22 m^3. In addition an important part of the charcoal produced is exported to neighbouring countries. Although this is declining because the activity is consuming the forest remnants and so the authorities exert greater control to prevent excessive deforestation. About 70 percent of the annual extraction from the natural forest is used for firewood and vegetable charcoal. This production is not sustainable because the extraction rates from native forests are much higher than the regeneration, with no management plan.

According to data from REDIEX[11], between January and November 2010 charcoal exports had a value of US$32.8 million, whereas in 2008 the value was US$401 million and US$37.9 million in 2009.

Farmers are making full use of the thinnings that they carry out in their reforestation plots. In the case of forest they make use of trees that have fallen, are twisted, very thin, competitors, etc. for use as firewood, charcoal and posts. Also, at the right time they exploit and market timber logs. This situation represents a very important source of income for the smallholder, especially in times of shortage of cash.

Case Study 26: Timber and charcoal production, Filemón Cabral, San Juan Nepomuceno District

Filemón Cabral is a farmer with 17 ha in the District of San Juan Nepomuceno. Since 1997 he has been engaged in forestry activities (reforestation) on an area of 0.75 ha with *Melia*, *Eucalyptus* and *Hovenia* species on his property.

In 2004, with help from the PMRN, he established a second plot of 0.75 ha of reforestation with exotic species (*Melia*, *Eucalyptus*, *Pinus* and *Hovenia*) and this gave him a total of 1.5 ha of reforestation and 1 ha of agro-fruit-forestry. In the last few years, the reforestation has constituted one of the principal sources of income for the farm with the products being sold as timber and charcoal. The farm also produces cash crops like cotton and *locro* maize principally, home-consumption crops such as various types of maize, beans, groundnut, sugarcane, cassava, vegetable garden, fruits, and animal raising: milk cows, poultry, pigs and honey bees.

[11] http://www.rediex.gov.py/cuadros-estadisticos-de-comercio-exterior-exp13

The farm is managed in its entirety on principles of conservation (NT and minimum tillage) on an area of 7 ha where Don Filemón cultivates the cash and home consumption plots.

Timber is marketed through buyers who come from San Lorenzo and charcoal through local traders. Agricultural crops are marketed communally through the Farmers' Organization Ara Pyahu Oñondivepa, which is a second level organization of which the San Fermin committee is a member (supported by PMRN) and Filemón Cabral is a member of this committee.

It can be confirmed (see the following table) that the income from reforestation (sale of timber and charcoal) has increased considerably in the last few years.

Reforestation plot, 0.75 ha, 12 years old

Product sold	No of harvests	Years since planting	Year of harvest	No plants	m^3	Price Gs/m^3	Gross income Gs	Total costs Gs	Net income Gs
Melia timber (Paraíso)	1º	8	2005	17	38	15 000	570 000	Assumed by the buyer.	570 000
	2º	11	2008	95	219	16 000	3 504 000	Assumed by the buyer.	3 504 000
Reforestation plot, 0.75 ha, 5 years old									
Eucalyptus charcoal		5	2008	150	150 bags	6000 Gs/bag.	900 000	322 500	577 500
12-year reforestation plot, from poorly performing or infected trees									
Eucalyptus charcoal		12	2008	No data	400 bags	4000 Gs/bag.	1 600 000	860 000	740 000
Total from the 2 plots							**6 574 000**	**1 182 500**	**5 391 500**

Filemón Cabral's charcoal oven.

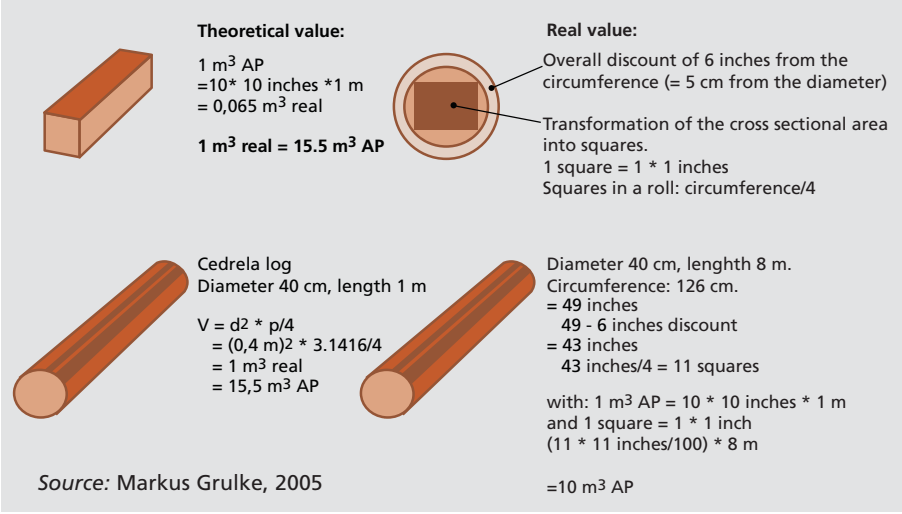
8.2 TIMBER IN LOGS AND SAWING

Commonly the great majority of farmers sell their timber products illegally, that is to say without management plans or transport authority, selling the standing trees at relatively low prices. Further the tree-buyers do the surveying and extraction of the trees without caring for the remaining forest. Also, the majority do not have legal title to their land and so in this way, with the traditional system of marketing, the smallholder producer is doubly harmed: he receives little money for the tree and his forest is damaged owing to harvesting with a high negative impact.

In Paraguay two types of measurements are used to quantify the volume of trees and logs, these are;

- **The 'real' cubic metre**, this is calculated from the volume of the cylinder and is corrected for the cone shape of the tree with the corresponding coefficient (it represents a volume of 1 m x 1 m x 1 m). It is mainly used for forestry inventories, transport authorities and international commerce.
- **The 'Alto Paraná' cubic metre**, is used for marketing logs and for all the activities relating to the harvest and extraction of trees from the forest. It is the unit which is used by Paraguayan producers and in the national market for the sale of timber logs. To convert 1 m^3 real to a m^3 Alto Paraná (AP) there is a theoretical relationship of: 1 m^3 real = 15.5 m^3 AP; nevertheless in the practice of marketing there is a discount for bark and textural defects and the 'square which enters the circumference' is calculated. By this means, a log of 20 cm radius and 8 metres in length which has a volume of exactly 1 m^3 real, after the transformation would have only 10 m^3 AP.
- **The metric inch**, is used to measure sawn timber. A metric inch is 2.54 cm x 2.54 cm x 1 m. 1 m^3 real = 1550 metric inches.

FIGURE 8.1
Measurements for tree volumes



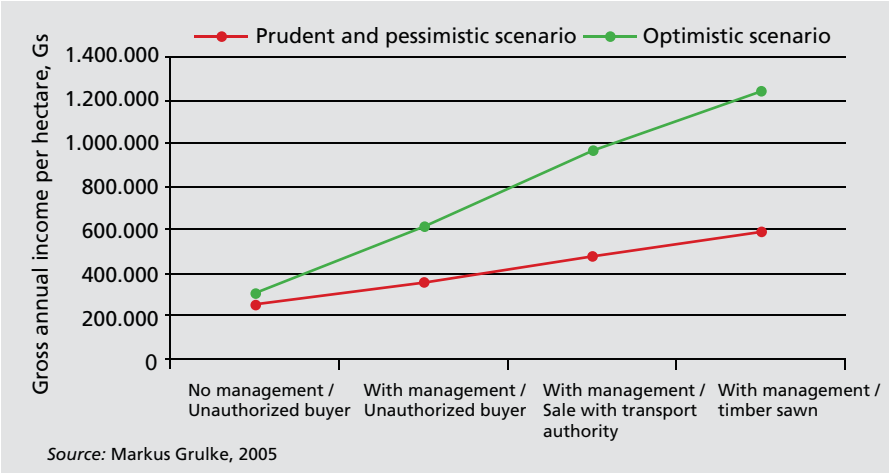
Source: Markus Grulke, 2005

The Project's farmers who have the necessary tools for forest management, such as a chain saw and draught animals with carts are already adding value to their raw material which is the standing tree. They process them to make beams, and planks and, at the same time, make use of the residues for firewood or as well sell them to the industries who use this type of fuel for their ovens, such as tobacco processors or brick makers.

PMRN recommends sawing the timber to give the producer a greater margin (added value). The following graph is from a study by Marcus Grulke and shows the economic potential of timber with added value.

The timber from a managed forest, with forestry authorization and already sawn has a value six times greater than timber sold illegally to unauthorized buyers.

FIGURE 8.2.
The economic potential of the sale of timber by the smallholder producer



Source: Markus Grulke, 2005

Case Study 27: Legal sale of timber, Culantrillo, Repatriación

This is the experience of a group of 12 farmers from 3 committees supported by the PMRN in the Culantrillo Company of Repatriación District, Caaguazú Department. They made plans to manage the forest to be exploited, all the process was detailed from the formulation of the documents, use of transport authorization and up to the use of the mobile saw mill. The advantages of the mobile saw mill are:

- Improvement of the precision of cutting;
- Increased yield;
- Reduced transport costs.

We can conclude that milling the timber gives a greater gross margin to the producer.

The requirements of those producers who do not have land title are the following:

1. Resolution of INDERT recognizing occupancy.
2. Register of the forest by producer, or in conversation with the INFONA authorities, if the sale of timber involves members of a committee, this register can be just one for the whole committee.
3. Photocopy of the identity card of the farmer.
4. Certificate or evidence of occupation by the farmer from INDERT.
5. Work plan for management formulated by the district forestry chiefs which contains:
   - Farmer's name.
   - Location and area of the plot.
   - Type and characteristics of the forest plots.
   - Inventory of the existing species and those to be exploited.
   - Commercial volume.
   - Details of the extraction plan, and of the network of existing tracks or those to be constructed, if relevant.

Also a tax for the Forest Registry of 50 000 Gs was paid. Through discussions with the authorities involved it was agreed that this payment can be paid per committee rather than by each farmer. The exploitation of the trees to be harvested was planned to be able to request the corresponding forestry authorizations for transport.

All this process should be accompanied by technical assistance from INFONA or some other entity. The PMRN undertook this process in the years 2006 and 2007. In this case the process took more than a year.

For marketing the timber logs, the best option, economically, for the producer was selected, and for that the sale of sawn timber with the use of a mobile saw mill was chosen.

Summary of results from Culantrillo

	m^3 AP	Value, Gs	Value, US$
Harvestable timber according to forest inventory	2400		
Total harvested volume	1232	24 866 688	5800
Volume harvested per hectare	76.9		
Volume sold	661	13 341 624	3100
Volume used locally	571	11 525 064	2700
Income per m^3 AP average		20 184	4.7
Cost of forestry authorization per m^3 AP		700	0.2
Cost of felling per m^3 AP		*1750	0.4
Cost of extraction per m3 AP		*3000	0.7
Total harvesting cost per m^3 AP		5450	1.2
Profit per m^3 AP		14 734	3.4

* These are labour costs assumed by the farmers with no cash payment

With the regional prices pertaining at the time, the income of the farmers for the sale of timber in logs (without authorization) would be 10 595 200 Gs compared to 24 866 688 Gs (sale of timber with forestry authorization). We note that the difference is 14 271 488 Gs to the credit of the producers. This is the amount that producers lose if they sell their timber in a scenario of illegality and informality.

8.3 NON-TIMBER PRODUCTS

Native forests are not only valued as producers of timber and firewood, they also offer non-timber products, **environmental services** such as the production of **clean water**, **oxygen**, **carbon sequestration** and the avoidance of soil erosion. However, this evaluation does not translate into economic income for the owner of the forest. Actually a monetary value is attributed to these intangible values by means of mechanisms of "payments for environmental services" and through "Reducing Emissions from Deforestation and Forest Degradation – **REDD**), "payments for nature conservation" and others. These instruments are being put in place in the country but their definite implementation has yet to be achieved.

The forest is important for landscape enhancement, protection against environmental phenomena such as microclimates for the survival of distinct species, as a refuge or reserve for flora and fauna and for aspects of biodiversity.

The most tangible non-timber uses of the forest are mainly based on medicinal plants such as *Dortensia brasilensis*, cat's claw (*Uncaria tomentosa*), Surinam cherry (*Eugenia uniflora*), *Peperomia ciclophyllia*, club begonia (*Begonia cucullata*), ambay pumpwood (*Cecropia adenopus*) amongst others. We also obtain from the forest edible products for human consumption, such as honey, fruits and animal protein which come from the rational and sustainable exploitation of wild animals.

Farmers also obtain from the forest the raw material for organic phytosanitary products, examples are: scratch bush (*Urera baccifera*); smart weed (*Poligonium acre*), *Rapanea lorentziana*. Leaf litter is also used as organic manure in vegetable lots and farm fields and also in nurseries as a substrate. Tannin can be extracted from the wood of the quebracho tree (*Schinopsis* spp.) this has been used since colonial times when it was an export product but today it is little exploited; there are other extracts, for example resin from *Bulnesia* spp.

Other benefits of the forest include the tourist industry for observing wild animals and for photographic safaris.

With these options, farmers have greater additional economic resources at the moment of exploiting their natural resources.

Case Study 28: Ecotourism on the River Aquidabán

On its way through Concepción Department, the River Aquidabán bathes the coast of the Punta Porá Ñú community some 32 km from Yby Yaú city on the road to Pedro Juan Caballero. Here are the members of the Agro Poty committee who practise CA, small breed animal raising, bee keeping, controlled fishing and ecotourism.

The members of this committee manage the forest within the guidelines of the PMRN. The managed forests are in the areas of protection for the River Aquidabán, following its margins and rich in timber species (such as *Torresea, Cedrela, Tabebuia, Cordia, Peltophorum, Piptadenia, Myrocarpus*, etc.). It is a source of firewood for domestic use, for bee production, fishing and a source of water for irrigating the horticultural production.

Each farm is adjacent to the river in whose margins, in the forest and metres from the river, are situated the rustic cabins with every comfort for a few days of fishing and canoe trips. All this is in full contact with the natural environment offered by the river and the managed forest, with nature trails to appreciate the exuberant tree and the huge bird population.

This activity brings the farmers an important additional income, all the guests are Brazilians who arrive from cities such as Ponta Porá and Dorados in the neighbouring country. They are attracted by the natural riches, the varied fish, the tranquillity of the environment, the good food and the amiability of the people.

Managed forest plot being used for bee keeping.

CHAPTER 9

Economic, social and ecological impacts

This Chapter presents some of the results of an impact evaluation carried out in 2010 and of an economic study from the same year.

9.1 YIELD AND LABOUR

Yield increase has one of the most dramatic impacts according to the farmers, together with the reductions in weed populations and labour requirements (See Table 9.1).

Already in the first year of implementation of the soil improvement measures, farmers achieved a considerable increase in yields compared with the same period and crop under the conventional system. This is due not only to the introduction of GMs but also to various other factors:

- An increase in plant populations/ha.
- Selected or improved seed.
- Sowing at the right time.
- Weeding at the right time.
- Green manures.
- Chemical fertilizer.

In the NT plots it was observed that soil fertility is maintained with GMs and that the farmer can increase and maintain yields without the need to purchase chemical fertilizers and without additional investments. If the farmer opts to buy chemical fertilizers and high genetic potential seeds, the possibilities for yield increases are even greater; however the costs of production and risks are both increased. It would be prudent, after a period of implementing a CA system, to evaluate the ratio of costs and benefits of the acquisition of these inputs. Yield increases over the years are shown in Table 9.1:

TABLE 9.1

Percentage of farmers with maize yield increases in the plots receiving technical assistance

Increase, percent	2005	2006	2009	2010
<0	15	15.7	4.3	0
0 – 49	32	32.5	22.4	30.7
50 - 99	30	30.1	26.7	7.7
100 – 149	7.2	7.2	22.4	15.3
>150	14	14.5	24.3	46.1

Source: Impact monitoring, 2010

In Table 9.1 it can be seen that in 2010, 46.1 percent of farmers achieved an increase in maize yield of over 150 percent in the plots supported by the PMRN packet (chemical fertilizer, GMs, maize population, and in some cases graded seed).

Case Study 29. Maize shelling in a very special and novel way, Narciso Galeano, Horqueta

Narciso Galeano has a total of 10 ha of which 1 ha is forest, 1 ha house and garden, 1 ha pasture for animal grazing, 0.5 ha agro-fruit forestry, 0.5 ha bananas and the remaining 6 ha are for agricultural crops of different types.

To improve the nutrition of his 11 children, of which 7 live in the house, he introduced a system of agro-fruit-forestry for the production of citrus. He also needed to count on a future supply of timber for his own use, explained Narciso Galeano. To that end he has planted 0.5 ha to a system of agro-fruit–forestry and is planning to expand it by at least 0.5 ha per year.

On the other hand, with the introduction of NT and the use of GMs and crop rotations, he increased his yields of maize and other crops. The increase in yields precipitated another problem: "*How am I going to harvest and shell all this maize without a sheller?*" he asked as he demonstrated his invention. "*The truth is that it is not a new system, but rather a traditional one that I learnt from my grandparents. Because of my actual yields I need to opt for another technology to shell my maize, owing to the increased production of maize on my farm*". The maize is placed in a recipient shaped like a cot and is then beaten with a stick. This is how he could shell his maize much more quickly and effectively.

The maize did not only serve to feed his family, but also with the surplus he was able to improve his animal production. He has lesser breed animals such as hens, pigs, ducks and guinea fowl which are used to feed the family and also for sale. He also has milk cows and produces cheese on the farm.

According to Narciso Galeano, the work of soil management with GMs is fundamental today on his farm, it doesn't matter if a farm is small or not because the needs are the same.

Thanks to the new practices introduced, crop yields were considerably increased, principally through the use of GMs. He also bears in mind the rotation of crops for agricultural production with the GMs. "*What impressed me most is the knowledge of how to use GMs*", commented the farmer.

SUMMARY

Name and District	**Narciso Galeano, Horqueta**
Technician	**Ever Almada**
Area of the farm	10 ha: 1 ha forest; 1 ha house and garden; 1 ha pasture for animal grazing; 0.5 ha agro-fruit-forestry; 0.5 ha banana; 6 ha different agricultural crops.
Family members	11 children of which 7 live in the house, 4 under 10 years of age and 3 older.
Main activities	Maize, beans, cassava, groundnut, banana, pineapple, and vegetables (kitchen garden with lettuce, tomato, onion, carrot, beetroot, garlic, parsley, etc) for home consumption. Cash crops: maize, sesame, watermelon, beans, banana, etc.
Marketing	Sesame, banana, beans, maize, castor bean, watermelon, vegetable production.
Economy	Watermelon: 1 million Gs; melon 10 million Gs; sesame 3.5 million Gs; *feijão* beans 2.5 million Gs; *poroto* beans 1 million Gs; maize 5 million Gs; castor bean 1.5 million Gs; and banana: 5 million Gs. **Total income: 29 500 000 Gs.** Costs: education 4.5 million Gs; inputs 4.5 million Gs; food: 11 million Gs; leisure activities 1.5 million Gs; medicines: 2 million Gs; 2 million Gs ; and incidentals: 2.5 million. **Total costs: 26.000.000** Gs.
Main impacts	Increase in production of maize and other crops.

Demonstration of Narciso Galeano's sheller.

TABLE 9.2
Maize yield (kg/ha) and percentages of farmers before and after implementation of PMRN measures

Maize yield kg/ha	Before percent	After percent
< 499	6.2	1.7
500 – 999	43.5	4.4
1000 – 1499	25.9	6.1
1500 – 1999	18.1	28.3
>2000 – 2499	3.1	27.8
2500 – 2999	2.6	17.2
3000 – 3499	0.5	10.0
> 3500	0	4.4

In Table 9.2 it can be seen that 59.4 percent of farmers are actually producing more than 2000 kg/ha of maize, whereas in the past years 75.6 percent were producing less than 1500 kg/ha.

In other crops there is also a positive tendency as can be seen in Table 9.3. However they do not reach the levels achieved in the comparison plots (NT vs Conventional) established in 2008, 2009 and 2010 as can be seen in Table 9.5.

TABLE 9.3
Average yields of crops by group, data of the PMRN socio-economic study of 2010

Crops	Units	PMRN		CONTROL		Difference	Percentage difference
		N° of cases	Average yield	N° of cases	Average yield		
Cotton Conventional	(kg/ha)	95	1191	13	801	390	33
Soya Conventional	(kg/ha)	11	2064	-	-	-	-
Cassava	(ton/ha)	542	20.3	75	16.7	4	18
Sesame Conventional	(kg/ha)	201	837	28	721	116	14
Tupí maize	(kg/ha)	443	1922	64	1333	589	31
Chipá maize	(kg/ha)	435	1563	56	1178	385	25
Locro maize	(kg/ha)	70	1931	4	1360	571	30
Pichingá maize	(kg/ha)	16	1340	1	600	740	55
Poroto beans	(kg/ha)	388	888	52	708	180	20
Manteca Peky beans	(kg/ha)	28	1285	2	1400	-115	-9
Feijâo beans	(kg/ha)	58	1077	6	939	138	13
Tobacco	(kg/ha)	12	2031	1	2000	31	2
Pumpkin (unit)	(fruit/ha)	37	1797	2	600	1197	67
Watermelon (unit)	(fruit/ha)	152	3069	14	1788	1281	42
Melon (unit)	(fruit/ha)	44	3788	6	2908	879	23
Sweet potato	(kg/ha)	46	9311	7	10 786	-1475	-16
Groundnut	(kg/ha)	226	1050	28	822	228	22
Tomato	(kg/ha)	6	7686	-	-	-	-

Source: Socio-economic study, Rubén Rolón, 2010

"One of the great advantages of NT and the use of GMs promoted by the Project, is the saving in labour – both family and contracted – that in general is one of the areas where most money is invested in the production cycle, habitually that needed for weeding. Maize is one of the crops where the Project has put most emphasis and it can be clearly seen that across the five Departments in the cases of cassava and tupí maize (see Table 9.4) the average percentage saving in labour is 44 percent."

TABLE 9.4
Labour saved in the maize and cassava crops

Department	Average percentage of labour saved in the maize crop	Average percentage of labour saved in the cassava crop
Concepción	71	67
San Pedro	40	43
Caaguazú	35	33
Caazapá	42	42
Paraguarí	43	49
General average.	44	44

Source: PMRN socio-economic study, 2.010, Rubén Rolón, adapted

Case Study 30: Good watermelon production on a 5 ha farm, Rubén Rodas, Horqueta.

Don Rubén Rodas does not have much land. In his 5 ha he has introduced an agro-fruit-forestry system for the production of pineapple, banana and citrus.

"*I cannot survive on the sale of cotton, that's why I had to find a system that gave me greater profit. With the help of technical assistance, little by little I have introduced a more intensive system. Before I didn't have a cash crop in the winter, I left the house to work off-farm to earn an income and cover the family costs*", commented the farmer.

In one plot, the farmer started to sow maize associated with pigeon pea and then with mucuna. After three years with GMs, the production improved a great deal in the plot. "I started to plant watermelon for export to Argentina in this same plot over the mucuna residues with a programme supported by REDIEX and the District Agricultural Development Council of Horqueta". The surplus production was sold on the local market. The average weight of the watermelons on the plot rose to 16 kg per fruit, whilst my neighbours, who did not practise CA, could only get 8 kg per fruit.

"*The great advantage was not only the higher yields, but more than that was the reduced weeding due to the cover of dead mucuna*", the farmer explained to us, showing his watermelon. The farmer obtained an income of 4 million Gs from the production of watermelon; 7.2 millions from sesame; 1.2 millions from *feijâo* beans; 0.9 million from *poroto* beans and also from maize. His annual gross income was 14.2 million Gs. The farmer was

surprised at the high production possible from a small farm, where hitherto he had only sown cotton and maize with the soil becoming poorer each year.

The farmer has three sons and they all still live on the farm and help with the work. For family consumption they have a vegetable garden where they produce lettuce, tomato, onion, carrot, beetroot, garlic and parsley. He has lesser breed animals such as hens, pigs, ducks and guinea fowl. Mostly for family consumption with the surplus marketed. He also has milk cows which provide milk for cheese production on the farm.

SUMMARY

Name and District	**Rubén Rodas, Horqueta**
Technician	**Milciades Acosta**
Area of the farm	5 ha.
Family members	The farmer, his wife and three sons.
Main activities	Production of maize, beans, cassava, groundnut, banana, pineapple and vegetables for home consumption. Cash crops are maize, sesame, watermelon, *feijão* and *poroto* beans. *Small breed animals: hens, pigs, ducks, guinea fowl, all for home consumption with the surplus being sold. Also milk cows for milk and on-farm cheese production.*
Marketing/ Economy	Watermelon 4 million Gs, sesame 7.2 million Gs, *feijão* beans 1.2 million Gs, *poroto* beans 0.9 million Gs and maize 0.9 million Gs. **Total annual gross income: 14 200. 000 Gs.** **Costs**: Education 1 million Gs, production inputs 3.5 million Gs, food 6 million Gs, leisure activities 1 million Gs. And other purchases. **Total costs: 11 500 000 Gs.**
Main impacts	No-till watermelon production for export and farm diversification with an agro-fruit-forestry system. with NT.

Rubén Rodas in his plot of watermelon sown through mucuna cover.

TABLE 9.5

On-farm crop yields with the "PMRN packet" compared to conventional plots. PMRN Comparative plots, 2008

Eco-region	Type of trial	N° of plots	Max. Yield, kg/ha	Average yield, kg/ha	Min. Yield, kg/ha	Av. % increase
	***K. Pyta* maize**					
Caaguazú/ Caazapá	*K. Pyta* maize in NT associated with mucuna or pigeon pea	70	4981	3120	1212	72.4
	Control, conventional	70	4233	1810	600	
Caaguazú/ Caazapá	*K Pyta* maize in NT, subsoiled	9	2680	1894	1426	50.2
	Control conventional	9	1.892	1.261	820	
Concepción/ San Pedro	*K. Pyta* maize in NT associated with mucuna or pigeon pea	60	5720	3546	1800	68.1
	Control, conventional.	60	3800	2109	800	
	***Chipa* maize**					
Caaguazú/ Caazapá	*Chipa* maize in NT associated with mucuna or pigeon pea	30	3400	2368	1350	12.1
	Control, conventional	30	2500	2113	1700	
	Cassava					
Caaguazú/ Caazapá	Cassava in NT on cover of mucuna or pigeon pea	5	24 780	20 820	15 300	39.5
	Control, conventional	5	20 200	14 930	9520	
Concepción/ San Pedro	Cassava in NT on cover of mucuna or pigeon pea	5	36 400	23 565	12 000	100.7
	Control, conventional	5	11 000	11 742	9 000	
	Cotton					
Concepción/ San Pedro	Cotton in NT on cover of mucuna or pigeon pea	9	3125	2024	1200	39.3
	Control conventional	9	2420	1453	750	
Caaguazú/ Caazapá	Cotton in NT on cover of mucuna or pigeon pea	9	2400	1202	600	45.0
	Control, conventional	9	1200	829	455	
	Sesame					
Concepción/ San Pedro	Sesame in NT on cover of mucuna or pigeon pea	5	1200	978	805	3.7
	Control, conventional			705		
	Tobacco					
Concepción/ San Pedro	Tobacco in NT on cover of mucuna or pigeon pea	3	3300	3000	2500	55.2
	Control, conventional			1933		
	Soya					
Caaguazú/ Caazapá	Soya in NT on cover of mucuna or pigeon pea	4	4820	4475	3450	17.7
	Control ,conventional			3801		
	***Poroto* beans**					
Concepción/ San Pedro	*Poroto* beans in NT on cover of mucuna or pigeon pea	2	1800	1400	1000	133.3
	Control, conventional			600		

TABLE 9.5 (Cont.)
PMRN Comparative plots, 2009

Eco-region	Type of trial	N° of plots	Max. Yield, kg/ha.	Average yield, kg/ha	Min. Yield, kg/ha	Av. % increase
	***K. Pyta* maize**					
Caaguazú/ Caazapá	*K. Pyta* maize in NT associated with mucuna or pigeon pea	30	4250	2601	1530	70.0
	Control, conventional	30	2560	1530	743	
Concepción/ San Pedro	Maize in NT associated with mucuna or pigeon pea	61	6100	2715	1200	322.9
	Control, conventional	61	2150	642	350	
	***Chipa* maize**					
Caaguazú/ Caazapá	Maize in NT associated with mucuna or pigeon pea	5	2530	1893	1112	54.5
	Control, conventional	5	1850	1225	600	
	Cassava					
Concepción/ San Pedro	Cassava in NT associated with mucuna or pigeon pea	6	24 700	19 000	15 000	93.9
	Cassava, conventional	6	20 200	9800	7000	
	Cotton					
Caaguazú/ Caazapá	Cotton in NT associated with mucuna or pigeon pea	4	1626	1253	932	55.3
	Cotton, conventional	4	913	807	656	
	Soya					
Concepción/ San Pedro	Soya in NT associated with mucuna or pigeon pea	3	4580	4475	4120	17.7
	Soya, conventional	3	4228	3801	3450	
	Sesame					
Concepción/ San Pedro	Sesame in NT associated with mucuna or pigeon pea	7	1250	1115	855	57.0
	Sesame, conventional	7	800	710	620	
	***Feijão* beans**					
Concepción/ San Pedro	*Feijão* beans in NT associated with mucuna or pigeon pea	4	1400	1150	900	91.7
	Feijão beans, conventional	4	700	600	450	

TABLE 9.5 (Cont.)
PMRN Comparative plots, 2010

Eco-region	Type of trial	N° of plots	Max. Yield, kg/ha	Average yield, kg/ ha	Min. Yield, kg/ha	Av. % increase
	***K. Pyta* maize**					
Caaguazú/ Caazapá	Maize in NT associated with mucuna or pigeon pea	53	4120	2647	1522	55.6
	Maize, conventional	53	2750	1701	300	
Concepción/ San Pedro	Maize in NT associated with mucuna or pigeon pea	16	5200	2424	1250	103.7
	Maize, conventional	16	2300	1190	867	
Caaguazú/ Caazapá	Maize I NT, subsoiled	4	3000	2527	1480	18.9
	Maize, conventional	4	2400	2126	1285	
	***Chipa* maize**					
Caaguazú/ Caazapá	Maize in NT associated with mucuna or pigeon pea	10	2343	1740	1380	53.4
	Maize, conventional	10	1422	1134	800	
	Cassava					
Concepción/ San Pedro	Cassava in NT associated with mucuna or pigeon pea	4	21 415	19 744	18 786	42.3
	Cassava, conventional	4	15 487	13 871	11 203	

Source: Own data, 2010

In Table 9.5 it can be seen that there is a significant increase in yields in the crops established in the plots promoted by the PMRN where the conventional agricultural system is compared with diverse CA practices. It is important to note that these plots were installed by farmers at the field level and they were accompanied by technicians. It may be that the plots do not have scientific rigour, but the results obtained from them have been one of the main tools to motivate and convince farmers about the effectiveness of the proposed system.

Case Study 31. No-till cotton, Cándido González, Yute

The system of production that Cándido González has been practising was the conventional one which consists of moving the soil with the plough and residue burning in the entire farm. The low yield and appearance of predominant weeds such as *Andropogon* spp., *Baccharis isabelae*, Brazilian satintail (*Imperata brasiliensis*), southern cone marigold (*Tagetes minuta*), southern sandbur (*Cenchrus echinatus*) etc., characteristic of degraded soils, obliged him to look for other alternatives or measures which could solve the problem which had been obstructing his progress – low productivity.

From 2005 he became a member of the San Pedro committee of the Aguaray-mi locality, Yuty District. The same year the committee benefited from the technology packet for the management of degraded soils (1 ha) of the PMRN and from that moment he started to introduce the practices of soil management by means of GMs. The remainder of his area continued to be managed in the traditional way.

The farmer registered his yields according to the chronogram of activities introduced by the Project:

Crop	Yield, kg/ha
1st year: *pytá* associated with pigeon pea.	*Pytá* maize 2545.
2nd year: *pytá* maize with mucuna.	*Pytá* maize 4330.
3rd year: CODETEC 405 cotton on mucuna cover.	Cotton 2591 with 4 months of drought.
4th year: lupin + black oat on cotton residue.	

Encouraged by the results, the farmer started to compare the yield of cotton with different types of treatment:

Comparison of the costs of production of cotton with the traditional system (control) (1 ha) vs cotton on residues of mucuna and pigeon pea (1 ha).

Cotton, traditional plot (control)

PHYSICAL INPUTS

Activity	Unit	Quantity	Cost/unit, Gs	Subtotal, Gs	Total, Gs
Weeding	Man day	5	20 000	100 000	100 000
Ploughing	Man day	4	40 000	160 000	160 000
Sowing	Man day	3	20 000	60 000	60 000
Thinning	Man day	2	20 000	40 000	40 000
Weeding (3 operations)	Man day	24	20 000	480 000	480 000
Insecticide application (3 operations)	Tank	22	5000	110 000	110 000
Harvest	kg	1230	400	492 000	492 000
TECHNICAL INPUTS					
Seed	packet	1	180 000	180 000	180 000
Systemic insecticide	litre	0.5	45 000	22 500	22 500
Contact insecticide	litre	0.5	70 000	35 000	35 000
Weevil control tube	Unit	1	60 000	60 000	60 000

Cotton on cover of mucuna and pigeon pea

PHYSICAL INPUTS

Activity	Unit	Quantity	Cost/unit, Gs	Subtotal, Gs	Total, Gs
Knife rolling	Man day	1	40 000	40 000	40 000
Weed killer application	Man day	1	20 000	20 000	20 000
Subsoiling	Man day	1	40 000	40 000	40 000
Sowing	Man day	2	20 000	40 000	40 000
Thinning	Man day	1	20 000	20 000	2000
Point weed control (2 operations)	Man day	6	20 000	120 000	120 000
Harvest	kg	2591	400	1 036 400	1 036 400
TECHNICAL INPUTS					
Seed	Packet	1	180 000	180 000	180 000
herbicide	litre	3	60 000	180 000	180 000

Comparative table

	Traditional system, Gs	System with cover, Gs
Physical inputs	1 442 000	1 316 400
Technical inputs	297 500	360 000
Total costs	1 739 500	1 676 400
Yield, kg/ha	1230	2591
Gross income	1 320 000	2 850 100
Net income	419 500	1 171 700

In this trial the farmer could see the good yields, the reduction in labour requirement for weed control and the low incidence of pests and diseases, principally in the cotton and maize crops. Also he could verify that the good soil cover maintained soil moisture. This latter point was in spite of the scarcity of rain which almost always affects the region each year, the yields were not depressed compared with plots without cover and other years.

These results achieved and observed by the farmer motivated him to change his entire production from the traditional system. He increased the area sown to GMs of different species (summer – winter) on his farm. Today he has 9 ha under NT with GM cover crops.

A cotton plot with cover crop on Cándido González's farm.

SUMMARY

Name and District	**Cándido González, Yuty**
Technician	**Diosnel Bareiro**
Farm area	14 ha. NT on 9 ha, 2400 m² of nurseries.
Family members	Wife: Silvia Balbuena; Children: Alber Fabián, Cristian David, Luz Gissela, Rolando Elías and Elián.
Main activities	Home consumption crops: cassava, maize, beans, groundnut. Cash crops: cotton, maize, sugarcane, onion. Summer GMs: 2 ha pigeon pea, 1 ha mucuna, 1.5 ha, 1.5 ha *Brachiaria brizhanta* grass as cover. Winter GMs: 2.5 ha black oat associated with lupin as cover, 2 ha cassava associated with black oat. Nurseries: 8 summer species with 200 m² each: setaria, canavalia, dolichos, forage sorghum, millet, mucuna, crotalaria and pigeon pea. Four winter species with 200 m² each: triticale, ryegrass, rye, forage radish. Vegetable plot: 100 m² with: tomato, chilli, cabbage, carrot, spring onion, lettuce and others. Large breed animals: 3 milk cows, 3 steers, 1 heifer, 1 bull, 1 pair of oxen. Small breed animals: 4 sows, 6 piglets, 1 boar, 60 hens, 30 chicks, 8 ducks, 2 turkeys. Pasture; 2 ha of *B. brizhanta* and 1 ha Cameroon grass. 2ha natural pasture. Molasses production: 1 sugar mill powered by animal traction.
Marketing	The main cash crops are; cotton, maize, sugarcane, molasses and onion.
Economy	The economy of the farm is based on the following; costs include education, clothes, health and food provisions:

9000 kg *pytá* maize/year	700 Gs/kg =	6 300 000 Gs.
120 tons sugarcane	105 000 Gs/ton =	12 600 000 Gs.
300 kg onion/year	1500 Gs/kg =	450 000 Gs.
2000 kg *chipá* maize/year	1800 Gs/kg =	3 600 000 Gs.
500 watermelons/year	5 000 Gs =	2 500 000 Gs.
3600 kg cotton/year	1500 Gs/kg =	5 400 000 Gs.
11 hens/year	25 000 Gs =	275.000 Gs.
100 eggs/year	8000 Gs =	800 000 Gs.
4 piglets/year	120 000 Gs =	480 000 Gs.
450 litres molasses/year	2800 Gs/l =	1 260 000 Gs.
3 steers/year	1 000 000 Gs =	3 000 000 Gs.
1629 litres milk/year	1000 Gs =	1 620 000 Gs.
240 kg GM seed/year	2000 Gs/kg =	480 000 Gs.
TOTAL		**38 765 000 Gs.**

Gross income:	**38 765 000 Gs.**
Costs:	**19 876 460 Gs.**
Net income:	**18 888 540 Gs.**

Main impacts	With his previous income the net profits were not superior to 5.6 million Gs/year. With this different CA system, net income is over 18.8 million Gs per year indicating a positive difference of 13.2 million Gs annually.

9.2 AREA UNDER NO-TILL

TABLE 9.6
Percentage of interviewed families with an area of NT (2005 to 2010)

Area under NT	2005	2006	2007	2008	2009	2010
0	23	14.6		8.9	0.0	0.6
< 1 ha	61	68.6	70.1	53.6	55.5	30.0
> 1 ha < 2 ha	4	4.7	11.0	19.3	20.1	45.9
> 2 ha	10	12	18.9	18.2	24.4	23.5

Source: PMRN impact monitoring 2005to 2010

According to Table 9.6 it can be seen that in 2010, 69.4 percent of farmers increased their area under NT whereas in the first years of Project implementation there were few who increased their area of NT. This gives an idea of the gradual adoption of the system with time. The same can be seen in Table 9.7 where there are 23 000 ha of GMs with 215 000 farmers assisted. However the multiplier effect is not obvious from this study.

TABLE 9.7
Green manure crops by group, type and Department

	PMRN				
	Total number of beneficiaries	GM crops		Total no of farmers	
		Total Farmers	Total area (ha)	With summer spp.	With winter spp.
TOTAL	14 985	13 256	22 936	12 720	7574
01.CONCEPCION	2270	2079	3332	2079	556
02.SAN PEDRO	3704	3062	6076	2883	1926
05.CAAGUAZÚ	4876	4438	7941	4132	2969
06.CAAZAPÁ	2564	2369	3899	2334	1676
09.PARAGUARÍ	1571	1308	1689	1292	447

Source: PMRN Economic study, Rubén Rolón, 2010

9.3 GREEN MANURE SPECIES

TABLE 9.8
Percentage of families using different species of green manure crops, 2007 to 2010

N° of spp.	2007	2008	2009	2010
0	4.9	0	5.8	0.5
1	35.9	43.75	25.1	19.4
2	35.9	12.5	32.7	30.6
3	15.5	25	14.9	21.5
4	7.7	18.75	13.1	14.5
> 4	0.0	0	8.4	13.4

Source: PMRN impact monitoring 2005 to 2010

Table 9.8 shows that the availability of the number of GM species per family rose from 2007 to 2010. Today 27.9 percent of farmers have 4 or more GM species and only 0.5 percent do not have seeds.

9.4 DIVERSIFICATION

Table 9.9 indicates that during all the years of Project implementation, in comparison with the 2005 data, farmers introduced new enterprises on their farms. Fruits and animals are especially important.

TABLE 9.9
Percentage of farmers who claim to have introduced new enterprises on their farms, 2005 to 2010

Year	Fruit crops	Sesame	Home consumption	Cash crop	Trees	Silvo pasture	Animals
2010	31.3	25.3	30.3	19.9	31.3	5.4	33.8
2009	32.1	21.6	35.1	24.6	30.6	3.4	25.1
2008	31.9	32.9	55.6	40.1	29.4	5.0	15.6
2005	13.4	7.7	16.8	19.2	15.6	4.7	5.6

Source: PMRN Impact monitoring, 2005 to 2010

Case Study 32: How we avoided migration to Argentina, Herminio Benítez-Martínez, Yuty

Twenty-five years ago Herminio Benítez and Cándida Martínez were married and built their house in Yaguareté Kora Company in Yuty District. From that day they formed a family and had 6 children. At the start Don Herminio worked on the farm accompanied by his wife, they had both good and bad times with their agriculture.

With the passing of years the situation with the family worsened, because the soil that they were working became degraded under the traditional system of manual weeding, burning and ploughing. Don Herminio was working with the BNF at that time and his account rose more and more each passing day because of the purchase of inputs and debts with the wholesalers. He discussed the situation with his wife and they reached the conclusion that they would have to go to Argentina to be able to escape from their debts. But Herminio did not want to go and leave his family, mainly because of the dangers, and they decided to stay.

In 2002 the committee "Jaikoporami'e Rekavo" was formed under the auspices of PRODESAL. From that time he received training. In 2004 the soil management and recuperation Project was formulated with PMRN. Then the life of Don Herminio started to change, according to his own words. He started to improve his production with less work, the abundance of produce returned like the old days and he managed to increase the number of animals (poultry, pigs, sheep and cattle) with the increase in his maize yields. All this was due to the change in production system from the traditional to CA, abandoning burning and the plough. In a short time the difference between the two systems was noticeable.

The CA system implied the use of special implements (knife roller, subsoiler, twin-hopper jab planters, etc.), an increase in the use of organic matter with the use of GMs and permanent soil cover. This was an important factor in the

improvement in yields and a reduced incidence of weeds. This can be verified by the difference in person-days used in each production system (presented in Table 9.10).

Maize is the main crop on the farm, as this signifies for the smallholder family more small-breed livestock, eggs, milk, meat, etc. With the traditional system the yield of *chipa* or white maize was 600 to 1300 kg/ha under the best conditions. Now, with CA, yields are 2200 to 2800 kg/ha for *chipa* maize and 4000 to 5300 kg/ha for *karape pytá* maize. The entire farm has seasonal GMs, both summer and winter, as well as the crops that they are associated with. The family economy stabilized. Today the farm produces three times more than in previous years with the conventional system, the farmer has an improved economy and a better quality of life, achieving greater stability for the family estate. This is how he was able to pay off all his debts.

Nowadays he works less per day with his 4 ha under the NT system; and the farm is well diversified with many enterprises: maize, cassava, beans, groundnut, watermelon and others. His wife also makes starch and maize flour which she sells in the town market. Finally Herminio and Cándida showed their appreciation of the Project, because thanks to it they did not migrate to Argentina and they are able to pay the university fees of their two sons.

Herminio Benítez is his field of soil recuperation with winter green manure.

SUMMARY

Name and District	**Herminio Benítez Martínez; Yuty**		
Technician			
Farm area	4 ha.		
Family members	Farmer, his wife and 6 children.		
Main activities	With NT from 2004.		
Marketing	The farmer markets; maize, cotton, onion, watermelon, starch, eggs, pigs, calves and sugarcane.		
Economy	The economy is based on the following; costs include education, clothing health and food provisions:		
	7000 kg *pytá* maize/year	700 Gs/kg =	4 900 000 Gs.
	120 tons sugarcane	105.000 Gs/ton =	12 600 000 Gs.
	350 kg onion/year	1.500 Gs/kg =	525 000 Gs.
	2000 kg *chipá* maize/year	1 800 Gs/kg =	3 600 000 Gs.
	1400 watermelons/year	5000 Gs =	7 000 000 Gs.
	2600 kg cotton/year	1.500 Gs/kg =	3 900 000 Gs.
	13 hens/year	25 000 Gs =	325.000 Gs.
	144 eggs/year	8 000 Gs =	1 152 000 Gs.
	4 piglets/year	120 000Gs =	480 000 Gs.
	170 kg starch/year	3.000 Gs/kg =	510 000 Gs.
	3 calves/year	1 000 000 Gs =	3 000 000 Gs.
	Total gross income	**37.992.000 Gs/year**	
	Gross income:	**37 992 000 Gs.**	
	Costs:	**25 442 112 Gs.**	
	Net income:	**12 549 888 Gs.**	
Main impacts	With his previous income the net profits were not superior to 2.6 million Gs/year. With this different CA system, net income is over 12.5 million Gs per year indicating a positive difference of 9.9 million Gs annually.		

9.5 FARMERS' PERCEPTIONS

TABLE 9.10

Percentage of farmers expressing their perceptions on soil quality related aspects, 2005 to 2010. The first 4 rows refer to men's views; the remaining 3 are the women's

Year	Higher yields	Less erosion	Greater profit	Fewer labourers hired	Less weeding	Fewer weeds	More soil moisture
2010	95.4	75.1	75	66	89	80	65
2009	84.1	64.4	63.3	55.3	75.8	65.5	68.6
2008	92.2	67.0	74.5	63.5	87.7	86.3	77.2
2005	44.4	30.6	27.8	16.7	38.0	n.a	30.6
Women 2010	96.1	**58.1**	**76.9**	**69.8**	**81.1**	**73.5**	**60.3**
Women 2009	84.0	42.6	68.1	47.9	75.5	55.3	47.9
Women 2008	90	57.1	68.5	60	87.1	74.6	55.7

Source: Impact monitoring, 2010

In Table 9.10 it can be seen that in 2010 there is a high percentage of men (95.4 percent) and women (96.1 percent) who believe that crop yields have risen. It can also be seen that the farmers do less weeding and receive higher profits. It is noticeable that there is a high percentage of farmers who perceive benefits from the system, compared with the 2005 data (there were no interviews with women in 2005).

In the same way, the data from the socio-economic study realized in 2010 indicate the same positive results:

TABLE 9.11
Perception of soil improvement after the management practices (PMRN)

	Total No. of beneficiaries	Yes	No	Not applicable
TOTAL	**14 985**	**13 956**	**156**	**873**
Concepción	2270	2092	48	130
San Pedro	3704	3165	108	431
Caaguazú	4876	4798	-	78
Caazapá	2564	2477	-	87
Paraguarí	1571	1424	-	147

Source: Socio-economic study, PMRN 2010

TABLE 9.12
Percentage of farmers expressing their perception of quality of life improvements, 2005 to 2010. The first 4 rows are men's replies

Year	We like living here, we don't want to sell	The youngsters attend school regularly	Firewood is available nearer	Food supply has improved	Marketing of produce	Better income
2010	89	68	58	67.5	29.9	49.7
2009	78.6	59.4	44.0	52.3	30.8	38.7
2008	79.7	56.0	50.9	53.7	30.8	50.0
2005	29.2	21.3	13.0	6.9	16.7	26.5
Women 2010	90.3	67.2	50.9	70.3	25.4	50
Women 2009	77.7	62.8	35.1	57.4	28.7	44.7
Women 2007	76.6	42.2	34.4	43.8	23.4	40.6

Source: PMRN Impact monitoring, 2005 to 2010

Table 9.12 shows that in 2010, 89 percent of men and 90.3 percent of women are not thinking of selling their farms and they enjoy living in the countryside, compared with only 29.2 percent of men in 2005. Other interesting aspects to point out are the increase in school attendance (68 percent for men and 67.2 percent for women in 2010 against 21.3 percent in 2005), and the improvement in family nutrition (67.5 percent men and 70.3 percent women in 2010 against 6.9 percent in 2005). These are impacts which definitely improve the quality of life of the beneficiaries and their families and guarantee a hopeful future for the following generations.

TABLE 9.13
Percentage of farmers expressing their perception on family participation in traditionally male activities, 2005 to 2010

Year	The children work in the farm and forest	The wife works in the farm and forest	The children help with green manure seed collection	The wife helps with green manure seed collection
Men 2010	75.0	52.0	67.8	61.2
Women 2010	72.2	67.9	72.7	77.7
Men 2009	66.3	47.2	60.7	54.1
Women 2009	64.2	60.0	67.4	67.4
Women 2008	71.4	60.6	74.3	79.7
Men 2008	72.4	61.5	70.8	61.8
Women 2007	46.9	35.9	57.8	57.8
Men .007	38.5	30.2	40.1	30.2
Men 2006	59.0	30.2	37.8	29.3
Men 2005	42.6	34.3	30.1	25.0

Source: PMRN Impact monitoring, 2005 to 2010

Table 9.13 shows, in general terms, an increase over time of the participation of children and women in the activities traditionally reserved for men. This shows a greater involvement of all the family in the farm tasks and could provide continuity to the system promoted by the Project.

9.6 ADOPTION, ADAPTATION AND INNOVATION

Adoption

Farmers implementing the PMRN promoted technology packet started to adapt and adjust what they had learnt according to their own reality. Many adaptations were observed in the field and it is always a task to quantify if the measures have been adopted or not, or if the adaptations signify a direct adoption by the farmer.

According to a study carried out by the Project, conducted by Fabio Nizz and Ademir Calegari (2009) the elements most adopted by the farmers were the following: GMs (91-100 percent); no burning (68-85 percent); no ploughing (85 percent); knife roller (90 percent); subsoiler (100 percent) and jab planters (85 percent). This coincides with field observations and the results of other interviews.

The least adopted elements, or those that presented most difficulties for the farmer to obtain, are: purchase of chemical fertilizers and herbicides, because of their high cost. The claim to have a minimum financial component (30 percent) is related to these purchases and is needed to scale out the measures.

It has been observed that after farmers have been successful in the plots supported by the PMRN, they managed to increase their area under NT with their own means.

According to the impact monitoring data increases in NT area can be observed with 69.4 percent of the interviewed farmers as pointed out in section 9.2, and Tables 9.6 and 9.7. Out-scaling was also seen in a study carried out in 2010 in which there was a total area of 22 936 ha with 14 985 beneficiaries. The figures in Table 9.7 indicate that the farmers in general achieved an improvement in the plots supported by the PMRN, however the multiplication and adoption of the promoted technologies is not as rapid as was expected.

In communities where the neighbours of the beneficiary farmers practise mechanized farming, scaling out is with greater numbers. This is associated with the mechanized farmers and the area is increased with the use of machinery and, sometimes, with the capital of the neighbour. In the last few years this strategy has been very successful, nevertheless in years of poor harvest the smallholder farmer runs the risk of losing everything, whereas the large scale farmer has more resources to weather the bad times for longer periods.

TABLE 9.14
Increases in area (ha) and numbers of benefiting families

Measure	TOTAL ha	TOTAL No of families
Reforestation	182.08	335
Native forest management	74.5	149
Agroforestry	89	229
Soil	2730.93	3351
Total	**3076.51**	**4064**

In the annual report 4064 families were identified with increased areas under the measures in a total of 3076 ha.
Source: PMRN Annual report

Beneficiaries' Innovations and Adaptations

Some of the innovations and adaptations are given which were observed in the field during the execution of the Project. These will not be described in detail. It is understood that some are isolated cases, others, on the other hand, are used frequently in the communities.

Machinery

- In the case of equipment, mention is made of the adaptation of the traditional ploughs, which in many cases were distributed by official institutions and have now been converted to effective subsoilers in the region of Caaguazú and San Pedro.
- Another adaptation, by non-beneficiaries, is the use of old tractor wheels pulled by a pair of oxen in order to manage weeds.
- In the Paraguarí region, a district where coconut producers abound, they adapted the trunk of a coconut palm pulled by a chain or rope to manage weeds before herbicide application.

- Incorporation of a third wheel to the two-row NT planter. This had the aim of reducing the load of the tool and adapting it to be pulled by horses, San Estanislao.
- Modification of the subsoiler by incorporating wheels to flatten weeds and to facilitate cutting by the disc coulter, Horqueta.
- Adaptation of the animal-drawn knife roller to a single horse, Concepción.
- Use of the lime spreader to apply organic manure, San Pedro and Concepción.
- Use of the animal traction NT equipment with tractors for small areas, San Juan Nepomuceno municipality.

Case Study 33: Factory for vegetable oils for human consumption and biodiesel, Eliseo Lugo, Choré.

Eliseo Lugo, a farmer of the Los Pioneros committee, Naciente Community, Choré District, San Pedro Department, was a beneficiary of the PMRN Project and introduced practices of soil recuperation. With the resulting yield increases, the farmers were in a dilemma as they had sufficient grains for home consumption and for their farm animals. They did not know where to market the surplus and so they looked at different options to solve the problem. One of those options was to not sell the raw products but rather to give them some added value. It was then that Eliseo contacted a friend of his, Ramón Cañete Nuñez, who was making machines for oil extraction and he lent one so that Eliseo could do some tests with it.

The machine is powered with a 2 hp electric motor which actuates a press through a belt and pulley transmission system. The press extracts the oil by pressure and this then falls under gravity at one end, whilst at the other end residues are expelled as pellets.

From 3.5 kg of sesame seed, 1 litre of oil can be extracted together with 2.5 kg of oil seed cake. The oil has a value of 25 000 Gs per litre and the oil seed cake 2000 Gs/kg, giving a gross income of 27 000 Gs/3.5 kg sesame. This is equivalent to a gross income of 7714 Gs/kg of sesame produced which is 71 percent more than the price of sesame sold as seed. There is also the saving in oil which the farmer no longer has to buy, and the high quality of the product.

With the machine it is possible to extract oil from all types of seed such as sunflower, coconut and castor bean for biodiesel which generates income for the smallholder farmers. As a result we agree with the farmer that it is a very valid alternative for them to process their produce. What remains to be done is for the group to find a refinery for their oil to give greater quality to their produce and to give a better presentation to the final product.

Apart from his agricultural activities the farmer has 1 ha of reforestation with native species such as *Tabebuia, Cordia, Piptadenia* and exotics such as *Melia* and *Eucalyptus*.

SUMMARY

Name and District	**Eliseo Lugo, Choré**
Technician	**Agronomist Manuel Galeano and Omar Aquino**
Area of the farm	20 ha.
Family members	The wife, 7 sons and 2 daughters.
Main activities	Maize, sesame, cassava. Reforestation 1 ha. Vegetables, fruits (orange, mandarin, grapefruit) for home consumption. Animal production: pigs, poultry, cows. Forage: Cameroon grass 0.5 ha; sugarcane 0.5 ha.
Marketing	Sesame and maize.
Economy	Previously the farmer sold sesame and maize to a value of 11 million Gs/ year; with costs (electricity, college, food, water, telephone, enterprise production costs) of 8.4 million Gs/year. Giving an annual net income of 2.6 million Gs. Later he increased his sesame production to 2 ha which produced 1900 kg. Now he doesn't sell the harvest and he gives it added value by producing oil. This generated 633 litres of oil sold at 25 000 Gs/l to traders of the region, and generating an income of 15 825 000 Gs without including the cake. With maize he obtained 3500 kg more than the 1500 kg that he used to get under the traditional system. The maize harvest was sold at 1000 Gs/ kg. He planted 3 ha which yielded 210 500 kg giving a gross income of 10.5 million Gs. **Gross Income: 26.325.000 Gs.** **Costs: 8.400.000 Gs.** **Net income: 17.925.000 Gs.**
Main impacts	Before NT he received an annual income of 2.6 million Gs, now, thanks to NT and the value addition of his produce, he receives 17.925 million Gs/ year.

Eliseo Lugo with his oil press

OTHER INNOVATIONS

In animal production

- Cultivation of pigeon pea for **direct grazing**, Vaquería Yhú.
- Cultivation of leucaena for forage and firewood, Itacurubí del Rosario, San Estanislao.
- **Small breed animals** fed with GM seeds, Horqueta, Caazapá, 3 de Febrero.
- Use of pigeon pea for **animal feed**, Nueva Londres.
- **Pasture** improvement with legumes, Itacurubí del Rosario.
- Introduction of fish farming in farm diversification, Itacurubí del Rosario, Covesap and Juan Manuel Frutos.

In fruit production

- Association of **pineapple with leucaena**, carried out by Evelio Castillo who used to have pineapple with banana and changed the banana enterprise for leucaena as an energy source (firewood).
- Farmers in Concepción use **mucuna** between rows of **banana** to control weeds and add nitrogen to the soil. The mucuna vines are cut by machete.
- Green manure adoption: **crotalaria, pigeon pea and mucuna** as crops to **protect pineapple from frost**. Farmer Diego Caballero, Santo Domingo committee, Guayaibi District, San Pedro Department.
- Association of **passion fruit** with **yerba mate, grapefruit** and summer and winter GMs, Caazapá.
- **Passion fruit** with oat, radish and lupin, Caazapá.
- Association of crotalaria with **watermelon** at the runner production stage, Concepción.
- **Watermelon** on mucuna residue, Loreto, Horqueta, Yby Yau.
- Incorporation of **fruit trees** on the farm, Caazapá.
- Association of cash crops (**banana and pineapple**) with summer and winter GMs.
- Association of oat with **pineapple** in Guayaybi and Choré.
- Association of **bitter orange** with canavalia, La Pastora.
- Cultivation of **pineapple** with pigeon pea, Yhú, Vaquería.

In green manure use

- Using mucuna to **control weeds**.
- The adoption of GMs as **cash crops.** It is worth noting that in some areas GMs replaced traditional crops such as cotton. This is the experience of Alejandro Morán, Bordenave committee, Coronel Oviedo District who incorporated lupin as a cash crop.
- **Pigeon pea pruning** and subsoiling, Caazapá and Caaguazú.
- **Use of winter GMs after the harvest of the cash crop.**
- Promotion of seeds of different **GM**s on the small farm, Paraguarí.
- Use of GMs to control soil erosion in sandy soils with pronounced slopes.

- **GM** seeds as an enterprise for alternative **income** for the family.
- GMs for family **food**.

In vegetable production

- Nematode control with crotalaria, especially for horticultural crops like **tomato and chilli** in the Blas Garay area, Caaguazú Department.
- Cultivation of **pumpkin** on oat residue, Vaquería, Yhú.
- Association of **pumpkin** between pigeon pea rows, Caazapá.
- Planting tomato on residue of mucuna and pigeon pea, Juan Manuel Frutos, Loreto, Horqueta.
- Onion crop on crotalaria straw, Yuty.
- Pigeon pea stakes as tutors for **tomato**, Loreto, Yby Yau.

In cassava production

- Cassava **planter** (CODIPSA, Repatriación).
- Association of oat with cassava, Juan Manuel Frutos, 3 de Febrero and Repatriación, La Norteña cooperative.
- Sowing pigeon pea between rows of cassava of more than one year (Repatriación).

In Stevia production

- **Stevia** on mucuna residue, Choré.
- **Stevia** on pigeon pea residue, Yuty.

In sesame production

- **Sesame** on mucuna cover, Yby Yau, San Estanislao.
- **Sesame** on oat cover, Vaquería, Yby Yau, San Estanislao.
- Late sowing of crotalaria/millet after the **sesame** harvest Yby Yau.

In maize production

- Association of oat and lupin with **maize** at the grain filling stage, Yuty.
- Association of oat with **maize** at flowering, Vaquería.

In forestry production

- **Forest enrichment** with a greater number of strips per hectare, Caazapá.
- Propagation of ***Torresea*** and ***Cedrela*** by stakes, Yby Yau.
- Association of **forestry species** with pigeon pea, Yhú, Vaquería.
- Natural regeneration management (**natural reforestation**) in agricultural fields (fallow), Yby Yau.

Others

- Association of **castor bean** with *Dolichos lablab*, Yby Yau.
- Planting **tobacco** on cover of oat and mucuna, Santaní and Choré.

- Use of the subsoiler to open furrows to plant **sugarcane and cassava** (Caaguazú, Caazapá, Guairá, San Pedro).
- Use of **treated seeds.**
- **Grading seeds** with a set of sieves.
- **Farmer meetings** in which they present their cases as a discussion forum, Caazapá.
- Inclusion of the royalty funds of the municipality **budget** for buying GM seeds and forestry seedlings, Vaquería.
- Contracting a **technician** with municipality funds.
- Forestry cooperative, Lima, Cuatro Vientos.

Case Study 34: Crotalaria tunnel for pineapple production, Diego Caballero, Choré.

Mr Caballero of Santo Domingo committee has a very diversified farm. The whole family works in agriculture and pineapple is the main cash crop and source of family income. The demands of the crop for soil fertility obliged the farmers of the region to introduce new production practices such as sowing GMs to recuperate the degraded soils. This is needed to produce food for human and animal consumption and the latest practice to be introduced is cover with crotalaria to protect against climatic factors such as frost and sunburn.

In the traditional system without cover or protection, the pineapples can be burnt. Also the farmers protect the fruits with newspaper which takes a lot of time, labour and money. Having access to different types of GM means that Mr Caballero has invented new system with the aim of avoiding the effects of frost in the winter and fruit burning from solar radiation.

Bending crotalaria over the pineapple comprises the use of *Crotalaria juncea* on the pineapple ridge. Once it reaches a certain height, 2 to 2.5 m, the tips are tied with string or tape so as to form a tunnel that offers cover to combat the damaging effects of severe weather conditions on the pineapple. As a further bonus good results are achieved from the addition of nutrients, reduction in nematodes and addition of organic matter to maintain soil fertility and improve the quality of the pineapples naturally.

The practice of bending the crotalaria implies planning from pineapple planting up to the moment of forming the tunnel. These activities include planting the pineapple in a double row using 35 000 plants/ha. After that, in November/December the GM is sown in two rows on the ridge of pineapple. This is with the purpose of using one row for each side of the tunnel. At the end of the winter the GM is cut and left on the ridge to serve as soil cover and consequently inhibit the emergence of weeds and reduce the task of weeding.

The system has also been successfully tested with pigeon pea, except that with this crop it is necessary to prune to avoid excessive shade which produces conditions favourable for the appearance of fungal diseases.

The unsuccessful experience of the farmers of the committee with forest clearing and burning for production led this family to reforest their farm for the supply of firewood and timber for construction, which generates income in the medium and long terms.

The farm has 15 ha of which 7.75 ha are devoted to CA with 0.25 ha under crotalaria and pineapple, 2 ha pineapple with oat, 2 ha reforestation, 0.75 ha forest management, 2 ha cassava on cover, 0.75 ha as a nursery for diverse GMs and other crops. The remainder of the farm is under natural improved pasture and for harvest where the large animals are, the rest is the areas for vegetable production, paddocks, house and garden.

The farmer started to use GMs such as pigeon pea, mucuna, black oat, white oat, lupin and crotalaria. All the green manures are associated with the crops cultivated on the farm (maize, cassava, pineapple, forest plantations and vegetables).

Comparative costings for labour, Gs

PRODUCTION COST, Gs							
Traditional production				Bending crotalaria			
Description	Quantity	Unit cost	Total cost	Description	Quantity	Unit cost	Cost
Planting	10 man-days	35 000	350 000	Planting	10 man-days	35 000	350 000
Staples for the stapler	3 boxes	13 000	39 000	Weeding	6 man-days	35 000	210 000
Stapler	1	15 000	15 000	Bending	3 man-days	35 000	105 000
Newspaper	200 kg	2500	500 000	Sowing crotalaria	1/2 man-day	35 000	17 500
Weeding	12 man-days	35 000	420 000	Crotalaria seed	20 kg	3500	70 000
Daily labour	17.5 man-days	35 000	612 500	Oat seed	80 kg	2500	200 000
Total			1.936.000				952 500
Difference							984 500

Difference in labour requirements

Description	Traditional production	With crotalaria tunnel
Man-days	39.5	19.5

The first production of pineapple reached an 80 percent yield, equivalent to 28 000 fruits. As far as quantity is concerned, there was no difference with the application of the practice, but there was a difference in quality of the harvested fruits. More than 70 percent was marketed as export quality achieving an income of 10.5 million Gs, and bear in mind that the land used was considered unproductive.

SUMMARY

Name and District	**Diego Caballero, Guajayvi**
Technicians	**Manuel Galeano and Javier Rolando Maidana**
Area of the farm	15 ha.
Family members	Diego Caballero, Teresa Sanabria, Natalia Sanabria.
Main activities	Pineapple as cash crop, vegetables and fruits for home consumption and sale to augment the family income. Small-breed animal raising for home consumption and sale to augment the family income.
Marketing	Marketing of the farm produce is in the local market and wholesale market of Asunción. The main crop is pineapple which brings an annual income of 10.5 million Gs.
Economy	The family economy is sustained by agricultural production, with an estimated annual income of 12.8 million Gs from which are to be subtracted the costs of education, water, energy to a total of 6.48 million Gs. Gross income: 12 800 000 Gs. Costs: 6 480 000 Gs. Net income: 6 320 000 Gs.
Main impacts	Increase in income, reduction of work with less hired labour, increase in soil fertility. Protection of pineapples against frost and sunburn. The practice of GM use was copied by neighbours, to whom the farmer sold GM seeds and so increased the farm income even more.

Farmer Diego Caballero bending crotalaria to protect the pineapple crop.

9.7 ADOPTION BY NON-BENEFICIARIES

With respect to multiplier effects, 55 percent of interviewed farmers in this 2010 impact monitoring study claimed to know neighbouring farmers who had started to copy CA practices. In 38 percent of cases, farmers know neighbours who apply practices of forest management.

In the 2009 annual report 564 non-beneficiary families were identified who had copied measures promoted by the Project. A multiplier effect was observed amongst the neighbours of the beneficiary farmers as can be seen in the following table.

TABLE 9.15
Measures adopted by non-beneficiaries in ha and number of families

Measure	TOTAL ha	TOTAL families
Reforestation	94.5	119
Management of native forest	13	22
Agroforestry	43.5	85
Soil	236.5	338
Total	387.5	564

Source: PMRN Annual Report, 2009

Today many farmers leave the natural regeneration of native species and avoid burning. In some areas, especially San Juan Nepomuceno and Repatriación, reforestation is an activity frequently carried out by both assisted and non-assisted families. In the 2010 socio-economic report, however, there was no evidence of these increases in area by non-beneficiaries.

Case Study 35: Better management of resources available on the farm, José Librado Medina, Capiibary

Don José Medina has a relatively large farm of 30 ha in Capiibary District. His main cash crop is cassava. In one plot on his farm he started to introduce the technology packet introduced by the PMRN. He started the measure with high density maize, sowing pigeon pea and applying the inputs bought with the Project's incentives. His maize yield rose from 1500 kg/ha to 4500 kg/ha. In the same plot he sowed mucuna and cotton over the residue, achieving a yield of 2478 kg/ha compared with 400 kg in previous years.

With these measures, the farmer started to introduce other enterprises on his farm. Today he has beans, groundnut, sesame, cotton, citrus, mango and pineapple. He also has 6.5 ha of colonial grass (*Panicum maximum*) for his cattle.

With the increased maize production, the women of the committee increased their numbers of lesser breed animals.

With the Project's help he planted 2 ha of *Eucalyptus grandis*, *Melia azedarach* and others and his remnant forest of 1 ha was managed with the technique of enrichment with native species. The forestry measures were complemented with maintenance work and reforestation owing to the scarcity of firewood for home use.

"*What makes me happiest is to know that my neighbours copied the new practices simply owing to the increased production of my crops managed in this way*", alleged Don Medina contentedly. That is how the farmer achieved a better management of his farm with diversification, production in the short, medium and long terms, and with better yields.

SUMMARY

Name and District	**José Librado Medina, Capiibary**
Technician	**Néstor Duré**
Area of the farm	30 ha.
Family members	Wife, 1 son, 2 grandchildren and 1 great grandchild.
Main activities	Cassava, sweet potato, beans, groundnut, cotton, sesame, cattle, citrus, mango, pineapple.
Marketing	Cassava and sweet potato, cattle.
Economy	10 to 12 million Gs income.
Main impacts	Diversification of the farm, small and large breed animals.

A view of the reforestation plot of farmer José Medina seen together with his son.

9.8 INCOME

The increases in productivity and marketing (see sections 2.4 and 9.1) has contributed to greatly increased family incomes according to statements made by the farmers as can be verified from Table 9.16.

The study carried out in 2010 shows that the average gross income of beneficiary farmers in the Project is 61.2 percent more than the income of control families. This tendency is maintained if the same analysis is applied

at Departmental level (See Table 9.16); the most outstanding cases are those of Concepción, San Pedro and Caazapá.

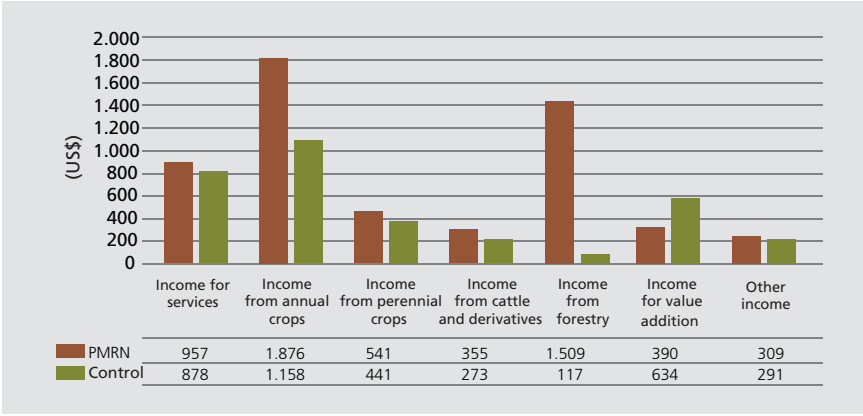
TABLE 9.16
Average gross income by family and Department, US$

Department	PMRN	CONTROL
	Av. Gross income/family	Av. Gross income/family
Concepción	4655	3531
San Pedro	5250	3122
Caaguazú	3475	2115
Caazapá	4355	2206
Paraguarí	2885	1802
Total, mean	**4181**	**2560**

Source: PMRN socio-economic study, 2010, Rubén Rolón

In 2005 and 2007 the average incomes of the assisted families were 258 and 253 US$ higher than the incomes of the control groups, according to a study carried out by GIZ in those years. It should be noted that the forestry activities show a high incidence in family income. This indicates that forest management and thinning of reforestation start to generate significant income. Once the farmers reach the final harvest the income will be increased further still.

FIGURE 9.1
Comparison of incomes by activity between PMRN farmers and a control group, US$



Source: PMRN socio-economic study, 2010, Rubén Rolón

Case Study 36. Starch factory, Santa María Committee, General Morínigo de Caazapá.

The Santa Maria committee started to be formed with the help of a catholic priest, Lucio Martínez tells us. Afterwards a DEAg technician, Fabio Vega started to help the committee with a MAG project (IRC) with the aim of

improving grain storage. At this time there was not much production and the committee could not make full use of the silos donated by the Grain Conservation Project of Helvetas.

In 2000 the German technical cooperation agency (GIZ) initiated a series of training courses for technicians and local farmers in NT production systems. Mr Lucio also remembers, whilst laughing, that the first knife roller that they brought was so big that not even a 2-wheel tractor could pull it. It took 2 teams of oxen to move the implement.

The first attempts with green manure mucuna in the field of Don Calixto were not very successful because the soil was so degraded. The mucuna did not prosper. At that time maize yields were 800 kg/ha and cassava 10 000 kg/ha. After 3 years the soils had been recuperated and the yield rose to 2500 kg/ha for *chipá* maize, 25 000 kg/ha for cassava and 2000 kg/ha for cotton. In addition to greatly increasing yields, the farmers noted that they worked with less expenditure of energy with the NT system. To plant cassava previously took 16 days/ha and now with the subsoiler it could be done in only 7 days.

Actually the 22 members of the committee increased their cassava yields to 12 ton/ha in 2003 and 33 ton/ha in 2007. This increase comfortably exceeded the family consumption needs and so the committee decided to transform the surplus by the extraction of starch for sale in local, regional and national markets.

An association of three committees was formed. The first task together which they gave themselves was the planning of the industrial unit, the investment necessary and the search for finance plans for the required capital. The capacity of the plant was estimated for the transformation of 600 tons of cassava, which was the amount of surplus cassava being produced annually as a result of the rise in yields. This quantity corresponds to the production of 90 000 kg of starch, to be sold at US$0.5/kg. With this plan and through many procedures they managed to get approval for a project for the installation of a starch extraction factory with financial help from the Agricultural Development Programme of the Oriental Region of Paraguay, Programme 2KR of MAG, which has paid out a total of 250 million Gs in the 2 stages of the project:

1. The first payment was of 97 million Gs (33.1 million for implements and materials + 63.9 million for infrastructure).
2. The second payment: 153 million Gs (140 million for machinery and equipment + 13 million for training).

Now approximately 200 families participate in the association which produces with conservationist practices, obtaining good yields in approximately 120 ha. They have cassava production in 40 ha and 15 ha reforested. With the members of the committee the Project promoted plantations of grapefruit and orange associated with native tree species and passion fruit in the farms of 16 families.

Inauguration of the starch factory of the Santa Maria committee of General Morínigo.

With the fruit-forestry system, combined with cassava, the area was increased to 25 ha with the incorporation of orange, grapefruit, native and exotic trees species into the production system. After three years there was the first citrus harvest. Approximately 500 000 fruits were sold at 80 Gs a unit representing an income of 40 million Gs for this enterprise.

Impact on family income

In 2003 a survey was carried out on the family income situation in Caazapá Department. The study included 21 farms which were members of the Santa Maria committee of the General H Morínigo Municipality and 11 non-member farms from the same municipality, in most cases neighbours of the committee members. In 2009 another survey was done on the 21 PMRN beneficiary families and with the non-beneficiary neighbours. Based on the survey results it was possible to determine the income derived from the sale of agricultural, fruit, forestry and animal products as well as the income from non-agricultural activities. At the same time the income *not* generated as a result of home consumption was also determined (e.g. meat, eggs, cassava, firewood, etc.) as well as the annual family costs. The results, in summarized form are given in the following table:

Annual average family income of 21 families of the Santa Maria committee compared with that of 11 non-beneficiary smallholder farm families, General H Morínigo Municipality, Caazapá, Paraguay. 2001 and 2009.

Group	2003			2009		
	Total of family incomes, US$	No. of families	Average family income, US$	Total of family incomes, US$	No. of families	Average family income, US$
Santa María committeee (beneficiaries).	45 002	21	2147	106 435	21	5068
Non-beneficiaries.	32 234	11	2930	16 509	11	1500

The table clearly highlights the increase in family income for the beneficiary families comparing 2003 and 2009. The income of the non-beneficiary farms that were not given technical assistance by the Project suffered a significant drop when the incomes for the two years are compared. The difference in income between the beneficiaries and non-beneficiaries is US$3568/family in 2009 in favour of the beneficiary group and was the result of the increase in cassava yield and the integration of the families in the implementation of the production chain, in this case of starch.

Another factor, no less relevant for the maintenance of family income was the planting of fruit trees (citrus) mixed with native species and associated with passion fruit. This enabled integration of the families into the production chain of fruit juice under the leadership of FRUTIKA.

Mr Lucio told us with pride that he built his own new house in 2009, constructed from timber from trees that he had planted 8 years previously with the help of the Project. And so not only is the effort visible, but also the tangible benefits of his work, thanks to the assistance proffered by various organizations and institutions.

9.9 GENDER

The majority of rural women devote themselves to traditional jobs such as caring for the children, the house, production, harvest, grain conservation, provision of firewood, food preparation, raising small-breed animals, making animal sub-products, and all this means that they have little time for participation in the productive activities of the farm.

The great majority of the farmer beneficiaries of the PMRN are men (95 percent). Nevertheless, the active participation of women accompanying the activities of training days, field days, educational trips, either as members of organizations or representatives of the farm, is of the greatest importance for the success of the activities developed.

According to interviews with farmers, only 5 percent of men said that they make decisions on farm work unilaterally; whereas 63 percent consult with their spouse and 32 percent consult with all the family (Nizz Narváez and Calegari, 2009).

In the case of training though, 52 percent stated that only the head of the family participated in this and 44 percent said that a family member alternated in the participation.

On the other hand, with reference to the participation of the family in the implementation of the promoted practices, 95 percent of them received full support.

The participation of women in the production system with the application of the technology packet had a positive response owing to the achievement of better and greater yields in the cash and home consumption enterprises. This produced more and better quality food for the family as well as the generation of surpluses for raising small animals, the continuous generation of income for the family, the availability of firewood, the saving of time and energy to be channelled into better care and attention to family members and to themselves (See Tables 9.12 and 9.13).

In a study of gender aspects[12] in the PMRN, the following relevant impacts were detected:

Improvement of leadership levels, participation in communal activities and women's organizations. The direct beneficiaries improved their position with respect to assuming decision-making roles in the organizations, having their opinions valued and taking action within them.

Autonomy and leadership and principally recognition and valuing of their participation on the part of their peers of organizations and in life.

The strengthening of organizational capabilities and the very success achieved by the Project increased their **self esteem** and self awareness of their physical and psychological limitations; creating a positive image of themselves.

Finally, in relation to the improvement of food supply, the interviewees mentioned that the families feel very satisfied…"*more united and happier, with fewer worries about the availability of food which generally used to be a major preoccupation for them*".

Improvement of the **capitalization of the farm** that was possible thanks to the increase in income. Some families invested in the improvement of the infrastructure of their houses and their production.

Recuperation of soil health meant that fathers and mothers could recall and relive the way that their parents had lived in the past "**maintaining with dignity the family by means of agriculture**", said the women with emotion.

Reduction of work load on the farms, emphasizing that they felt the impact as a result of being directly responsible for the agricultural production and contracting off-farm labour.

Valuing the domestic work performed by women, principally by men who sporadically assume some of the typical duties of the women when they participate in Project activities.

[12] Venus Caballero: Aspectos de Género (Gender aspects), 2008

However the Project does have some **limitations with respect to gender**: there is a lack of professional women in the team; its technical staff need training on matters of gender; there is little promotion of the incorporation of women and youth at organizational levels.

9.10 ENVIRONMENTAL IMPACTS

The soil management activities realized in the framework of the Project have a positive environmental impact in comparison with the traditional system of ploughing and burning. These measures contribute to the potential for the adaptation of crops to **climate change**.

With the reduction in soil erosion, the increases in carbon sequestration and biomass production, the increase in water retention in the soil, the reduced extreme temperatures on the soil surface because of the cover, more micro-organisms in the soil, and less compaction, there is a major contribution not only to better adaptation to the effects of climate change but also to the reduction of greenhouse gas emissions.

With CA 4 to 25 tons of dry matter are being added to the soil per hectare per year. This accumulation of carbon in the soil can capture about 0.58 ton C/ha/year.

Reforestation and native forest management are also contributing to the mitigation of the effects of climate change, as well as offering environmental services such as improvement of water courses, micro-climates, biodiversity, landscapes, clean air and soil protection.

It can be estimated that a native forest can capture around 100 tonnes of carbon per hectare, and in reforestation 220 tonnes of carbon per hectare in a 15 year period. This translates to 1 to 2.5 tonnes of C/ha/year.

CHAPTER 10

Lessons learnt

During the years of execution of the PMRN several awkward problems arose of different types: political; administrative; technical; and organizational amongst others. The directors of the technical team of the Project were constantly looking for answers to solve or ameliorate these difficulties, either individually or collectively and they were taken as real challenges. In this Chapter we would like to shape the lessons that we have learnt, many of which were successfully applied, others are still pending. The aim is to raise awareness amongst the different stakeholders about the importance of the work that was developed by the Project and above all the political, social and economic impacts that it will come to have. At the same time we hope that these experiences or challenges may be useful and used to help in the design and planning of future projects at national level.

SOIL COMPONENT

How to start

At the start the measures for degraded soil were initiated with winter GMs rather unsuccessfully due to the demands that these species have on soil fertility. With this we can stipulate that the degraded soil measures should be initiated with summer GMs, principally with the use of pigeon pea. Under all conditions it is best to let the pigeon pea develop over two years.

Time of sowing

The Project established a calendar for sowing both crops and green manures. It is important that the GMs are sown in the appropriate season (October to December) and without weeds which will act as competitors. This will have a significant effect on the good development of the GMs and in achieving a good soil cover. At the start many farmers prioritized their regular activities instead of following the calendar recommended by the technician "in the project plot".

The strategy of arranging local visits and visits to neighbours' plots at opportune moments helped to convince the farmers to sow in "their plot" at the precise and opportune time. To see a neighbour's plot weed free and with greater yields was the most important factor in convincing farmers.

Inputs

The Project started its soil recuperation activities by using chemical fertilizers (NPK) to improve maize development. The farmers for a while maintained

the perception that the yield increases were due exclusively to the use of these inputs provided by the Project. As a result they considered it not viable to continue the recuperation process in the rest of their farm as they didn't have the resources to buy the inputs. Consequently it is recommended that future projects, or similar technological packets, to initiate in 50 percent of the plot the application of all the inputs that could be provided by the project and in the remaining 50 percent not to use any type of inputs except the GM management. This will result in the rapid comprehension and adoption of this measure by the farmers.

Green manure seed production by the farmers is a fundamental element for sustainability of the application of the promoted technology. Without GM seeds of various species, at least 3 to 5, it is very difficult to give continuity to the NT system, and makes the implementation of an adequate system of rotation, succession or association difficult. It should be emphasized that farmers use those green manures that they find easiest to reproduce or acquire and manage and that give the best results in raising yields or in the effectiveness of weed suppression. In most cases the summer green manure most adopted was mucuna and amongst those for winter, black oat.

At the beginning of the Project there was insufficient GM seed nationally to implement the measures, to such an extent that on more than one occasion it was necessary to import seed from Brazil. This made the Project insist on the establishment of individual or group nurseries, but even this did not always guarantee that all farmers would get enough seed. As a result it is recommended that GM nurseries, or the possession of sufficient seed, is a prerequisite to become a beneficiary of any similar project.

Today, marketing GM seed by the farmers represents a significant opportunity to generate additional income.

The use of pigeon pea as part of the process of soil recuperation has contributed significantly to a revaluation of the crop because of its multiple uses, especially in human and animal diets. Also genetic material was rescued which had been lost or was not known about, and new varieties of the crop were introduced (such as Brazilian dwarf pigeon pea).

Maize and yield

In terms of production systems, maize represents one of the principal elements in the food of the Paraguayan family. Because of that it was considered in the rotational sequences of the promoted measures. Thanks to the use of maize in the scheme of degraded soil recuperation, the yields of the crop were raised considerably. These yield increases were a determining factor in motivating farmer interest and facilitating the adoption of the system. Mainly for the women, who are responsible for feeding the family. This contributed to a better acceptance and adoption of the NT measures by the women who in many cases were the ones who insisted that their husbands asked for assistance from the Project to ensure continuity in the working of the system.

Another factor that helped with the increase in maize yields was the use of improved varieties and increasing the planting density. Genetic materials that were degraded or practically lost were recuperated. Improvement of varieties was achieved by a process of selection of ears and the use of sieves to classify seeds, a practice promoted with insistence by the Project.

Lastly it can be stated that it is of the greatest importance to achieve some successful result in the short term. This motivates the continued adoption of promoted measures in spite of the difficulties and obstacles encountered along the way.

Case Study 37: From subsistence to cash enterprise, Francisco Alfonso, Horqueta.

Farmer Francisco Alfonso has a wife and 10 children, of whom 4 still live on the farm and help with the agricultural work. On his 20 ha the farmer produces a variety of cash crops such as: maize, beans, cassava, groundnut, banana, pineapple and vegetables (a family garden with lettuce, tomato, onions, carrots, beetroot, garlic, parsley, etc.). Also as cash enterprises he has: castor bean, sesame, watermelon, *feijâo* beans, etc. He has small-breed animals like hens, pigs, ducks and guinea fowl mostly destined for home consumption but with a marketable surplus. He also has dairy cows for the provision of milk and on-farm cheese production.

"The recuperation of soil fertility started with 1 ha of maize where previously it produced 800 kg/ha., and now produces 4916 kg/ha", recounts the farmer. "With this high production I managed to produce a total of 9 tonnes of maize. I am producing maize in 2 or 3 stages for its subsequent sale in local markets". The most important thing is that he produces with less work and fewer production costs by means of direct sowing technology.

The farmer is a member of an organization called CEPROHOR which does joint marketing of their products, eliminating intermediaries. The products with most demand are: maize, sesame, *feijâo* beans, *poroto* beans, and castor bean amongst others.

Two years ago they started with CA and got good remuneration for their products and so improved family incomes. His principal enterprise is actually maize which gives an income of 13.5 million Gs, next is sesame with a value of 4.263 million Gs, and castor bean with a value of 750 000 Gs.

Of the 20 ha total the farmer has 4 ha of forest and 1 ha of reforestation with eucalyptus which is 50 percent harvested. He sold each tree for 1.5 million Gs. He also mills planks and beams to a value of 2 million Gs. the remainder he has left to harvest in the future.

Apart from the economic impact on the farm, one of the most outstanding aspects for Don Francisco's wife is the availability of food of excellent quality for her children.

SUMMARY

Name and District	**Francisco Alfonso, Horqueta**
Technician	**Ever Almada**
Area of the farm	20 ha.
Family members	The farmer, his wife and 10 children.
Main activities	Production of maize, sesame, castor bean and animals.
Marketing	Maize: 9 tonne to 1500Gs/kg, value 13.5 million Gs. Sesame: 870 kg to 488 Gs/kg, value 4.263 million Gs. Castor bean: 500 kg to 1500 Gs/kg, value 750 000 Gs. Sale of eucalyptus trees: 1.5 million Gs each. Beams and planks: 2 million Gs. **Total gross income: 22 013 000 Gs.**
Economy	Outgoings of 18.5 million Gs for education, food, inputs and other items.
Main impacts	Improvement of maize production, communal marketing and raising small-breed animals.

"Thanks to PMRN I produced 4916 kg of maize after 2 years of recuperation of my soils (before the plot only produced around 800 kg/ha)", some expressions of Francisco Alfonso.

Use of machines

The recommendation is to provide farmers with hand jab planters, knapsack sprayers and knife rollers as the basic tools for adoption of the NT system. Implements such as subsoilers, animal traction sprayers and direct planters are useful but not essential to assure implementation of the system.

It would be very convenient if the farmers, in addition to sharing labour could also, somehow, either with cash or crop production collaborate to acquire the CA inputs and implements and so achieve a better sense of the value of the acquisitions and a greater sense of obligation to implement and adopt the system.

FORESTRY COMPONENT

Management of native forest

The care and maintenance of natural regeneration, as well as the management of secondary forest remnants can easily be achieved with little inconvenience on small farms, and results in direct benefits for the farm family. The introduction of these practices represented a change from an environmentalist focus to one of production on the part of the smallholder farmer and so resulted in greater adoption of the measures.

Enrichment

At the outset the Project promoted the enrichment of native degraded forests. With time it could be verified that the majority of them had abundant natural regeneration with excellent development which led to the recommendation of not enriching systematically but rather only according to necessity.

Fallow management

The natural regeneration which occurs in *kokuere* (fallow land or land out of production) develops very rapidly and in some areas after a few years can already produce cash. As this natural regeneration comprises principally pioneer species their growth is often better than planted species owing to their adaptation to the soil and climate of the place. It is **recommended** not to burn these plots and to avoid the entry of cattle, with the aim of allowing the natural regeneration to develop and to be exploited in the future.

Marketing logs

The legal marketing of products from the native forest remains an obstacle because of the established exigencies and requirements. The lack of institutional support for the sector prevents the farmers from realizing forest exploitation legally and this is prejudicial for them as they have to sell at lower prices to intermediaries. The Project contributed case by case to improve this difficult

situation which the farmer has to deal with to sell his products. It is worth mentioning that the legal marketing of timber products remains difficult. The activity requires an enormous effort and dedication on the part of technicians and farmers and because of that requires a very large investment in human resources, a limiting factor for the Project.

Integration of trees on the farm

It is important to point out that the Project was originally designed to promote forestry measures. These measures were little accepted, either by technicians or farmers. By means of the introduction of CA practices and also the forestry practices, the inclusion of trees in farming operations was to some extent accepted. For this reason it is recommended that agriculture and forestry should be complementary as this contributes to a greater acceptance of the measures. Promoting forestry measures independently will probably result in less and slower adoption. This contributed to the fact that many farmers implement forest management and reforestation on their own initiative and without external assistance.

It should be noted that the forestry measures promoted could achieve success without financial incentives if there was technical assistance both capable and committed to this important work.

Pruning and thinning

With reference to the reforestation systems it was shown that there is a resistance on the part of the farmer to manage the plantation, especially the thinning. This continues to be a negative aspect that until now has not been possible to overcome in spite of the training and campaigns promoted by the Project. Apparently thinning for the farmer represents a loss of trees. Not to do this is deeply rooted in the culture, and the same thing is often noted in agriculture. It is complicated to make it appear logical to the farmer that he should reduce plant numbers to ensure increased production. Something that may appear logical and simple to some, for the farmer it remains a difficult concept.

On the other hand pruning became a normal routine operation within the care of the plantations. In this practice it is important to control excessive cutting so that the developing trees are not adversely affected.

Agroforestry

At the beginning this was a measure little known by technicians and farmers, but with the inclusion, especially of fruit-forestry plantations, the measure gained notable acceptance. The measure had little diffusion initially due to the lack of understanding and, mainly, the lack of experience of the technicians and farmers.

Forest and green manure seed certification

The Project showed that it is feasible to produce GM seeds and acquire forestry species seed at farm level.

The formalization of the production, supervision and marketing of GM seeds by the State, as well as the guarantee of seed quality, registration, grading, definition and multiplication of varieties by means of competent authorities (SENAVE) is still pending and it is difficult to achieve it at farm level without institutional support.

The lack of a register and certification of native species forestry seeds is very worrying. The Project took some initiatives for the initial identification of seed producing trees at field level, nevertheless these actions did not resonate and there was no agreement on the part of the responsible authorities. It is considered of the utmost importance that the State begins to work in this area.

Professional development and education

During the implementation of the Project, there was much investment in technician training in forestry and CA. There is a deficit in the formation of agricultural technicians, both at secondary and tertiary levels, in aspects related to the management and conservation of the soil and forest. This makes it necessary to revise the curricula of agricultural schools and universities.

Also the inclusion should be considered of analysis and discussion of these themes within the schools and colleges so that the students absorb and involve themselves from an early age in these new production systems. This will ensure that they project a positive image and attitude to the smallholder farm family. It will be important to work on these aspects which remain a pending debt of the Project.

Trials

It should be noted that, even though the Project realized research activities on the measures and activities being promoted, these did not have scientific rigour. From the start there was a link with the Choré agricultural experimental station and, but only in the last years, with the FCA. The links with these institutions were insufficient for a greater and better dissemination of the large number of results observed in the field.

Apparently the lack of collusion between research institutions and the Project was due to the lack of diffusion of the results of the Project's work and the low credibility that it often had, something which the Project was determined to rectify over time.

Due to this experience it is recommended that support is developed from institutions dedicated to research to facilitate the capture of trial results that contribute to the needs of the scientific community, but also and importantly comprise valid tools for the technicians in their task of raising awareness of the promoted measures within the beneficiary farmer community.

Adoption and multiplier effects

According to our monitoring, increases were achieved for the area under NT, reforestation, agroforestry, forest management, GM nurseries, practices adapted and positive results were obtained for yield, labour requirement, and machinery use amongst others.

It is difficult to measure the level of adoption, bearing in mind that the majority of farmers continue to receive technical assistance. Nevertheless, it is estimated that 20 percent of the assisted farmers did not apply the measures, of these the majority is because of migration, that is to say that they sold their farms and ceased to be completely dedicated to agriculture in their regions. Forty percent are applying the measures with full confidence and conviction and very probably they will continue applying the learnt measures in their own way. The remaining 40 percent are applying some of the practices of the system, but not in a constant and systematic way. Of these, some will be converted to future adopters. But this will depend on many factors and is difficult to foresee.

With regard to the multiplier effects, it could be observed that there are farmers who are not directly supported who have adopted the measures promoted by the Project, just by copying from neighbours. There are clear indications that this is happening, however this type of diffusion is only just starting.

According to interviews conducted with farmers, 55 percent claim to know of neighbours who are starting to copy NT techniques, and 38 percent know of neighbours who are copying forest management practices. The land of these farmers could not be verified, however the effects are frequently observed. Apparently the incorporation of some of the practices is occasional and not massive.

The low multiplication of NT practices by non-beneficiary farmers is probably due to an erroneous but generalized preconception that many farmers have about the implementation of the technology. There exists a strong belief, on the part of the farmers, that the use of chemical fertilizers, acquisition of tools and implements and technical assistance is an indispensable condition or prerequisite for them to insert themselves into the system.

Probably the Project did not insist enough on the application of NT with low cost technology packets, that is to say with only the use of GMs and manual jab planters (*matracas*). This aspect should be examined and critically analyzed.

It seems that reforestation is one of the measures most accepted by farmers who are not supported directly, but there is no concrete evidence.

ADMINISTRATION

Transparency

The execution of the Project was realized through cash payments to the accounts of the committees for the acquisition of machinery, equipment, inputs and for the payment of forestry incentives. The implementation of the different administrative mechanisms, such as signing the agreement documentation, opening a joint bank account, submission of accounts, the coordinator as co-signatory to the committee account, the inspector reviewing inputs and machinery before payment to the providers, and a permanent programme of field visits, allowed greater transparency and honesty in the management of money, and on the other hand a better internal control of the base level organizations.

Timely transfer of funds

The transfer of incentives for the purchase of agricultural inputs was delayed on several occasions, causing serious upheavals in the implementation of the promoted measures, mainly those related to the soil. These delays were due to, on the one hand the strict bureaucracy of the State for the passage of funds coming from Germany to the Project's account; and on the other hand, the delays in the internal administrative processes to obtain the funds.

A reduction in these delays was achieved, but they were never completely eliminated. This deficiency, therefore, continues to be a problem at Project level and perhaps at country level. To solve these inconveniencies there is not yet a solution or feasible recipe to recommend to future projects.

Traders

One drawback that the PMRN had was the lack of businesses dedicated to the distribution of machinery, equipment and inputs for NT directed at smallholder producers in the different regions of action of the Project. This caused many difficulties at the time of making purchases for the distances

involved and the delays in delivery. There were also problems in obtaining inputs of the right quality and machinery and equipment that had the required specifications according the Project's procedures manual, which was adjusted on several occasions. The demands and controls established by the Project induced a sense of formality and seriousness in the suppliers of the input goods and also acted as a filter for those companies who did not wish to conform to these types of controls.

On this particular point it is recommended to establish the biggest possible number of control mechanisms with the objective of demonstrating the transparency and seriousness with which the work is carried out. Amongst the mechanisms of control successfully implemented we can cite the following; the supervisors, permanent control of accounts, co-signing of accounts, letters of agreement with companies, verification forms, etc.

TECHNICAL ASSISTANCE

Contracting direct and constant technical assistance

Technical assistance is the basis of the success of a Project. Many problems can be overcome if there is access to technical assistance which is trained, dedicated, motivated and opportune. The Project tried different types of technical assistance over the years.

One of the success factors of the PMRN was, without doubt, the contracted technical assistance.

An integrated agricultural and forestry focus for the farm with clear indicators and established goals, helped the technicians to gain confidence and assist with a precise and directed message. This was first to convince themselves about the possibility of achieving the goals, and then to transmit this confidence to produce positive changes on the farm, in the farmer and in his family.

The selection and incorporation of the technical assistance, exclusively by technical criteria, is another outstanding factor which contributed to the success of the Project.

Not all technicians are dedicated to extension and working mainly with smallholder producers, neither do they all have the vocation or professional profile to be extensionists. Because of this several of them were changed during Project implementation which only persevered with and retained those that had a service vocation and a spirit of solidarity.

On the other hand, the technicians should not have an exaggerated number of farmers to attend, a number between 100 to 150 is considered to be acceptable in one nearby area according to the organizational level of the assisted groups. Another important aspect is that the technical assistance should be constant, without permanent staff changes and above all a presence in critical periods. This should be maintained for a prudent length of time (3 to 4 years) to guarantee sustainability.

In the case of technical assistance it is recommendable to establish clear goals and indicators that can be applied and can be gradually increased in complexity. Also the implementation of strict supervision of the planned work and constant evaluation will result in success and will contribute positively to excellence. It is very important to establish regional consolidated nuclei to carry out the work harmoniously. Equally it is recommended to invest constantly in the training of the technicians involved in the proposed work. And also to insist on systems of evaluation which are practical and reliable, so that any necessary adjustments can be made, both in the implementation of the measures and in the diffusion methodology.

The PMRN team

One of the strengths that the PMRN had was the good fellowship that reigned between the members of the technical and administrative teams of the Project in its lifetime. It should be pointed out that these good relationships facilitated in a large measure the achievement that each situation demanded year after year. On the other hand, although there was a hierarchy at the field technician level, this never impeded the harmonious and orderly execution of the work in the different regional coordination groups.

ORGANIZATION

Farmer selection

Not all members of rural communities have the vocation for farming and these types of productive projects funded by donations are exploited by them to associate and receive benefits without having a production focus. Later on this generates disasters and desertions within the organizations, prejudicing some members who perhaps have good intentions for the implementation of the project.

Over time the Project revisited the selection criteria for farmers and made them more rigorous each time, leaving to one side those who only wanted to receive handouts from the governmental institutions. With these changes to the selection procedure, the adoption rate was improved.

The selection criteria and the increase in exigency to comply with the promoted measures produced different reactions in different committees. Some farmers stopped, occasioning a high level of desertion, and in other cases the reaction contributed favourably to the strengthening of the organization of the group and to establishing a system of internal control, many times headed by the representatives and leaders of the organization.

It is considered important that this type of project helps farmers with a semi-entrepreneurial vocation, whereas the rest need another type of support, directed more at covering unsatisfied basic needs. It would be ideal to demand of the farmers a cash contribution and a requirement to receive support from the project.

Committees

The Project worked with organized committees. It could be shown that in many committees there is a certain amount of distrust between the members and a lack of positive leadership. Apparently the committees acquire greater responsibility when there is a social control (within the committee) over them. In the case of organized groups, it is recommended to form and train them constantly and this is work that the technicians should take on. For this it is important that they are trained in conflict management or in organizational and social aspects of the committee, and that they have sufficient time to attend to this type of activity.

Gender

At the outset the Project did not contemplate the direct participation of the farm family in its implementation. With time it became clear that giving space to the family members, contributed to better adoption of the promoted measures.

It can be affirmed that the women gained space and authority in the farmer committees taking on positions and responsibilities that were habitually reserved for men. At the same time men took on roles that were traditionally considered to be taken on by women.

MARKETING

Production chains, sales

The involvement of the Project in marketing products from the beneficiary farms was not included in the original proposal. In reality the increase in yields, the surplus production, the production of GM seeds and the forestry products (firewood and timber) obliged the Project to look for mechanisms to market these products. To meet this challenge required the backing of the directors and technicians to establish agreements with private sector companies.

Leading on from this assumed obligation, it could be seen that the incomes of the assisted families grew, which led to the understanding that the sustainability of the CA system must be accompanied by improved family economies, if it were not the case then the adoption of the promoted system would be jeopardized. However assistance with marketing continues to be something which farmers ask for. It is recommended that support for marketing and the insertion of producers in production chains ought to form part of the technical proposal for this type of projects.

Credit

The Project works by means of the transfer of incentives from donations for the farmers. At the time of Project design, this seemed to be the only valid pathway. Apparently there exists the culture of accepting credit, at least amongst the farmers who are mini-entrepreneurs as is evidenced by examples such as CODEVE in Repatriación, COVESAP in Itacurubi del Rosario, COVEPA in General Aquino, and others. With the increase in productivity and sale of products, the need for farmers' credit grew for investment on the farm. This was an aspect not contemplated by the Project in its strategy for financing the system with farmers. Under present conditions it is considered feasible and recommended to include a line of credit with a financial institution or CAH.

POLITICS

Counterproductive incentives and coordination bodies

The Project furthered CA, native forest management and reforestation, measures that are fully contemplated in the policies of MAG. Nevertheless the ministry on many occasions had to take the lead with technical proposals supported or tolerated by de-centralized governments who opposed the efforts of MAG. On many occasions it could be seen that the plough was being promoted for smallholder farms with tractors from municipalities, local governments or Itaipú Bi-national hydroelectric company as part of political campaigns, destroying what the farmers had built with much patience and sacrifice.

Many smallholder farmers complained about the attitudes of mechanized farmers who continued with their practices such as clear felling forest, felling river course protection woodland, spraying without protection strips, without any intervention from the local, national or sometimes international authorities.

On the other hand if there was support from the authorities of the time for the implementation of the work done in the Project framework; this was many times occasional, circumstantial or not constant.

Raising awareness amongst the national, departmental and municipal authorities was partially achieved on the importance of the work being

executed by the Project and principally to include in the proposals or plans of the government, activities promoting conservationist measures when budgets included royalty funds.

In many cases great advances were made in this sense, thanks to the implementation of the so-called inter-institutional coordination bodies installed with the help of GIZ and then SIGEST. This work of coordination between the different public and private institutions which make up these bodies did not have force when the decision-taking authorities (governor, superintendent) were not involved or assumed direct responsibilities relating to the theme.

For this reason it is of fundamental importance that any project tries to involve, from the outset, the local authorities using the SIGEST system, which MAG is actually supporting, to better coordinate local activities. Intervention in the planning of the participatory budget is also an opportunity to channel funds to the productive sector.

Furthermore the need arises to promote, as a project, the design of public policies that focus on and value efforts for the better management of soil and forest resources, having in mind results in the short, medium and long terms. To achieve this adequate staff and time are required in the delineation of a project which promotes these goals, both at central and decentralized government levels. This is apart from the obligation and political good will on their part and the support from social organizations involved in rural development.

These policies should necessarily contemplate mechanisms which facilitate the widespread use of conservationist measures, considering at the same time a credit policy in accordance with the specific demands that the system generates.

CHAPTER 11

Factors of Success and Failure

On interviewing farmers, they always appear content with the results on their farms, however there is a percentage of desertion by farmers, non-adopters and farmers who regress to the traditional system. The question arises about why these farmers, in spite of the success which they themselves manifest, do not adopt the system on their farms and why is there not greater auto-diffusion or scaling out of the system? Maybe they are not technical factors, but rather external factors or social or cultural pressures that influence the farmers?

To evaluate this question, a social study was carried out, on factors of success and failure, by two consultants: Fabio Nizz and Ademir Calegari. The most important findings contained in their report, as well as from workshops with technicians and farmers are presented in this last section of the book.

PROJECT SUCCESS FACTORS

Consolidation of organizations: The committees or organizations who develop and practise the conservation production measures with great success are, usually, those which have organized many years ago, where the participants are known to each other, there are formal meetings, where the group spirit of cooperation is noticeable, where there is a high degree of obligation to the group and a very clear vision of the goals.

Homogeneity of the group: The committees formed with contemporary members, or at least without great age differences, with well constituted and stable families, whose members have uniform interests, with clear objectives for the group and with the intention of progressing in the development of better technologies, they haven't encountered insurmountable barriers to the adoption of CA innovations and some problems, such as the late delivery of inputs, have been solved on their own initiative.

Management leadership: When the exercise of positive leadership is given for community authorities, technicians and especially the leaders and other members of the organizations, the committees show keen interest in obtaining even more knowledge and experience which will enable them to continue improving the management of soil and other resources and so advance and obtain even greater returns from their agricultural production.

Permanent technical assistance: Successful committees are those which have received, from the PMRN or DEAg, continuous and opportune technical assistance at the right moment and uninterruptedly. This is considered to be both helpful support and a certain type of pressure which gives security to their field operations and constitutes one of the principal reasons for the great success of the Project.

Positive results: The positive results achieved with increasing yields, saving labour, reduced weed pressure have contributed enormously to allow the committee members to achieve success and advantages in the pursuit of the NT system.

Technology packet: The suite of technology packets promoted by the PMRN (technical assistance, knowledge, inputs, equipment, machinery, etc.) enjoys great acceptance by the farmers and is, without doubt, another of the reasons for the success of the Project.

Management team: The technical group which makes up the PMRN is characterized as a cohesive group of people binding the Project and empowered by its objectives, with great capacity for participation in its discussions of evaluation.

Case Study 38: Sow over weeds? From neighbours' taunts to community leadership, Don Quijote from Sangina Cué, Lima.

Arnaldo Cabral, a young man of 29, lives with his wife in Sangina Cué community, Lima District 10 km from the town of General Resquín, where he works on is 10 ha farm.

In 2007 Pedro Alvarenga, a PMRN technician, designated to the General Resquín area, visited Arnaldo who shared his worries about low agricultural yields, especially of maize. The technician proposed the formation of a committee, which was later called Santa Lucía, with the aim of receiving support from the Project in agricultural production with NT.

The committee was formed, mostly of young people as the older adults had no confidence in the new form of working. The reception of equipment and inputs by the beneficiaries was programmed for the end of 2008. After debating with the technician over the pros and cons of NT, Arnaldo was convinced by the new technology and did not want to wait for the production of GM seeds and receipt of the inputs provided by the Project, which would only happen the following year.

In dialogue with the technician they arrived at an agreement; whilst he was producing GM seeds and waiting for the inputs, he would use areas infested with colonial or Guinea grass (*Panicum maximum*) which is very common in the region. He would use this as an alternative cover on which to plant

maize. Together with the technician, Arnaldo organized meetings with his neighbours and they explained the idea. There was no response and Arnaldo stood alone like Don Quijote fighting against imaginary monsters.

He was lent a knife roller to flatten the vegetation and then he applied systemic herbicide to kill the green grass. The ridicule of his neighbours was not long in coming: "you're crazy, the insects will eat all the crop, this is madness, it's the work of wasters". Arnaldo continued and planted maize through the dry residue of the colonial grass. Very soon Arnaldo and his neighbours saw the first results. Arnaldo only invested half a day in rolling the grass and another half day in herbicide application, he did not weed even once and the maize, which before would have given 15 000 to 2000 kg/ha , leapt to 4000 kg/ha. The jeering neighbours were astonished by the production.

When the inputs arrived in 2008, Arnaldo already increased his maize production to 3 ha and produced GM seeds: pigeon pea and oat. Now in the meetings, the neighbours listened intently to Arnaldo on how to produce with CA.

SUMMARY

Name and District	**Arnaldo Cabral**
Technician	**Pedro Alvarenga**
Area of the farm	8 ha.
Family members	Arnaldo Cabral, his wife and one young daughter.
Main activities	Crops of maize , cassava and chilli, he also has milking cows.
Marketing	All production is sold at the farm gate, they also sell milk and cheese.
Economy	Today the family income has improved thanks to the good production from the soil.
Main impacts	Sowing crops of colonial grass residue, more time to do other jobs on the farm, such as milk and cheese production.

FAILURE FACTORS

Desertion

In total the Project suffered a desertion of 22 percent of the supported farmers (up to March 2009).

In the study conducted by Fabio Nizz, 66 percent of those interviewed averred that: "the advantageous results of the application of the measures are not immediate, on the contrary at the beginning there is the need for much dedication and work which only starts to reduce from the second year".

It is very difficult to identify the reasons for which farmers do not finish the process of applying the measures and the later adoption. By means of questionnaires applied to this segment it was shown that 93 members left their committees for the following reasons:

- 67 for not complying with project norms.
- 21 migrated (to Argentina, Spain, etc.).
- 4 because of illness.
- 1 because of death.

In the same study the farmers mentioned their motives for desertion:

TABLE 11.1
Motives for desertion

Results not very significant	23%
Committees not consolidated	14%
Little humanity in colleagues	14%
Inadequate management leadership	13%
Informality of the technician	12%
No opinion	24%

Source: Fabio Nizz, 2009

Community, neighbours

Also according to the interviews, 74 percent of farmers mentioned as discouraging factors, their neighbours, and it can be concluded that: "To generate and develop projects with impacts, the community must be taken into account, not only in the generation of the Project, but also in the selection of the first actors or experimenters and then to extend to the rest of the community in a climate of joint or community work. If this is not done, the others will feel marginalized and second rate" and "the lack of humanity is related to the lack of confidence between the members and the lack of effort on the part of the farmer". Fabio Nizz and Ademir Calegari, 2009.

In answer to another question put to the farmers, they mentioned their reasons for abandoning the measures:

TABLE 11.2
Reasons for abandoning conservation measures

Results not very significant	15%
Disorganization of the committee	11%
Too many meetings	10%
Little financial help	10%
Absence of CA in the region	12%
Lack of land	12%
Committee sanction	13%
Can't be bothered	22%

Source: Fabio Nizz, 2009

There were other reasons identified which are explained as follows:
Exclusive interest: Farmers who join committees or associations exclusively to be integrated into the Project or only to have access to inputs and equipment, often without even understanding the aims and minimum requirements of the Project, are those who abandon the measures when any difficulty is encountered, and they also can cause the failure of the group.

Committee problems: There are some committees with 'congenital' problems because they are formed by members with unfocussed and disunited thoughts and aims.

Absence of leadership: The lack of leadership in many committees, both from the actual leaders or other members of the group.

Intermittent technical assistance: The members of those committees that have not had constant and monitored technical assistance at the right moment when it is needed, be it due to a high rotation of technicians; a certain negligence by the committees; the lack of insistence by them; or infrequent presence of the technicians in the field with the committees, results in weak adoption of the measures. The discontinuity of technical assistance, especially in former periods, was mentioned several times by the interviewees, indicating that it was prejudicial to the work of the committees.

Inadequate selection of users: This is related to the inadequate selection of the committees, and within the committees, of members who do not have the real vocation of an agricultural producer.

Lack of effort: One negative factor that was often mentioned in the interviews is the lack of effort of those who abandon the measures.

Lack of training for the different family members: If the training by the technical assistance is channelled almost exclusively towards the family heads, it constitutes a failure factor, because the other family members do not receive the empowerment required to take the process forward.

Belief that to practise the conservation measures requires a lot of investment: The packet should be accompanied by a good illustration that the conservation measures are practical with what the fallow (*kokueré*) generously provides in abundance, the weeds, with a machete and a traditional planting stick.

Inadequate management of resources at field level at the beginning of the Project: The opaque management of resources and other means and goods, on the part of the technicians of some of the contracted companies and some organization leaders, was a risk factor because of the suspicion aroused.

Inadequate equipment and timing: The same effect was produced by the late delivery of equipment and implements in conditions that were not appropriate for their use, and others which did not fully correspond to the needs of the users.

Dependency culture: The characteristic of the agricultural producer of needing to be controlled for good compliance with his assumed obligations is a highly negative factor for Project success.

CONCLUSIONS ON THE FACTORS FOR SUCCESS AND FAILURE

Apparently the organizational factor is of the utmost importance. However the justification is rather contradictory bearing in mind the benefits recognized by the same farmers, and there is no clear tendency.

The fact that 24 percent of those interviewed have no opinion with respect to their abandonment of CA, and 22 percent who said that they could not be bothered, indicates that there are other reasons for the non-adoption of the promoted systems, which are still difficult to understand and not very clear.

ANNEX 1
List of common and scientific names of trees, green manures and weeds

GREEN MANURES			
Local and English[13] names	**Scientific name**	**Use**	**Observations**
Avena negra. Black oat	*Avena strigosa*	Green manure.	winter
Crotalaria	*Crotalaria juncea*	Green manure.	
Canavalia o Cumanda guasu. Canavalia	*Canavalia ensiformis*	Green manure.	
Cumandá yvyra'i o Guandu. Pigeon pea	*Cajanus cajan*	Green manure, bush.	
Lupino blanco. White lupin	*Lupinus albus*	Green manure.	winter
Mucuna ceniza. Mucuna	*Styzolobium* spp. *cinereum*	Green manure.	
Nabo forrajero. Forage radish	*Raphanus sativus*	Green manure.	winter
FRUIT TREES			
Local and English names	**Scientific name**	**Use**	**Observations**
Acerola. Barbados cherry	*Malpighia punicifolia*		
Aguacate. Avocado	*Persea americana*	Fruit	
Banano. Banana	*Musa x paradisiaca*	Fruit	
Coco. Coconut	*Agrocomia totai*	Fruit, forage.	In paddocks, pasture, farm and contour lines.
Durazno. Peach	*Prunus armeniaca*		
Grosella. Roselle	*Hibiscus sabdariffa*		
Guavira pyta. Gabiroba	*Campomanesia xanthocarpa*	Fruit, shade.	In paddocks and pasture.
Guayaba. Guava	*Psidium guayaba*	Fruit	
Higo. Fig	*Ficus carica L.*	Fruit	
Limón tahiti. Tahiti lemon	*Citrus limón var. tahiti*	Fruit	
Mamón. Papaya	*Carica papaya*	Fruit	
Mandarina. Mandarin	*Citrus nobilis*	Fruit	
Mango. Mango	*Mangifera indica*	Fruit	
Mburucuyá. Passion fruit	*Pasiflora edulis*	Fruit	
Mora. Mulberry	*Morus nigra*	Fruit	

[13] Where available

FRUIT TREES (*continued*)			
Local and English names	**Scientific name**	**Use**	**Observations**
Naranja. Orange	*Citrus sinensis*	Fruit.	
Naranja hai (petit grain). Bitter orange	*Citrus aurantium*	Essence.	
Níspero. Loquat	*Eryobotria japonica*	Fruit.	
Ñandypa. Huito	*Genipa americana*	Fruit.	
Ñangapiry. Surinam cherry	*Eugenia uniflora*	Fruit.	
Pakurí. Bakupari	*Rheedia brasiliensis*	Fruit.	
Pomelo. Grapefruit	*Citrus paradisi*	Fruit.	
Uva. Grape	*Vitis vinifera*		
Yvapurû. Jaboticaba	*Myrciaria cauliflora Berg.*	Fruit bush.	Not widespread.
GRASSES			
Local and English names	**Scientific name**	**Use**	**Observations**
White moneywort	*Alysocarpus vaginalis*	Forage.	Legume.
Brachiaria. Beard grass	*Brachiaria brizantha; B. Humidicola; B. decumbens*	Forage.	Legume.
Centrosema. Butterfly pea	*Centrosema pubescens*	Forage.	Legume.
Camerún. Cameroon grass, elephant grass	*Pennisetum purpureum*	Forage.	Legume.
Colonial, or Guinea grass	*Panicum maximum*	Forage.	Legume.
Pasto estrella. Stargrass	*Cynodon plectostachium*	Forage.	Legume.
Pasto jardín. Crabgrass	*Digitaria* spp.	Forage.	Legume.
Pasto jesuita (siempre verde). Tropical carpet grass	*Axonopus compressus*	Forage.	Legume.
Stylo	*Stylosanthes* spp.	Forage.	Legume.
TREES			
Local and English names	**Scientific name**	**Use**	**Observations**
Cancharana	*Guarea canjerana*		
Cedro. Brazilian cedar	*Cedrela fissilis*	Timber, agroforestry shade.	In paddocks, pasture, farm and lines.[14]
Cedro	*Cedrela tubiflora*	Timber.	In paddocks, pastures, farms
Eucalypto. Eucalyptus	*Eucaliptus camaldulensis*		Poorly drained soils, lowlands.
	Eucaliptus citriodora		
	Eucaliptus dunnii		
	Eucaliptus grandis		
	Eucaliptus saligna		Poorly drained soils.
Grevilea. Silky-oak	*Grevillea robusta*		Windbreaks.

[14] Field boundaries, road sides, erosion control strips, windbreaks, etc.

TREES (*continued*)			
Local and English names	**Scientific name**	**Use**	**Observations**
Guajayvi	*Patagonula americana*	Timber.	In paddocks and pastures.
Guaviju	*Eugenia pungens*	Fruit tree.	
Guatambú. Ivory wood	*Balfourodendron riedelianum*	Timber, agroforestry, shade.	In paddocks, pasture, farm and lines.
Hovenia. Oriental raisin tree	*Hovenia dulcis*	Agroforestry, forage, shade.	Lines.
Incienso	*Myrocarpus frondosus*		High value species.
Inga guasu. Inga	*Inga uruguensis*	Fruit-forestry, forage, shade.	In corals, pasture, in association with yerba mate and citrus or firewood plantations.
Inga'i	*Inga marginata*	Forage, shade.	With grass.
Kai Kay'gua. Brazilian mahogany	*Cariniana excelsa*		
Kamba aka. Bastard cedar	*Guazuma ulmifolia*	Agroforestry, forage, shade.	With grass, in lines.
Kurupa'y kuru	*Anadenanthera colubrina*	Timber, fruit-forestry, forage, posts.	In paddocks, pasture, farm, in association with yerba mate, citrus or firewood plantations.
Kurupa'y ra	*Parapiptadenia rigida*	Timber, frut-forestry, shade, posts.	In paddocks, pasture, in association with yerba mate, citrus or firewood plantations.
Kurupika'y	*Sapium* sp.	Timber.	In paddocks, pasture.
Lapacho. Pink ipê	*Tabebuia impetiginosa*	Timber, agroforestry, shade.	In paddocks, pasture, farm and lines.
Lapacho negro o Tajy hu. Pink trumpet tree	*Tabebuia heptaphylla*	Timber, agroforestry, shade.	In paddocks, pasture, farm and lines.
Laurel guaika. Apici	*Ocotea puberula*	Shade.	In grassland.
Laurel hu. Yellow laurel	*Nectandra angustifolia*	Timber, shade.	In paddocks, pasture.
Laurel moroti. Stinkwood	*Ocotea diospyrifolia*	Timber, shade.	In paddocks, oasture and farm.
Leucaena. White lead tree	*Leucaena leucocephala*	Forage.	Legume.
Manduvi'ra. Monkey-pod	*Pithecellobium saman*		
Mbavy	*Banara* sp.		
Paraíso gigante. Bead tree	*Melia azederach*	Timber, agroforestry.	Lines.
Peroba o Yvyra rómi	*Aspidosperma polyneuron*		
Petereby. Princewood	*Cordia trichotoma*	Timber, shade.	In paddocks, pasture and farm.

TREES (*continued*)			
Local and English names	**Scientific name**	**Use**	**Observations**
Petereby moroti	*Cordia glabrata*	Timber.	
Pino. Pine	*Pinus taeda; Pinus elliottii*	Timber.	
Tacuara. Bamboo	*Bambusa guadua*	Forage, shade.	In grassland.
Tatajyva. Yellow wood	*Chlorophora tinctorea*	Shade, fruits.	In grassland.
Taperyva guazú. Brown heart	*Ferreira spectabilis*		
Tatare	*Pithecellobium scalare*	Timber, forage, shade.	Paddocks, pasture.
Timbó. Earpod tree	*Enterolobium contortisiliquum*	Timber, shade.	Paddocks, pasture.
Toona (Cedro australiano). Australian red cedar	*Toona ciliata*	Timber, fruit-forestry.	Lines, in association with yerba mate and citrus.
Urunde'y mi. Urundel	*Astronium urundeuva*		
Urunde'y pará	*Astronium* sp.		
Ysapy'y	*Machaerium* sp.		Paddocks, pasture.
Yvyra ju	*Albizia hassleri*	Timber, agroforestry, forage, shade.	Lines, in grassland, good N fixer.
Yvyra ovi	*Helietta apiculata*		
Yvyra pepe	*Holocalix balansae*	Fruit-forestry.	In association with yerba mate and citrus.
Yvyra pyta. Yellow poinciana	*Peltophorum dubium*	Timber, fruit-forestry, forage, shade.	In paddocks, pasture, in association with yerba mate, citrus.
Yvyra ro	*Pterogyne nitens*	Timber, agroforestry, shade.	Paddocks, pasture, lines.
Yvyra rómi o Peroba	*Aspidosperma polyneuron*	Madera – Construcción.	
Villetana. Mulatto tree	*Triplaris caracassana; Triplaris brasiliensis*	Firewood and charcoal.	Low lying or hydromorphic soils.

ANNEX 2

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Forest Management and Conservation Agriculture:
Experiences of smallholder farmers in the Eastern Region of Paraguay

This is a book which examines in great detail the design and implementation of a rural development project for smallholder farmers in Paraguay. Over a period of seven years, from 2003 to 2010, the project applied the basic concepts of conservation agriculture, forestry and agroforestry benefiting 17 thousand farm families in the Eastern Province of the country. The practices promoted closely paralleled those being recommended for sustainable crop production intensification by FAO which seek to enhance agricultural productivity whilst protecting the natural environment and improving ecosystem services.

The conservation agriculture practices focus on hand and animal powered systems of direct planting, permanent soil cover and crop associations, successions and rotations. Agroforestry practices incorporate trees into agricultural systems to ensure a steady supply of fruits and other cash crops which diversify the income streams and nutrition of the farming families. Finally the importance of forest managements and reforestation are emphasized to ensure that deforestation is combated and reversed and that forestry exploitation is both profitable and sustainable.

The book gives a clear-eyed analysis of the lessons learnt and the factors for success and failure and so is an invaluable resource for those contemplating similar projects in the future.

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