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END OF TOUR REPORT

E. DON HANSEN
SOIL CONSERVATION ADVISER
CHEMONICS INTERNATIONAL CONSULTING DIVISION
CONTRACT GOB/AID-511-059-008-HCC

DECEMBER 1981 - JANUARY 1985

A. Introduction

One of the objectives of T-059 Project between MACA and USAID is to carry out land clearing for the future agricultural development in the Gran Chaco region of Bolivia. In 1978 the Project financed a heavy machinery pool under the responsibility of CODETAR. This pool mainly consists of D-7 Caterpillar tractors with earth-moving blades.

During the first Project evaluation made in 1981, it was quite evident that the clearing of forest cover from valley lands was causing problems of soil erosion. The evaluation group recommended that the Project provide technical assistance which could deal with the serious deterioration of the new agricultural lands in the southern area of Bolivia.

This fact led to my recruitment by Chemonics International in December 1981, for a period of approximately 37 work-months. My initial terms of reference were defined as follows:

Soil Conservation Technician: Will cooperate with field personnel of the office of IBTA in Yacuiba in advising ranchers and farmers in the Gran Chaco on methods of erosion control. The adviser will also coordinate with CODETAR, BAB, the Integral Cooperative and others in the following tasks:

a. Review existing soil surveys in the Gran Chaco and verify their usefulness and detail in the field.

b. Define appropriate areas in the Chaco for three basic land uses: agriculture, livestock/grazing, and forests or natural preserves.

c. Define conservation and management practices for the three principal

types of land uses.

d. Prepare a manual on soil conservation and management practices applicable to the Gran Chaco, which can be used as material for distribution for the preparation of booklets and pamphlets for farmers.

e. Provide training on soil conservation and management practices to extension agents, field supervisors, and equipment operators working in institutions that contribute to the Chaco program, especially IBTA, CODETAR, BAB, the Integral Cooperative, and others.

f. Assist in developing farm conservation and management plans according to agricultural and ecological conditions of the Chaco, including appropriate methods of land clearing, tillage and farm management.

g. Coordinate with BAB in identifying means of providing credit incentives for farmers who wish to apply soil conservation and management practices.

As work progressed, efforts were concentrated mainly in tasks c, d, e, and f, which are directly related with training and support to farmers.

Despide the fact that the Adviser's work under the T-059 Project was limited to the Gran Chaco, we hope it will eventually meet the challenge of the erosion problem in other affected areas within Bolivia.

B. Initial Training in Erosion Control

In February 1982 it was my good fortune to be in Salt Lake City, Utah for the annual meeting of the International Erosion Control Association, Inc., (with headquarters in California). Since I was a member of this Association, it was valuable for me to learn of the erosion problems and some of the solutions which have been tried in the western United States. It also gave me a chance for direct contact with erosion control companies, contractors, suppliers, technologists, agronomic and forestry representatives of western universities, and government agencies. When I arrived in Yacuiba a full report was made to the Chief of Party of Chemonics in Bolivia.

Shortly after my arrival in Yacuiba on March 14th, 1982 my first

counterparts, Messrs. Walter Peñaranda and Jorge Balderrama, both of IBTA, were assigned to work with me. Ing. Peñaranda had just completed his Master's Degree in soils from New Mexico State University, Las Cruces, New Mexico. Jorge Balderrama, who had a great interest in soil conservation, had been working as extension agent in the region for several years.

At the beginning of our work we had our first contact with Ing. Julio E. Luna from the Instituto Nacional de Tecnología Agropecuaria (INTA), Metán, Argentina. This proved of great benefit to us. Ing. Luna had worked for 15 years in erosion control projects in the Metán area. Consequently a trip was arranged in late June 1982 to take Jorge Balderrama, Walter Peñaranda and myself to learn first hand of the work Julio and his technicians had accomplished in this northern area of Argentina. By lectures, slide presentations and visits to the field we were able to see land clearing operations and construction of terraces. The terraces serve to control erosion and act as a guide to plant fields of beans and safflower (Carthamus tinctorius) on the contour. We were able to see actual field operations which had been accomplished successfully. Thus began an important personal relationship with Ing. Julio E. Luna and his group of technicians from INTA, in Metán.

The contact with Julio and his technicians resulted in a training trip to Argentina. The trip was made from October 18 to 22, 1982 which included seven technicians from: the Agricultural Bank of Bolivia; National Community Development Service; Integral Cooperative, and CODETAR; my two counterparts of IBTA; and myself.

A second training trip to Argentina developed for the 15th to 18th of November, 1982, during which Ing. Julio E. Luna took eight campesinos and Bolivian farmers, my two counterparts and myself on a tour of land clearing projects in the Río Hondo, Metán area. This trip gave the participants first hand information concerning techniques of land clearing operations, especially the advantage of the "sucio" land clearing method rather than the "limpio". It also gave participants the opportunity to learn of the personal views of the Argentine farmers concerning land clearing operations relative to the soil conservation practices, which came later by the construction of terraces.

At the beginning of 1983 Ing. Walter Peñaranda resigned and was not replaced. My other counterpart, Ing. Jorge Balderrama, has done an excellent job working with local farmers and others in applying soil conservation methods to conditions in the Chaco.

C. Current Training and Education

Training in the field of soil conservation has been three-fold during 1984.

First was the selection of three recent agricultural graduates for scholarships in soil conservation. The objective was to select from a total of 10-15 applicants three individuals to work with us during the construction of terraces from September to December 1984. The trainees should learn from personal experience all techniques used in planning, survey, construction, land preparation, planting on the contour and maintenance of terraces and canals after construction. At the end of December the scholarship would terminate. The trained individuals would be considered for next year to work in an organized program of erosion control or for additional training in Argentina, Brazil or the United States.

Secondly, the first intensive course in soil erosion control was organized and held at Yacuiba from November 5 to November 16, 1984 with the assistance of USAID, MACA and Chemonics. From a field of fifty-two applicants twenty-one were selected. Participants work in MACA, IBTA, CBF, CORDECO, CORDEBENI, SEARPI, CORDECH, University of San Andrés, CDF, and several others. They represented all the major areas of Bolivia from Beni to Yacuiba. Actually twenty-five completed the course which included the three scholarship holders, plus a participant from Argentina who had participated with the trainees and attended the course on his own initiative.

The course was supervised by Ing. Juan Arandia, a short-term adviser with Chemonics. Visiting professors for the course were Ing. Julio E. Luna from INTA, Metán, Argentina and Mr. Frederick C. Tracy from Chemonics International in Tegucigalpa, Honduras. All participants received a great stimulation in a week of practical training in the field, after the first week of intensive instruction in the classroom on erosion control.

Thirdly was the program of video-filming (October 15-27, 1984) of our work in erosion control in the Humid Chaco. This was headed by Mr. Omar Serritella, from Chemonics in Washington, D.C. All aspects of our erosion control program were filmed for a documentary video-cassette program. After editing and printing this film will provide a documentary of erosion and erosion control techniques used in the Bolivian Humid Chaco. This will become an integral part of education and training of a wide range of Bolivian personnel for the immediate future, particularly in this area of the country. Hopefully, will help stimulate an active erosion control program in all of Bolivia.

D. Technical Objectives for Erosion Control in the Humid Chaco

The mountain range of Aguarague begins in the Argentine Republic and crosses the Department of Tarija in a south-north direction into the Department of Chuquisaca. It forms a barrier at the southeast area of the Bolivian territory. This spur of this mountain range lies close to Yacuiba valley and its environs. It forms a zone that, by its characteristic climate with a relatively high rainfall of an average annual rainfall of 1146 mm/annual (34 years average), becomes what is known as the Bolivian Humid Chaco. This area geographically includes the Yacuiba valley, north to Palmar Grande and further north to the valley areas in the vicinity of Villamontes. It also includes the Caraparí valley adjacent and northwest of Yacuiba. The relatively high average precipitacion, coupled with the fact that rainfall intensity can attain a high value of more than 100 mm. in 24 hours, over the adjacent mountainous terrain can at times create an outwash from the foothills into the valley. The high run-off resulting from this situation easily erodes sandy lands when these have been cleared and remain without proper protection. The deterioration of these eroded land continues each year during the rainy season, usually from December to the following May.

This combination of geographical, soil and weather characteristics brought about the following objectives for erosion control:

1. Demonstrate systems for adequate control of erosion in agricultural fields of the area.

2. Train Bolivia technicians in erosion control practices.

3. Create awareness among campesinos, institutions and the general public regarding the necessity to control and prevent erosion of Chaqueño lands.

A final decision was made to construct contour terraces on various farms which would serve as demonstration areas. Farmer participation would be on a voluntary basis. The first demonstration area was constructed on the 20 hectare farm of Mr. Antonio Mogro using a heavy farm tractor and disc plow to raise six terraces which had been located in a conspicuous area in Campo Grande. Somewhat later a roadgrader was rented from CODETAR by use of which a higher berm and deeper canal on each terrace was obtained. It was also decided that in order to spread the effectiveness of these demonstrations, each farmer would be offered construction of terraces on a cost shared basis. The T-059 Project would pay one-half the cost of construction if each farmer would pay one-half the cost. This procedure would have two advantages: 1) to promote construction of terraces and increase the demonstration effect, and 2) give each farmer a vested interest in the program, so that he himself would care for and maintain the terrace system.

The second demonstration area was on the farm of Mr. Alberto Quiroga, with the construction of 18 terraces in an area of 38 hectares. It was on this farm that the final techniques and design for construction were developed. Two roadgrader operators of CODETAR were trained to better control the operation of the machine to build a higher berm and deeper canal to more adequately serve its full purpose as an erosion control structure.

E. Contour Terrace Construction (1983 - 1984)

Shallow gullies of less than 0.5 meters should be filled in with the roadgrader. A Caterpillar tractor with dozer blade is needed to fill the deeper ones. Terrace construction should follow after these gullies are filled. In a field where there are no gullies yet formed, terrace construction can proceed with roadgrader. Caterpillar tractor with dozer blade is used to complete the ends of the terraces where the roadgrader is too long to reach the end.

The following specifications for contour terraces were developed:

Distance Between Terraces

Slope (percent)	Horizontal Distance (meters)
1-3	100
3-5	80
5-8	60

Height of Berm

Guardian Terrace	70-80 cms.
Regular Terrace	50-70 cms.

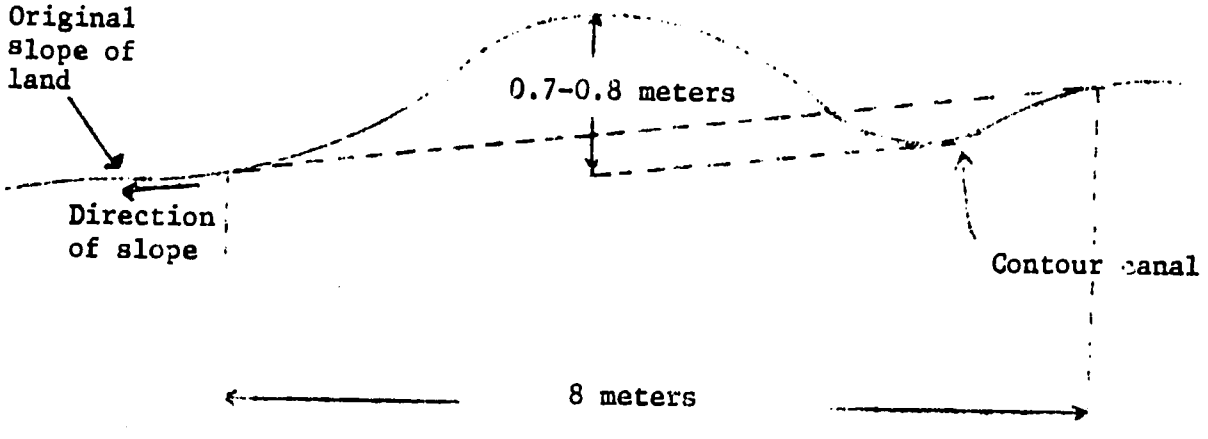
Width of Terrace Area

8 meters

After a short period of experience in construction of contour terraces, both trained operators of CODETAR developed the capability to carry out construction of each terrace in eight passes with the roadgrader. By so doing, all contour terrace berm heights averaged 70-80 centimeters.

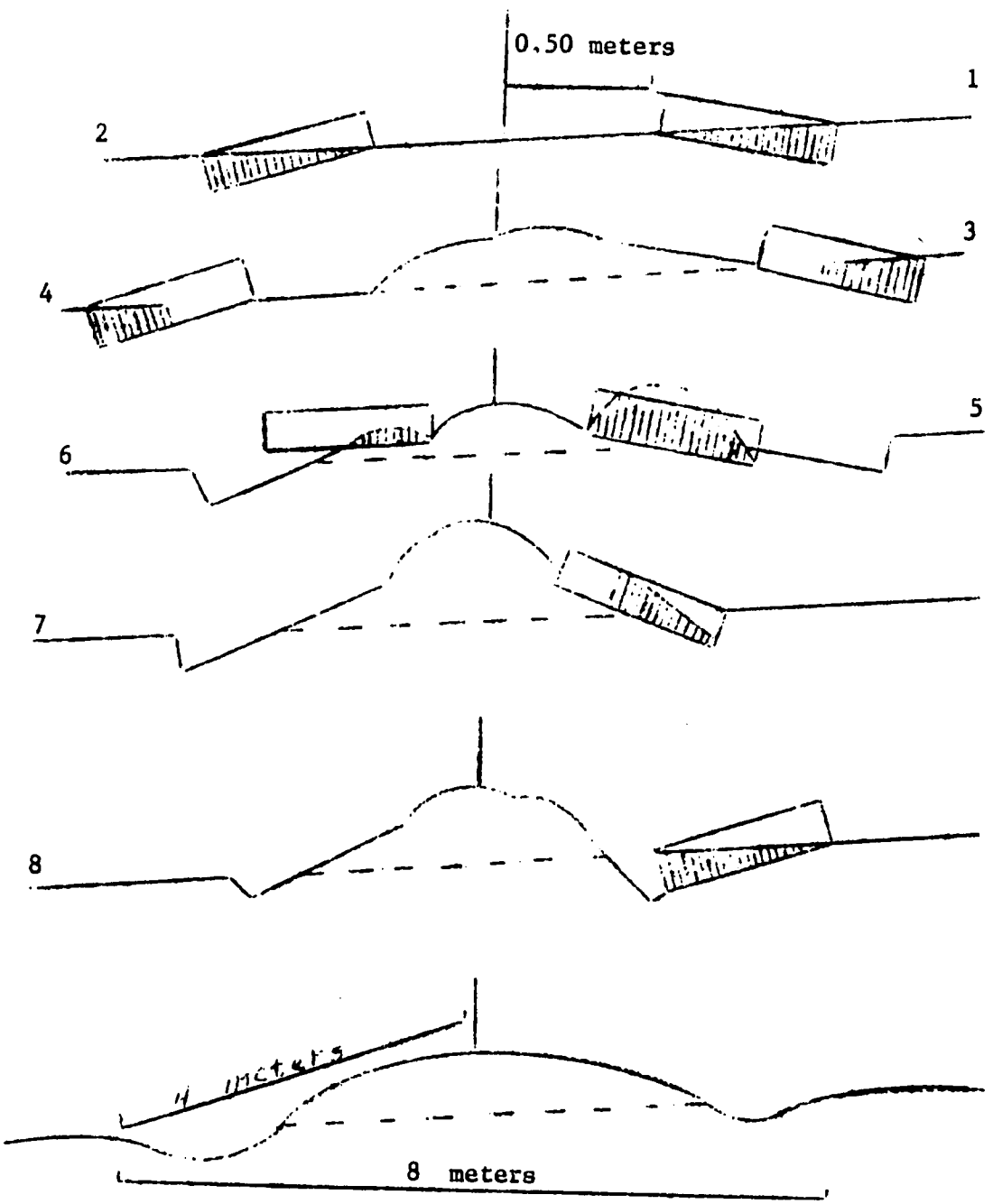
The diagram in Figure 1 illustrates the cross-section of the terraces with maximum berm height after construction:

Figure No. 1 CROSS-SECTION OF CONTOUR TERRACE CONSTRUCTED BY ROADGRADER



Four passes are made on each side as illustrated in Figure No. 2. The difficult part of the construction for the roadgrader operator, which both operators mastered, was to keep the wheels of the front-end of the roadgrader up on the ridge of the terrace so the blade can push the soil up to the highest extent possible, usually 0.8 meters above the bottom of the canal.

Figure No. 2 SCHEME FOR CONSTRUCTION OF TERRACES BY USE OF ROADGRADER



Each terrace should be checked with a level and rol along the length of the terrace. Reading should be made first in the bottom of the canal and then opposite at the top of the ridge at several intervals for the full length of the terrace. The difference in readings should be 0.8 meters in the guardian or highest terrace and a minimum of 0.5 meters in the other terraces. Special attention should be made in those areas where a terrace has crossed a gully or low area that the ridge height is maintained 0.5 - 0.8 meters over the canal bottom. When all terraces are complete from end to end, and ridge height over canal is up to the minimum elevation for both the guardian and other canals, terracing is complete.

Table No. 1 TERRACES CONSTRUCTED DURING 1983 TO DECEMBER 1984 IN THE HUMID CHACO

YEAR CON-STRUCTED	COOPERATOR	LOCALITY	HECTARES TERRACED	SLOPE %	TERRACES CON-STRUCTED	TOTAL TERRACE LENGTH METERS
1983	1. Antonio Mogro	Campo Grande	22[a]	2 - 4	6	2.980
1983	2. Alberto Quiroga	Lapachal Alto	38[a]	2 - 7	18	6.860
1983	3. Felipe Gutiérrez	Campo Grande	10	2 - 4	8	1.855
1983	4. Arcil Vásquez	Campo Grande	25[a]	4 - 6	6	2.280
1983	5. Eliodoro Flores	Campo Grande	09	2 - 4	8	1.530
1983	6. Juan Castillo	Campo Grande	40	1 - 2	8	2.300
1983	7. I.P.C.	Sanandita	10[a]	1 - 2	4	1.657
1983	8. IBTA Experimental Station	I N T I	20	1 - 2	6	2.740
1983	9. Nicolás Choque	Campo Grande	20	2 - 4	13	2.160
1984	10. René Pantoja	Lapachal Bajo	10[a]	1 - 3	4	645
1984	11. Alberto Quiroga	Lapachal Alto	37[a]	3 - 5	9	4.290
1984	12. Guido Vásquez	Campo Grande	30	3 - 5	7	1.780
1984	13. Rufino Vallejos	Campo Grande	21[a]	1 - 2	3	1.140
1984	14. Marcelo Pantoja	Pananti	150	1 - 3	4	2.390
1984	15. Jorge Palacios	Yaguacua	60	1 - 5	12	7.860
	T o t a l s		502	-	116	42.467

[a] Planetabled hectarage, others are estimates.

F. Rainfall Records

Associated with the construction of terraces in the Yacuiba area has been the rainfall records. The information for this area has been furnished by AASANA at the Yacuiba Airport, at an altitude of 530 meters or 1768 feet above sea level. The record of rainfall data for the past five years has been very important for planning erosion control for the future. It will be noted in Table 2 that the average monthly rainfall for the six critical months of October through December and from January to March has been responsible for the accompanying serious erosion damage to fields, roads, railroad, streets in Yacuiba and other outlying village areas. This year, 1984, hit a new high for the month of March. A level of 725 millimeters was registered in only 13 days. It was during this relatively short period that the greatest erosion damages occurred extensively throughout the Yacuiba valley area. More farmers than ever have been prompted to think more seriously about obtaining technical help in battling this serious problem and have been asking for construction of terraces on their properties.

Table No. 2

AVERAGE RAINFALL REGISTERED BY AASANA AT THE YACUIBA AIRPORT - 34 YEARS - 1950 - 1983

Month	Jan	Feb	Mar	April	May	June	July	Ag	Sp	Oct	Nov	Dec	Total
mm[a]	218	190	204	100	34	16	7	10	8	54	110	162	1113
Inches	7.6	7.5	8.0	3.9	1.3	0.6	0.3	0.4	0.3	2.1	4.3	6.4	43.8

[a]millimeters

Table No. 3

RAINFALL REGISTERED IN A PERIOD OF 6 YEARS (1979-1984)

AASANA - YACUIBA AIRPORT

(S22°01' - W64°43')

Year		Jan	Feb	Mar	April	May	June	July	Ag	Sp	Oct	Nov	Dec	Total
1979	mm	361	239	539	153	26	16	17	48	11	34	163	279	1886.0
	in	14.2	9.4	21.2	6.0	1.0	0.6	0.7	1.9	0.4	1.3	6.4	10.4	74.0
1980	mm	358	226	309	79	11	16	11	10	0	115	156	134	1425.0
	in	14.1	8.9	12.2	3.1	0.4	0.6	0.4	0.4	0	4.5	6.1	5.3	55.6
1981	mm	470	373	143	267	67	1	1	16	2	0	95	15.7	1592.0
	in	18.5	14.7	5.6	10.5	2.7	0.1	0.1	0.6	0.1	0	3.7	6.2	62.8
1982	mm	263	220	478	311	9	27	34	6	10	11	126	180	1675.0
	in	10.3	8.7	18.8	12.3	0.4	1.1	1.3	0.2	0.4	0.4	5.0	7.0	66.0
1983	mm	497	287	104	175	175	18	34	4	5	37	91	255	1682.0
	in	19.6	11.3	4.1	6.9	6.9	0.7	1.3	0.2	0.2	1.4	3.6	10.0	66.3
1984	mm	460	330	725	148	8	84	5.8	129	0	68	153	N.A.	(2110.8)[c]
	in	18.1	13.0	28.5	5.8	0.3	3.3	0.2	5.1	0	2.7	6.0	-	83.1
Average	mm	401.5	279.2	283	188.8	49.3	27	17.1	35.5	5.6	39.4	126.2	201	1728.5
	in	15.8	11.0	15.0	7.3	1.4	1.0	0.7	1.4	0.2	1.5	4.9	7.9	68.5

[c] Partial

G. Cost of Terrace Construction

The cost of the construction of terraces becomes an item to be considered for the future because of the high inflation rate in Bolivia. Table No. 4 below gives the present rental cost for 1985 of the roadgrader, D-7 and D-4 tractors. The peso values in case of higher inflation, which is likely, are only good for several months.

Table No. 4 RENTAL COST OF HEAVY MACHINERY PER HOUR, MAY TO SEPTEMBER 1985

Heavy Machinery Used	Rental Cost per hour $b.	Rental Cost per hour $US
Roadgrader	500,000.--	25.--
D - 7 Tractor	900,000.--	45.--
D - 4 Tractor	500,000.--	25.--

Since the financing for use of the roadgrader and Caterpillar tractor in southern Bolivia Humid Chaco is on a cooperative basis, the cost to the farmer is one-half the above amounts. The average cost per hectare is shown in Table No. 5.

Table No. 5 COST OF TERRACE CONSTRUCTION PER HECTARE, 1985

	Cost per Hour ($US)	Hours per Hectare	Cost per Hectare
Roadgrader	25.--	0.45	11.25
Caterpillar D-7	45.--	0.15	6.75
TOTAL COST PER HECTARE			$US 18.00
FARMER'S SHARE OF COST			$US 9.00

H. Final Observations

1. Grass Waterways

Most farmers, and especially small farmers, are reluctant to utilize crop land on which to construct drainageways or grass waterways for terrace canals. They prefer to dispose of the excess run-off water through the fence at the end of the terrace into an access road. These are usually at 500 to 1,000 meters intervals within the Yacuiba valley. This is a simple solution, but one that is not valid technically, because it encourages erosion of the roadway. In time roads become gullied and intransitable. It also encourages gully formation from the roadway back into farmers fields.

High intensity rains of about 110 mm. which fell in the last days of December 1984, afforded us the opportunity to examine and check on the canals and terraces built during the 1984 dry season. During these field observations, there was some erosion that occurred in four farmers fields because of the inadequate capacity of roadways serving as drainageways. Drainage from fields should be directed into grass waterways constructed on the edge of the field itself, parallel to the roadway. But this has two disadvantages. First of all the grass waterway is only on one farmers property and cannot be extended onto neighbors' properties below. The terminus of the grass waterway still has to be discharged into the roadway. Secondly, it takes an important amount of farm land out of small holdings.

A conservation law needs to be formulated. This would encourage the construction of grass waterways for drainage from both east to west, and west to east into the center of the valley to promote proper drainage without the danger of erosion to serve all land holders. With the present land-tenure system this seems to be impossible with all the small land holdings.

These drainageways would need to be spaced from 500 to 1,000 meters apart, and to allow for development of access roads from interior farms to the main highway in the middle of the valley alternated with the grass waterways to provide for sufficient drainage and at the same time safely protect adjacent lands from erosion damage.

2. Conservation and No-Till Tillage

Adequate conservation drainage coupled with terrace construction is of primary importance. But this should also be followed by the introduction of direct seeding drills and the beginning of no-till type of farming, i.e., rotation of two crops a year of not plowing or disking but seeding directly into stubble of previous crops with a special drill. Ever so often soils can be loosened with a chisel tool pulled by tractor instead of plowing or disking. The main idea is to keep crop residues on the surface to help protect against erosion. This method is proving successful in the United States, Argentina, Brazil and other countries and is the method to follow for the future.