

# OIL CONSERVATION PROJECT (MAG/ GTZ)

## ECONOMICS OF NO- TILL COMPARED TO CONVENTIONAL CULTIVATION SYSTEMS ON SMALL FARMS IN PARAGUAY

### POLICY AND INVESTMENT IMPLICATION

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### SUMMARY AND CONCLUSIONS

(Only the summary, conclusions and recommendations are presented here)

Please refer to the main author or to the MAG- GTZ Soil Conservation Project for the full report.

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*This report documents the findings of a study into the economics of no- till systems compared to conventional cultivation systems on small farms in Paraguay. The study was conducted during a three month period in May- July 1998 and was funded by the MAG- GTZ project "Desarrollo y Difusion de Sistemas de Aprovechamiento del Suelo Orientados a su Conservacion".*

*Soil erosion and soil degradation in the tropics are now considered to have reached catastrophic levels and threaten the viability of agriculture in much of the tropics. Facing the debilitating effects of declining productivity and incomes, due to soil erosion and soil degradation in conventional cultivation annual cropping systems, farmers throughout the tropics have been quick to adopt no- till, in what is becoming recognised as a technological revolution. Practical experience in Paraguay and elsewhere in South America suggests that no- till in combination with green manure crops and crop rotations are cost-effective methods of soil conservation. Uneconomic unsustainable conventional cultivation systems are transformed into economic sustainable ones with the potential to generate enormous private and social gains.*

*No- till was introduced on tractor- mechanised medium and large farms in Paraguay in 1990. By 1997 some 480,000 ha, 51% of the total cultivated area in Paraguay, was no- tilled. The total economic benefits arising from this spectacular adoption of the technique are enormous. Their magnitude can be appreciated from the US\$941 million that has been calculated for the year 1997. This estimate includes the savings in lost nutrients in the soil that was saved from erosion on the no- tilled areas, plus the costs saved in reduced tractor hours, less fuel and lowered inputs of fertiliser.*

*In comparison to the meteoric rise of no- till on tractor- mechanised farms, no- till has hardly reached small farms. While the number of small farms in Paraguay total almost 248,000 and occupy 1.5 million ha, the area of no-till on small farms has been estimated at only 4,500 ha. This area includes areas occasionally no- tilled. The area permanently no- tilled on small farms is likely to be less than 2,000 ha involving no more than 150 farmers.*

*It is estimated that 1.2 million people live on small farms, 80% of whom live below the poverty line. Rural poverty has been increasing and small farm families have been suffering from declining incomes and deteriorating levels of nutrition and health. As a consequence, urban drift has been escalating. The urban population, as a percentage of the total Paraguayan population, increased from 37% in 1972 to 50% in 1992. A root cause of urban drift is undoubtedly declining productivity due to soil erosion and soil degradation and diminishing farm incomes. It is most unfortunate and ironic that many of the small*

soil degradation and diminishing farm incomes. It is most unfortunate and ironic that many of the small farmer families who abandon their farms in search of a better life in fact face worsening conditions. Most end up living in and around cities in impoverished slum areas.

Despite the worsening situation faced by small farmers, and the significant number who have been abandoning their farms and moving into urban areas, they still make a major contribution to the Paraguayan economy. While small farmers occupy only 6% of the country's agricultural area they still generate 35% of the sector's output. This is a major contribution to the economy since the agricultural sector is the backbone of the Paraguayan economy generating 26% of the economy's Gross Domestic Product, 90% of all exports and employs 37% of the workforce.

### **Edelira and San Pedro**

The report documents detailed case studies of seven farms in two representative regions of the country where most experience has been built-up with no-till on small farms - Edelira and San Pedro. Farms studied were selected as being representative of most small farms and varied in size from 5- 20 ha. In Edelira farmers had 5 or 6 years of experience with no-till and in San Pedro the two no-till adopters had only 2 years of no-till experience. The performance of these farms before the adoption of no-till, i.e. when the farms were conventionally cultivated, were compared to their performance after the adoption of no-till. Two farms which have not adopted no-till, one in each region, were also analysed in-depth to provide a further check on the current performance of conventional cultivation systems. In addition detailed analysis was carried out of five typical farms in Paraguari considered representative of small farms on an estimated 367,400 ha of extremely degraded soils of Central Paraguay.

This study shows that the yields of cotton, soybeans, tobacco and maize, important income earning crops for small farmers, have been falling rapidly in unsustainable conventional cultivation systems. These systems enter an ever increasing downward spiral of diminishing yields and incomes and inevitably reach a point where farmers are forced to abandon their farms.

Soil fertility and organic matter levels rise rapidly when no-till and green manure crops are introduced immediately raising significantly farm incomes. Under conventional cultivation, in most cases small farmers do not use any fertiliser, very little if any manure and generally no soil conservation measures are taken. Due to significant soil erosion, high quantities of soil nutrients and organic matter are lost. In the opinions of the no-till adopter farmers', crop yields immediately improve under no-till. Crop yield data are provided in the report for each of the case study farms. These clearly illustrate trends of declining yields under conventional cultivation and immediately increasing yields after the adoption of green manure crops and no-till. An example of the dramatically quick response to the introduction of no-till and mucuna is the introduction of tobacco on the two no-till farms studied in San Pedro. In the second year of using no-till, tobacco has been reintroduced into these farming systems. A highly profitable crop demanding higher levels of fertility, previously tobacco was only viable to grow for one or two years after the felling of forest on newly cropped land. This is a sign that soil fertility has rapidly recuperated.

The study shows that crop production costs fall substantially after the adoption of no-till. Not only are soil preparation costs saved, but farm labour requirements fall and the cost of weeding in most instances also lowers. On one of the farms studied in Edelira, soil preparation for soybeans costed US\$59/ ha accounting for 24% of the total production costs. These costs were eliminated under no-till. On the same farm, substantial savings (US\$76/ha) in the costs of weeding were realised under no-till compared to conventional cultivation and annual farm labour requirements fell from 300 person-days to 239 person-days.

The study clearly demonstrates that the financial performance of conventional cultivation systems is poor and that in contrast no-till offers an almost instantaneous and dramatic improvement. Not only do crop incomes rise but crop production costs are significantly reduced. The order of magnitudes are illustrated below. Conventional systems are calculated to be marginally economic when all factors of production, including family labour, are costed at market rates. In distinct contrast, the farming systems where no-till and green manure crops have been introduced have shown a dramatic improvement.

### **Summary Farming System Results for Edelira**

Item	Unit	CONVENTIONAL CULTIVATION			
		Farmer			
		Bruno	Mendoza	Florencio	Victor
Farm Area	Hectares	20	9,2	18	19,5
- Labour	Person-	381	181	300	379
- Net Farm Income	day US\$	567	1.960	2.844	2.905

- Return to Labour		US\$/ día	1,49	10,85	9,47	7,66
<b>NO- TILL</b>						
Item	Unit	Farmer				
		Bruno	Mendoza	Florencio	Victor	
Farm Area	Hectares	20	9,2	18	19,5	
- Labour	Person-	0	132	239	350	
- Net Farm Income	day US\$	0	3.184	3.853	5.778	
- Return to Labour	US\$/ día	0	24,15	16,14	16,52	
Incremental Net Farm Income	US\$	0	1.224	1.008	2.873	
% Increase in Net Farm Income	%	0	62	35	99	

While the conventional farming case study (Sr. Bruno) currently has a net farm income of less than US\$600 and a return to labour of less than US1.50 per day, all three farms where no-till has been adopted have net farm incomes between about US\$3,200 and US\$5,800 with returns to labour from US\$16 to US\$24 per day. This is an impressive improvement over the farm that is still conventionally cultivated where the poor performance of the farm is primarily due to its heavy reliance on soybeans. Not only does it have a low yield (average 2,500 kg/ha) but the farmer also receives a relatively low price for his crop from a local soybean trader (12%- 15% below what the local farmer co-operative Colonias Unidas pays). He also pays a high rate of interest for credit borrowed from the trader (5% per month = 60% per annum) which significantly raises his costs of production. This farmer is caught in a proverbial vicious cycle of dependency on his local trader - a common occurrence amongst small farmers. The results of the no- till adopters are equally impressive when they are compared to the past performance of these farms when they were conventionally tilled. The increases in net farm incomes have been between 35% and 99%.

#### Summary Farming System Results for San Pedro CONVENTIONAL CULTIVATION

Item	Unit	Farmer		
		Augustín	Lucas	Oporto
Farm Area	Hectares	20	9,2	18
- Labour	Person-	183	164	163
- Net Farm Income	day US\$	1.416	571	1.448
- Return to Labour	US\$/ día	7,74	3,49	8,88

#### NO- TILL

Item	Unit	Farmer		
		Augustín	Lucas	Oporto
Farm Area	Hectares	20	9,2	18
- Labour	Person-	0	154	171
- Net Farm Income	day US\$	0	1.919	2.538
- Return to Labour	US\$/ día	0	12,46	14,84
Incremental Net Farm Income	US\$	0	1.348	1.090
% Increase in Net Farm Income	%	0	236	75

The current net farm income on the conventionally cultivated farm of Sr. Agustín is US\$1,416, which is about comparable to the net farm incomes (on a per hectare basis) earned on the other two farms when they were conventionally cultivated. What is particularly impressive is how the net farm incomes and returns to labour have increased only 2 years after the introduction of no- till, particularly on the small 5- hectare farm.

Farmers in Edelira and San Pedro have been receiving readily available high- level technical assistance, initial stocks of green manure crop seeds and free no- till machinery and equipment. All farmers interviewed acknowledge the need for continuous technical assistance. However, the detailed analyses carried out in the study suggest that even if farmers were to pay themselves for the initial seeds of green manure crops and for the machinery/equipment in small groups of 3-4 farmers per group, these technologies would still be highly profitable for them. The study therefore shows that no-till would have a high economic pay-off to the state and is financially attractive to small farmers.

Before a significant number of small farmers can adopt no- till, they will need access to competent technical assistance and long-term credit that afforded by state to small farmers, particularly in the

technical assistance and long-term credit at affordable rates to purchase a minimum of equipment and machinery. Depending on what equipment and machinery are purchased, costs per farmer would vary from about US\$800-US\$3,000 for a group of three farmers and from US\$600 to US\$2,200 for a group of four farmers. At the current interest rate charged by the CAH of 17.5% interest per annum, loans of at least 6-7 years duration would be needed.

### Paraguari

Paraguari was selected as representative areas of extremely degraded soils in Central Paraguay. No-till has not yet reached small farmers on these poorly degraded soils.

The likely financial impact of a proposed MAG- GTZ fertility restoration programme, and the introduction of no- till and green manure crops, were evaluated in the study for a 5- hectare model farm. The data on which this model is based was obtained by studying in detail five typical farms in Paraguari and Ybycui. The farm model analysis also incorporated the results of 11 pilot parcelas which were installed on small farms by the MAG- GTZ Soil Conservation Project in 1997. The proposed fertility recuperation interventions involve restoring the fertility on 1 hectare of a farm over three years. The results are shown for a scenario in which 75% of the costs of the technical inputs of lime, seed and fertiliser in the first year are subsidised. Such a policy would be necessary for the programme to be financially viable and acceptable to small farmers. A projection is also made of the likely financial performance of the farm if soil fertility was restored and no- till was adopted over the total cultivated area of 3.75 ha. It would probably take a typical small farmer from 9-12 years to reach this stage. The results are also impressive as can be seen in the table below. The net farm income is estimated to rise substantially from **minus** US\$176 to **positive** US\$298 while labour reduces slightly from 126 to 118 person- days.

**Summary Farm Model Results for Paraguari**

	<b>Total Revenue US\$</b>	<b>Total Costs US\$</b>	<b>Net Farm Income US\$</b>	<b>Total Labour Person- days</b>
<b>Present</b>	781	957	-176	126
<b>First Year</b>	1015	1402 <sup>1</sup>	-388	167
<b>Second Year</b>	1015	1159	-145	128
<b>Third Year</b>	954	921	33	126
<b>Future</b>	1621	1323	298	118

<sup>1</sup>This cost includes the US\$ 150 required for the two matracas and the maize silo.

The Paraguari results indicate that for a model 5- hectare farm under conventional cultivation the system is uneconomic when all factors of production are costed at market rates. The main reason for this is the very low crop yields realised on the extremely degraded soils where cotton yields average 800 kg/ ha, mandioca 8 t/ ha and maiz colorado 600 kg/ ha. Farmers continue to farm under such circumstances minimising their production costs. In the majority of cases no fertiliser or pesticide inputs are ever purchased. They use their own seed and rely on family labour which they do not have to pay for, although of course both have opportunity costs. In many instances farmers own their own work oxen, or they hire these from neighbouring farmers and pay for this in production or through their own labour.

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The study also explores the capability of a typical small farmer to service loan commitments. A typical farmer would need to borrow between US\$400 to US\$500 to finance the cost of two matracas, a small 2,000 kg maize silo, as well as 25% of the cost of the technical inputs required in the first year and 100% of those required in the second year. The study shows that this would be financially feasible providing a loan for at least 4 years was provided, interest was charged at the current CAH rate of 17.5% and interest only was charged in the first year and principal was repaid in equal annual instalments for the remaining three years. It would be necessary however, to incorporate loan repayment delay and loan write- off clauses to cover possible crop failures due to circumstances beyond the control of the farmer, such as severe drought or pest attack, to eliminate the risk of financial ruin.

The results for Paraguari indicate that, investment in fertiliser and high green- mass producing green

manure crops, and the introduction of no- till/ green manure crops, on small farms in the extremely degraded soil zones of Central Paraguari would be highly economic to the nation and to the small farmers.

### **A Proposed Programme for the Restoration of Soil Fertility in Central Paraguay**

A 4- year first phase programme proposed for recuperating soil fertility on the extremely degraded soils of Central Paraguay is detailed in the report. The first phase would consist of four components: (1) 250 farm demonstration plots; (2) machinery and equipment; (3) extension; (4) technical assistance. The costs of this programme have been calculated at about US\$1.1 million inclusive of price contingencies. Government of Paraguay would need to contribute about 60%. Farmers' labour contributions are estimated to total about US\$180,000, equivalent to 19% of the programme costs. A line of credit for participating farmers would total about 21%. Including the credit portion of the project costs means that farmers' will pay 40% of the total programme costs. The project would need specialist technical support, which it is assumed will be provided free of charge by GTZ to the Government of Paraguay.

During the course of the project 25 extensionists would be trained extensively in the techniques of no-till, crop rotations, participatory on- farm development and in assisting farmers to organise the operation and maintenance of manual and animal traction no-till machinery. These extensionists would be dedicated full- time to the programme and would work directly with 250 small farmers.

Through the planned extension activities, involving national congresses and local symposia and field days, contact would be made with at least 2,000 other small farmers. In addition training courses funded through the programme at the DEAG Training Centre in San Lorenzo would be an integral part of the extension activities. These training courses are designed to widen the impact of the programme beyond the extensionists and small farmers directly involved. An additional 60 extensionists and 240 leader small farmers would be trained in the basic principles of soil conservation and the restoration of soil fertility on the extremely degraded soils, in no- till and green manure crops. They would be selected from other parts of Central Paraguay where soils are extremely degraded. This would provide an opportunity for them to learn from the first phase field experiences and to help set the stage for a subsequent second- phase expanded programme.

### **Immediate Government Support**

Because it will be imperative for the successful adoption of no- till and crop rotations that well trained competent extension services and long- term credit are accessible to small farmers, as a next step the study strongly advises that Government immediately support two pilot programmes. The first should be the first phase programme proposed in this report for the restoration of soil fertility in Central Paraguay summarised above. The second should be a small farmer no- till/ crop rotation expansion programme in Itapua and San Pedro which would focus on building- up technical capacity for ensuring the necessary extension services and long- term credit are built up in these regions. It is recommended that these services should be supported through the local farmer co- operatives that exist in these regions.

This report has specified the resource requirements and institutional arrangements for the first proposal. There is a need to specify these for the second programme. While this was outside of the scope of the study, the report does provide considerable data and analysis on which a detailed proposal could be formulated.

### **Conclusions**

1. The study has shown that no- till and crop rotations are sustainable and are much more profitable to small farmers than conventional unsustainable cultivation cropping systems.
2. Clearly the technology of no- till/ green manure crops/ crop rotations works just as well for small farmers as it does for medium and large mechanised farmers. Potentially huge economic, environmental and social benefits could be realised if this technology could reach a substantial numbers of small farmers in Paraguay. However, while this technology can be extended relatively easily to medium and large farmers who have the resources to easily access them, it will be much more difficult to extend them to small farmers. This is because small farmers do not have the resources to access them, especially technical assistance and credit.
3. To raise the rate of adoption of the technology will require important policy and institutional reforms and considerable Government financial support. Nevertheless the extent of the social,

*economic and environmental benefits that will arise from this technology adoption will justify the very considerable resources and efforts that will be required. Small farm families will be the major beneficiaries, a target group well worthy of this assistance. However, it would also be economic to society. Not only will it potentially halt urban drift with its heavy social costs, it would at the same time substantially reduce the currently high costs to the state of soil erosion.*

4. ***It is concluded that no- till and crop rotations constitute a technological revolution for small farmers. Never before has the senior author analysed such an impressive technology for small farmers in more than twenty years of extensive experience analysing small farm systems in South America, Africa and Asia. To the authors' knowledge, no other farming techniques have been shown to have such a high impact on farmers' incomes, reduce their production costs and risks, and at the same time be environmentally sustainable and generate very considerable net social gains to society. To realise these private and social benefits will be a major challenge that will call for considerable effort and dedicated support.***
5. *The report highlights that to achieve greater spread of the technique considerable policy reform, capacity building and institutional strengthening will be required. Support will be required for this from the Government of Paraguay and international organisations particularly on two fronts: (1) **small farmer technical and organisational support** which will be indispensable for the successful introduction/adaptation of no- till technologies on small farms and to enable small farmers to organise themselves so that they can capitalise on these. This support has important policy implications - who will provide the services and the linkages that will need to be defined between DEAG/ DIA/ farmer co- operatives/ NGOs? (2) **credit and institutional support** needed to provide sustainable lines of credit for small farmers and to strengthen linkages between small farmers/farmer co-operatives/banks to make this work.*
6. *Due to the complexity of the situation a step- by- step process is called for. As an immediate step the two pilot programmes are highly recommended for testing and developing the mechanisms which will be needed to realise a significant spread of these technologies amongst Paraguayan small farmers. Should these programmes be successfully implemented, the stage would be soundly set for an expansion of no- till on small farms in Paraguay. Any attempts at expanding no-till on small farms in Paraguay, before the policy and institutional reforms and other pre- requisites recommended in the report are soundly in place, would not be advisable as it would lead undoubtedly to costly misuses of scarce resources.*

## RECOMMENDATIONS

Throughout this report a number of specific recommendations have been made. The more important general recommendations arising from this study are highlighted below.

Enormous socio- economic and environmental benefits could be obtained from the restoration of the fertility of extremely degraded soils and from the substitution of conventional cultivation systems with crop rotations and no- till. Unlike medium and large farmers who have the technical and financial capacity to realise a lot of these benefits themselves, small farmers will require a lot of publicly-funded help if they too are to benefit from these technologies. Government support in the following areas is strongly recommended since it will be essential and fully justified on socio-economic and environmental grounds:

1. Provide an on- farm research and development support service to enable small farmers to successfully introduce no- till and green manure crops on their farms. The providers of this service would need to be MAG. Government would need to train a small number of DIA and DEAG personnel for this since this capability does not exist at present. Technical assistance would be needed to build up capacity within these institutions to competently provide the level of service that would be needed.
2. Support a specific extension programme aimed at the expansion of no- till and crop rotation techniques as rapidly and cost-effectively as possible. Specific training for this would be part of this programme and would need to be implemented by DEAG. The extension personnel to be trained to provide the extension service would be Government employees as well as employees of the private sector, especially farmer co- operatives and NGOs. Wherever feasible and cost-effective, private sector extension service providers should be contracted by Government to provide the necessary extension services. It will be imperative that Government funds this extension programme for at least the medium- term and possibly over the longer term (5- 10 years). This is because the adoption and spread of these technologies will be much slower and more complex amongst small farmers than it is among medium and large mechanised farmers.

3. Ensure that **long- term credit** is available for small holders to: (a) purchase individually the necessary technical inputs of seeds, fertilisers, matracas and grain storage silos, etc; and (b) to purchase in small groups manual and animal traction no- till machinery imported into Paraguay mostly from Brazil. In the case of extremely degraded soils, there will be a need for a specific line of credit and separate programme to fund the initial inputs required to bolster the levels of fertility to more normal levels. Loans for up to 4 years would be needed for this. In the case of (b), loans of from 5- 7 years would be needed. It is recommended that the CAH, and wherever possible farmer co- operatives, would be the most appropriate institutions to administer these lines of credit. Such credit would need to be subject to normal financial viability criteria and be made available only to farmers who are supported by the recommended on-farm development and extension services. Loan repayment assistance clauses in the case of recuperation of soil fertility, to cover the risk of crop failures, are recommended.
4. Ensure lines of **short- term credit**, subject to the normal financial viability criteria, are available to small farmers to purchase seeds, fertiliser and pesticides that would be needed to successfully establish no- till and green manure crops.
5. Although outside the scope of the study, it is recommended that Government urgently overhaul its policies for assisting small farmers so that there is a coherency and consistency in the policies of the different institutions. There is also an urgent need for major institutional restructuring of State credit institutions to reduce the current drain on limited Government resources caused by the enormously high costs of administering credit to farmers.

There is need now to move beyond purely technical aspects of no- till and green manure crops in small farming systems. It is now known that technically no- till and green manure crops work well under small farm conditions. Not only have they been well accepted by the few small farmers who have had the opportunity to use them, but it is now known from the findings of this study that they are highly profitable for small farmers. However, while there is a need to continue this technical work along the lines recommended above, there is an urgent need now to ensure that farmers can get access to trained and competent extension services as well as the seeds of green manure crops and the necessary machinery and equipment. Up to now these have been provided without any charge to a very small number of farmers through MAG- DEAG with the assistance of GTZ.

Emphasis needs to be placed now on:

1. providing funds for the training and functioning of the needed extension services;
2. developing sustainable seed production of green manure crops;
3. ensuring small farmers get access to affordable credit to buy the necessary no- till equipment and to organise themselves to operate and maintain this equipment.

It is recommended that pilot projects be initiated in Itapua with the Colonias Co- operative and in San Pedro with the Small Farmer Co- operative there. A number of groups of small farmers should be formed (3- 4 per group) and assisted to access credit. These co- operatives can act as intermediaries to prepare investment plans to present to banks (CAH possibly BNF) and to administer the loan repayments. Short- term technical assistance is recommended to build up capacity in these two co- operatives for this.

For the immediate future, two specific programmes are highly recommended:

1. A programme for the recuperation of soil fertility and the introduction of no- till/ crop rotations in Central Paraguay with activities focused in the Departments of Paraguari, Corillera and Caaguazu;
2. A small farmer no- till/ crop rotation expansion programme in Itapua and Edelira.

These immediate programmes are recommended now to prevent spreading limited manpower resources too thinly, since the institutional capacity to implement them is very limited, and to ensure that there will be measurable impacts. From these programmes, important experiences and lessons will provide a sound foundation for expanding later cost- effectively into other parts of Paraguay and institutional capacity will have increased through these initial programmes.

A limited number of simple crop variety and fertiliser trials on- farms should be an integral part of these immediate programmes. This is because there are absolutely no crop yield data, under small farm conditions in Paraguay, of the main crop varieties at differing levels of fertiliser and for alternative crop rotations incorporating residual nutrients of green manure crops. It is imperative that these data be generated as soon as possible so that farmers can rationally decide on what crop varieties, levels of fertiliser and green manure crop/crop rotations, best suit their needs. This development work, which should be practically based on-farms, should be part of the soil conservation efforts of DEAG, but will need to be done in close association with DIA. It will be imperative that trials

efforts of DEAG, but will need to be done in close association with DIA. It will be imperative that trials are kept simple yet comprehensive enough to be meaningful. Emphasis would be placed on farmer participation/farmer acceptability of the options tested and on economic analysis of data rather than statistical analysis.