Appendix 1

The Extent of Human-Induced Soil Degradation by L. R. Oldeman, V. W. P. van Engelen and J. H. M. Pulles

As indicated in chapter IV of the explanatory note of the World Map of Human-Induced Soil Degradation (Oldeman, Hakkeling and Sombroek, 1991) all units delineated on this GLASOD map have been digitized and linked to a GLASOD database, in which the legend entries of each delineated unit are stored. UNEP'S Global Resource Information Database (GRID) has conducted processing of this database for an assessment of desertification (Deichmann and Eklundh, 1991)[1]. With the incorporation of the GLASOD database into GRID, this dataset is now available to scientists and decision-makers who wish to use it for specific projects. The GLASOD database is accompanied by a users guide.

ISRIC has also processed this database for the preparation of a chapter on global soil degradation for the State of the Environment Report of UNEP, to be published in 1992.

Since its publication in 1990, ISRIC has been flooded with requests about the actual areal extent of the various soil degradation types as illustrated on the world soil degradation map. Because of the type of map projection – Mercator projection – the scale of the map increases from the equator towards the Poles (see section 2.1 of the explanatory note). Therefore there is a need to complement this note with some quantitative information on the areal extent of the delineated surfaces.

5.1. Major divisions of the earth surface

The GLASOD map covers the land surface between 72 degrees North and 57 degrees South. All quoted figures therefore relate to that portion of the earth surface (13013 million ha). The GLASOD map indicates not only units that are infrequently to dominantly affected by human-induced soil degradation, but also units that are considered to be for 100% so-called wasteland or for 100% stable: the dark, respectively light grey units on the map. These grey-shaded areas occupy a total of 5044 million ha. This implies that the areas on the map coloured in different shades of bluish green (water erosion), yellowish brown (wind erosion), red (chemical deterioration) and pink (physical deterioration) occupy a total of 7969 million ha.

As explained in section 3.2.2 the status of soil degradation is an expression of the severity of the process. The severity of the process is characterized by the degree to which the soil is degraded and by the relative extent of the degraded land within the delineated unit. This implies that only a portion of de delineated unit is degraded. A mapped unit may for example be indicated by Wt3.3 and Et1.2. This implies that strong topsoil loss by water erosion occurs frequently (10 to 25% of the unit affected) and that

1 Deichmann, U. and Eklundh, L. 1991. Digital data for land degradation studies: A GIS approach. GRID case study, series no. 4.

the light topsoil loss by wind erosion occurs commonly (5 to 10% affected). In other words, between 15 and 35% of the delineated unit is affected by human-induced soil degradation, while between 65 and 85% is not affected. This portion is called "other terrain" and includes terrain that is non-degraded (naturally stable, or stabilized by human activities). But it may also include non-used wasteland. This "other terrain" portion of the earth is about 6000 million ha. The terrain that is affected by human-induced soil degradation occupies an area of 1964 million ha worldwide. Table 1 gives these areal divisions for Africa, Asia, South America, Central America, North America, Europe and Australasia.

Table 1

Major terrain divisions of the GLASOD map (in million ha)

	non used wasteland (dark grey)	Stable land (light grey)	"Other terrain" (non-degraded by human activities)	human induced soil degradation	total land surface
Africa	732	441	1 299	494	2 966
Asia	485	1 426	1 597	748	4 256
South America	28	368	1 129	243	1 768
Central America	53	27	163	63	306
North America	75	1 043	672	95	1 885
Europe	1	116	614	219	950
Australasia	95	250	434	103	882
World	**1 469**	**3 671**	**5 909**	**1 964**	**13 013**

5.2 Types of Human-induced Soil Degradation

Water erosion is by far the most important type of soil degradation occupying around 1094 million ha or 56% of the total area affected by human-induced soil degradation. On a world scale the area affected by wind erosion occupies 548 million ha (or 38% of the degraded terrain). Chemical soil deterioration covers about 239 million ha (12%) while physical soil deterioration occupies around 83 million ha (4%). Loss of topsoil by water or by wind erosion is by far the most important subtype of displacement of soil material. These subtypes cover an area of respectively 920 million ha (water erosion) (365 million ha in Asia and 205 million ha in Africa), and 454 million ha (wind erosion). Loss of nutrients is the major subtype of chemical deterioration of the soils (135 million ha of which 68 million is located in South America) followed by salinization (76 million ha, of which 53 million ha in Asia). Soils affected by pollution cover worldwide an area of 22 million ha, of which 19 million ha is located in Europe. Compaction is by far the most important subtype of physical soil deterioration. It occupies world-wide 68 million ha: 33 million ha is found in Europe and 18 million ha in Africa. For further details reference is made to tables 2-9 of this annex.

5.3 Degree of Soil Degradation

Four degrees of soil degradation are recognized.

A light degree of soil degradation, implying a somewhat reduced productivity of the terrain, but manageable in local farming systems is identified for 38% of all the degraded soils (or 749 million ha). A somewhat larger percentage (46%) has a moderate degree of soil degradation. This portion of the earth surface – 910 million ha – has a greatly reduced productivity. Major improvements often beyond the means of local farmers in developing countries are required to restore the productivity. More than 340 million ha of this moderately degraded terrain is found in Asia and over 190 million ha is located in Africa.

Strongly degraded soils cover an area of 296 million ha worldwide of which 124 million ha in Africa and 108 million ha in Asia. These soils are not any more reclaimable at farm level and are virtually lost. Major engineering work or international assistance is required to restore these terrains.

Extremely degraded soils are considered unreclaimable and beyond restoration. Their worldwide coverage is around 9 million ha, of which over 5 million is located in Africa.

For further details reference is made to table 2-9.

Table 2

Human-induced Soil Degradation for Asia, expressed in million hectares[1]

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	99.8	215.0	50.5	-	365.2
Wd	Terrain Deformation	24.7	26.7	22.9	-	74.4
W	**WATER**	**124.5**	**241.7**	**73.4**	-	**440.6** (59%)
Et	Loss of Topsoil	116.7	48.9	+	0.2	165.8
Ed	Terrain Deformation	15.7	17.3	14.5	-	47.5
Eo	Overblowing	-	8.9	-	-	8.9
E	**WIND**	**132.4**	**75.1**	**14.5**	**0.2**	**222.2** (30%)
Cn	Loss of nutrients	4.6	9.0	1.0	-	14.6
Cs	Salinization	26.8	8.5	17.0	0.4	52.7
Cp	Pollution	-	1.5	0.3	-	1.8
Ca	Acidification	0.4	2.5	1.2	-	4.1
C	**CHEMICAL**	**31.8**	**21.5**	**19.5**	**0.4**	**73.2** (10%)
Pc	Compaction	4.6	5.0	0.2	-	9.8
Pw	Waterlogging	0.4	-	-	-	0.4
Ps	Subsidence organic soils	0.7	1.0	0.2	-	1.9
P	**PHYSICAL**	**5.7**	**6.0**	**0.4**	-	**12.1** (2%)
	TOTAL	24.5 (39%)	344.3 (46%)	107.7 (14%)	0.5 (1%)	747.0 (100%)

[1] Asia includes the Asian part of the U.S.S.R.

Table 3

Human-induced Soil Degradation for Africa, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	53.9	60.5	86.6	3.8	204.9
Wd	Terrain Deformation	3.6	6.9	11.7	0.4	22.5
W	**WATER**	**57.5**	**67.4**	**98.3**	**4.3**	**227.4** (46%)
Et	Loss of Topsoil	79.1	84.2	7.4	-	170.7
Ed	Terrain Deformation	9.2	5.1	-	-	14.3
Eo	Overblowing	-	-	0.5	1.0	1.5
E	**WIND**	**88.3**	**89.3**	**7.9**	**1.0**	**186.5** (38%)
Cn	Loss of nutrients	20.4	18.8	6.2	-	45.1
Cs	Salinization	4.7	7.7	2.4	-	14.8
Cp	Pollution	-	0.2	-	-	0.2
Ca	Acidification	1.1	0.3	+	-	1.5
C	**CHEMICAL**	**26.0**	**27.0**	**8.6**	-	**61.5** (12%)
Pc	Compaction	1.4	8.0	8.8	-	18.2
Pw	Waterlogging	0.4	0.1	-	-	0.5
Ps	Subsidence organic soils	-	-	-	-	-
P	**PHYSICAL**	**1.8**	**8.1**	**8.8**	-	**18.7** (4%)
	TOTAL	173.6 (35.1%)	191.8 (38.9%)	123.6 (25.0%)	5.2 (1%)	494.2 (100%)

Table 4

Human-induced Soil Degradation for South America, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	34.9	51.9	8.3	-	95.1
Wd	Terrain Deformation	11.0	13.2	3.8	-	28.1
W	**WATER**	**45.9**	**65.1**	**12.1**	-	**123.2** (50.6%)
Et	Loss of Topsoil	12.7	10.0	-	-	22.7
Ed	Terrain Deformation	13.1	5.3	-	-	18.4
Eo	Overblowing	-	0.8	-	-	0.8
E	**WIND**	**25.8**	**16.1**	-	-	**41.9** (17.2%)
Cn	Loss of nutrients	24.5	31.1	12.6	-	68.2
Cs	Salinization	1.8	0.3	-	-	2.1
Cp	Pollution	-	-	-	-	-
Ca	Acidification	-	-	-	-	-
C	**CHEMICAL**	**26.3**	**31.4**	**12.6**	-	**70.3** (28.85%)
Pc	Compaction	2.9	0.8	0.3	-	4.0
Pw	Waterlogging	3.9	-	-	-	3.9
Ps	Subsidence organic soils	-	-	-	-	-
P	**PHYSICAL**	**6.8**	**0.8**	**0.3**	-	**7.9** (3.2%)
	TOTAL	104.8 (43.1%)	113.5 (46.6%)	25.0 (10.3%)	-	243.4 (100%)

Table 5

Human-induced Soil Degradation for Central America, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	0.4	14.2	6.5	-	21.1
Wd	Terrain Deformation	0.2	8.1	16.9	-	25.2
W	**WATER**	**0.6**	**22.3**	**23.4**	-	**46.3** (74%)
Et	Loss of Topsoil	-	2.4	0.5	-	2.9
Ed	Terrain Deformation	0.1	1.6	-	-	1.7
Eo	Overblowing	-	-	-	-	-
E	**WIND**	**0.1**	**0.4**	**0.5**	-	**4.6** (7%)
Cn	Loss of nutrients	0.1	4.0	0.1	-	4.2
Cs	Salinization	0.3	1.5	0.5	-	2.3
Cp	Pollution	-	0.2	0.2	-	0.4
Ca	Acidification	-	-	-	-	-
C	**CHEMICAL**	**0.4**	**5.7**	**0.8**	-	**6.9** (11%)
Pc	Compaction	-	0.1		-	0.1
Pw	Waterlogging	0.8	3.3	0.8	-	4.9
Ps	Subsidence organic soils	-	-	-	-	-
P	**PHYSICAL**	**0.8**	**3.4**	**0.8**	-	**5.0** (8%)
	TOTAL	1.9 (3%)	35.4 (56%)	25.5 (41%)	-	62.9 (100%)

Table 6

Human-induced Soil Degradation for North America, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	13.7	46.1	-	-	59.8
Wd	Terrain Deformation	-	-	-	-	-
W	**WATER**	**13.7**	**46.1**	-	-	**59.8** (63%)
Et	Loss of Topsoil	2.5	30.8	1.3	-	34.6
Ed	Terrain Deformation	-	-	-	-	-
Eo	Overblowing	-	-	-	-	-
E	**WIND**	**2.5**	**30.8**	**1.3**	-	**34.6** (36%)
Cn	Loss of nutrients	-	-	-	-	-
Cs	Salinization	-	-	-	-	-
Cp	Pollution	-	-	-	-	-
Ca	Acidification	0.1	-	-	-	0.1
C	**CHEMICAL**	**0.1**	-	-	-	**0.1** (+)
Pc	Compaction	0.5	0.4	-	-	0.9
Pw	Waterlogging	-	-	-	-	-
Ps	Subsidence organic soils	-	-	-	-	-
P	**PHYSICAL**	**0.5**	**0.4**	-	-	**0.9** (1%)
	TOTAL	16.8 (18%)	77.4 (81%)	1.3 (1%)	-	95.5 (100%)

Table 7

Human-induced Soil Degradation for Europe, expressed in million hectares[1]

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	18.9	64.7	9.2	-	92.8
Wd	Terrain Deformation	2.5	16.3	0.6	2.4	21.8
W	**WATER**	**21.4**	**81.0**	**9.8**	**2.4**	**114.5** (52.3%)
Et	Loss of Topsoil	3.2	38.2	-	0.7	42.2
Ed	Terrain Deformation	-	-	-	-	-
Eo	Overblowing	-	-	-	-	-
E	**WIND**	**3.2**	**38.2**	-	**0.7**	**42.2** (19.3%)
Cn	Loss of nutrients	2.9	0.3	-	-	3.2
Cs	Salinization	1.0	2.3	0.5	-	3.8
Cp	Pollution	4.1	14.3	0.1	-	18.6
Ca	Acidification	0.1	0.1	-	-	0.2
C	**CHEMICAL**	**8.1**	**17.1**	**0.6**	-	**25.8** (11.8%)
Pc	Compaction	24.8	7.8	0.4	-	33.0
Pw	Waterlogging	0.5	0.3	-	-	0.8
Ps	Subsidence organic soils	2.6	-	-	-	2.6
P	**PHYSICAL**	**27.9**	**8.1**	**0.4**	-	**36.4** (16.6%)
	TOTAL	60.6 (27.7%)	144.4 (66.0%)	10.7 (4.9%)	3.1 (1.4%)	218.9 (100%)

[1] Europe includes the European part of the U.S.S.R.

Table 8

Human-induced Soil Degradation for Australasia, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	79.4	2.2	0.1	-	81.7
Wd	Terrain Deformation		1.0	0.1	-	1.1
W	**WATER**	**79.4**	**3.2**	**0.2**	-	**82.8** (81%)
Et	Loss of Topsoil	16.3	-	0.1	-	16.4
Ed	Terrain Deformation	-	-	-	-	-
Eo	Overblowing	-	-	-	-	-
E	**WIND**	**16.3**	-	**0.1**	-	**16.4** (16%)
Cn	Loss of nutrients	0.2	0.2	-	-	0.4
Cs	Salinization	-	0.5	-	0.4	0.9
Cp	Pollution	-	-	-	-	-
Ca	Acidification	-	-	-	-	-
C	**CHEMICAL**	**0.2**	**0.7**	-	**0.4**	**1.3** (1%)
Pc	Compaction	0.7	-	1.6	-	2.3
Pw	Waterlogging		-	-	-	-
Ps	Subsidence organic soils		-	-	-	-
P	**PHYSICAL**	**0.7**	-	**1.6**	-	**2.3** (2%)
	TOTAL	96.6 (94%)	3.9 (4%)	1.9 (2%)	0.4 (+)	102.9 (100%)

Table 9

Human-induced Soil Degradation for the World, expressed in million hectares

	Type	Light	Moderate	Strong	Extreme	Total
Wt	Loss of Topsoil	301.2	454.5	161.2	3.8	920.3
Wd	Terrain Deformation	42.0	72.2	56.0	2.8	173.3
W	**WATER**	**343.2**	**526.7**	**217.2**	**6.6**	**1093.7** (55.6%)
Et	Loss of Topsoil	230.5	213.5	9.4	0.9	454.2
Ed	Terrain Deformation	38.1	30.0	14.4	-	82.5
Eo	Overblowing	-	10.1	0.5	1.0	11.6
E	**WIND**	**268.6**	**253.6**	**24.3**	**1.9**	**548.3** (27.9%)
Cn	Loss of nutrients	52.4	63.1	19.8	-	135.3
Cs	Salinization	34.8	20.4	20.3	0.8	76.3
Cp	Pollution	4.1	17.1	0.5	-	21.8
Ca	Acidification	1.7	2.7	1.3	-	5.7
C	**CHEMICAL**	**93.0**	**103.3**	**41.9**	**0.8**	**239.1** (12.2%)
Pc	Compaction	34.8	22.1	11.3	-	68.2
Pw	Waterlogging	6.0	3.7	0.8	-	10.5
Ps	Subsidence organic soils	3.4	1.0	0.2	-	4.6
P	**PHYSICAL**	**44.2**	**26.8**	**12.3**	-	**83.3** (4.2%)
	TOTAL	749.0 (38.1%)	910.5 (46.4%)	295.7 (15.1%)	9.3 (0.5%)	1964.4 (100%)

5.4 Causative factors of soil degradation

Five different causes of physical human intervention were identified that have resulted in soil degradation: deforestation and removal of the natural vegetation; overgrazing of the vegetation; overgrazing of the vegetation by livestock; agricultural activities – an improper management of agricultural land; overexploitation of the vegetation cover for domestic use; and (bio)industrial activities leading to chemical pollution. Table 10 indicates the total areas affected by these five causative factors for each continent and worldwide.

Table 10

Causative factors of soil degradation, expressed in million ha of terrain affected

	deforestation	overgrazing	agricultural mismanagement	overexploitation	(bio)industrial activities
Africa	67	243	121	63	+
Asia	298	197	204	46	1
South America	100	68	64	12	-
North and Central America	18	38	91	11	+
Europe	84	50	64	1	21
Australasia	12	83	8	-	+
World	**579**	**679**	**552**	**133**	**23**

More than 50% of the degraded soils caused by deforestation is located in Asia, followed by South America (17%). Deforestation is the major cause of soil degradation in South America, Asia, but surprisingly also in Europe (mainly the eastern and central portion of Europe). In Africa deforestation is relatively speaking less important as cause for soil degradation.

Overgrazing is by far the most important cause of human-induced soil degradation in Africa and Australasia, although the total area of degraded soils in Asia caused by overgrazing is also impressive (197 million ha).

More than 35% of the degraded soils caused by improper agricultural management can be found in Asia. It is the most important causative factor of human-induced soil degradation in North and Central America.

Overexploitation of the vegetative cover for domestic use is of secondary importance as a causative factor of soil degradation worldwide. Of the total of 133 million ha degraded soils by overexploitation almost 50% is located in Africa.

(Bio)industrial activities play as yet a minor role in soil degradation worldwide. It has been reported as cause for soil degradation on only 23 million ha. However, it is significant to note that 21 million ha are located in Europe.

5.5 Concluding remarks

Since no systematic evaluation of the status of human-induced soil degradation has been made in the past, it is not possible to indicate the rate of human-induced soil degradation. Although statements of annual loss of land as a result of soil degradation have been made frequently, Blaikie noted that "statistics (on soil erosion and deforestation) are seldom in the right form, are hard to come by and even harder to believe, let alone interpret". A reliable understanding of the consequences of human manipulation and natural perturbations of land is needed for policy formulation and decision-making. The global assessment of the status of human-induced soil degradation as presented here is the first systematic evaluation of the state of the human environment and will hopefully assist policy-makers and decision-makers to view the seriousness of human manipulations of the soil resources in a global perspective.

Errata

location on GLASOD map	map symbol	correct symbol	map colour	correct colour
United Arab Emirates, eastern part	Et.1.3/Cs2.2 g/a		medium brown	dark brown/ orange
Soviet Union, east of Kiev	Pc1.3/Wt2.2 f/a ·		medium pink/blue	dark pink/blue
Ethiopia - Djibouti	Wt1.3/Et1.3 g		dark blue/brown	medium blue/brown
Australia, south-west	Wt1.3/Cs4.1 f/a	Wt1.3/Cs3.1 f/a	medium blue/red	
Brazil, NW Rio de Janeiro (2 units)	Wt1.2/Cn2.3 a		light blue	dark blue
France, central	Wt1.2/Cp1.1 a	Wt1.2/Cp1.1	light blue	
Greece south-west	Cn1.4/Wd2.2 f/a	Cn1.4/Wd2.2	dark red	
Mauritania - Mali	Et2.5 g/a ·	Et2.5 g/a ·	very dark brown	
Bhutan	Wt2.1/Wd1.1 f/g ·		medium blue	light blue
New Caledonia	Wd3.2/Wt1.3 f/a		very dark blue	dark blue
Argentina	Wt1.3/Wd2.2 a	Wt1.3/Wd2.1 a	dark green	medium green
Spanish Sahara		Western Sahara		

Source: Oldeman, L.R., R.T.A. Hakkeling, W.G. Sombroek. GLASOD 1991: An Explanatory Note. ISRIC/PNUE; pp. 27 - 34.

Appendix 2

Importance of resource conservation as seen by staff of partner organizations in developing countries

Evaluation of a survey amongst DSE fellowship-holders in agriculture and forestry

Objectives of the study

The conservation of natural resources is gaining importance in German development cooperation. Implementing resource conservation measures in development projects, however, often poses serious problems. One reason is the attitude of the target groups, who accord no priority to resource conservation, because it entails investments for the individual farm enterprise that bring no short-term return. Key also, though, for the implementation of resource conservation is the attitude of technical staff in extension services and ministries and of policymakers.

To obtain more information about how this group views conservation of natural resources and how they assess its role in their various countries, a survey was organized in November 1992 in collaboration with the DSE Food and Agriculture Development Centre amongst 57 DSE fellowship-holders from 32 African, Asian and Latin American countries.

Resource conservation as seen by DSE fellowship-holders

The questions pertain to four areas:

- Definition and significance of resource conservation for those questioned
- Resource conservation measures in the respective home countries
- Awareness of institutions responsible and target groups of the need for resource conservation
- Priorities in resource conservation as seen by those questioned

For the most part, the questions were answered. Regardless of the personal standpoint of the respondent, the answers differ greatly, especially to the open questions, as the need for resource conservation varies greatly by country and region. Nevertheless, certain trends are discernible that must be catered for when planning and implementing resource conservation projects.

A total of 56 questionnaires were filled out and evaluated. The findings are summarized below:

[1] Those questioned come primarily from Africa (28) and Asia (20).

[2] Most of those questioned work in sub-humid (31) and semi-arid (16) areas.

[3] Those questioned work predominantly in agriculture and forestry (50).

[4] Only 20 of those questioned work in development projects.

[5] The term "resource conservation" is construed in very different ways: the majority of those questioned understand it to mean nature conservation in the broadest sense; for 18 it denotes the protection of rare animal and plant species and 15 associate it with erosion control or soil conservation. Conserving resources for future generations and safeguarding the ecological balance are also mentioned several times.

[6] Answers to the question on the advantages and disadvantages of resource conservation can be summarized as follows:

Advantages: raising output and income

Disadvantages: high labour input and high costs

Resource conservation measures are thus considered necessary for economic reasons (costly mineral fertilizers) and ecological reasons (degradation of soil through erosion).

[7] The most important resource conservation measures were considered to be:

- Erosion control (31)
- Integration of trees (29)
- Afforestation (23)
- Biological plant protection (27)
- Mixed cropping (22)
- Integration of livestock (21)
- Rotation (20)

[8] The emphasis given to resource conservation in their own countries is gauged very differently by the respondents. The majority are clearly of the opinion that resource conservation in their own country is considered important (45 = 80%), in 17 cases even extremely important.

[9] There is wide agreement that resource conservation measures in agriculture and forestry need to be stepped up (47). This is viewed as an important task of government and local authorities. Assistance from the GTZ is desired here.

[10] International organizations (16) and the GTZ (22) are most cited as sources of funding for resource conservation measures.

[11] The institutions in charge of resource conservation are considered by most of those questioned as insufficiently aware of the issues in agriculture and forestry (32). Financial and personnel constraints are seen as particularly severe.

[12] Target group awareness is also considered by most of those questioned (39) to be inadequate. This is attributed to the low education level, poor information and economic problems.

[13] Technical assistance in these activities is sought largely through exchanging experience with other projects (33) and specialist literature (22). Information stems for the most part from national sources, but much is also sought abroad, for example in Germany (in the case of GTZ projects) or North America.

[14] A large number of fellowship-holders (32) have gained more than 3 years experience in resource conservation.

[15] In most of the partner countries, a number of projects/organizations are involved in in resource conservation, with the GTZ (28) and FAO (23) cited most often.

[16] The greatest need for resource conservation measures exists in soil (27) and forest (22) conservation.

Summary evaluation of answers

The fellowship-holders are largely engaged in the agriculture and forestry sector. They work in all sections of the public services, extension, administration and education. Though only a part are involved in German Development Cooperation projects, they are nevertheless representative of development project personnel. The opinions expressed are thus highly relevant for German projects in agriculture and forestry.

As the survey answers clearly show, conserving natural resources is considered by all respondents to be necessary and important. As might be expected, the definition of natural resources and resource conservation proved difficult for the DSE fellowship-holders. What gives ground for optimism is their opinion that in nearly all countries, resource conservation is accorded high or very high importance. Ranked as in particular need of conservation are soil and forest resources. As in industrial countries, they cite the major constraint on implementing resource conservation measures as cost and hope that donor organizations will provide assistance here. Local organizations and authorities should be involved in implementing measures alongside international organizations. Although most of the respondents work for public services, they expect little help from this quarter. Target group motivation is rated as low due to poor education and lack of information.

Conclusions and future action

Summarizing, the fellowship-holders view resource conservation in general and soil conservation in particular as an important task. Although this also holds for the governments of most countries, it does not induce them to take direct action for cost reasons. The hope is that international and bilateral donors will help.

For German development cooperation, this means that action must be taken in planning and implementing resource conservation measures, especially in soil and forest resources, in providing training and information to technical and scientific staff engaged in resource conservation measures and in raising awareness amongst target groups.

Evaluation of the DSE question

[1] Originnaires

Africa	28	50%
Asia	20	36%
Latin America	4	7%
No entry	4	7%

[2] Climatic zone [1]

arid	5
semi-arid	16
sub-humid	31
humid	12

[3] Area of activity

agriculture	34	61%
forestry	14	25%
crafts	0	
education	1	2%
other	3	5%

[4] Staff member in a development project	20	36%

[5] What do you understand by resource conservation? [2]

a)

conserving resources for future generations	8	15%
careful use of resources	8	15%
efficient use of resources	7	13%
maintaining the ecological balance	9	16%
development of resources	3	5%
all measures to maintain agricultural production	1	2%
health and human welfare	1	2%
measures to increase welfare/prosperity	2	4%
conservation of renewable and non-renewable resources	2	4%
rehabilitation of damaged resources	1	4%

b)

water conservation	10	18%
soil conservation	13	23%
forest conservation	9	16%
conservation of flora and fauna	18	32%
erosion control	15	26%
use of mineral fertilizers	1	2%
improved technologies	4	7%
fallowing	0	0%
rotation	0	0%

1 Overlapping is possible because projects can be implemented in various climatic zones.

2 The answers to this question are divided in two groups: more general questions (a) and more specific questions concerning for example resource conservation measures, e.g. erosion control (b).

bush fire prevention	4	7%
efficient irrigation	4	7%
biological plant protection	3	5%
desertification control	3	5%
dams	4	7%
pollution prevention	5	9%
plant protection	5	9%
afforestation	8	14%
green manuring	1	2%
nature conservation	2	4%
climate protection	3	5%
appropriate soil tillage	2	4%
avoidance of overgrazing	1	2%
dune protection	2	4%
equal pay	1	2%
training, upgrading, extension	1	2%
food storage	1	2%

[6.1] Advantages and disadvantages of resource conservation [3]

Advantages:

no entry	30	
raising fertility, productivity and income	7	27%
protecting flora and fauna	5	19%
promoting rural development	4	15%
conserving resources for future generations	4	15%
maintaining ecological balance	4	15%
maintaining long-term yield	3	12%
alleviating hunger and poverty	2	8%
preventing pollution	2	8%
protecting the climate	1	4%
saving money	1	4%
restoring destroyed resources	1	4%

Disadvantages:

no entry	34	
high costs, labour input	7	32%
population need resources	6	27%
higher unemployment	3	14%
change of customs/habits	3	14%
prohibitions foster illegal behaviour	2	9%
inhibits development	2	9%
protection areas disadvantage minorities	1	5%
spread of wild animals	1	5%

3 Percentages pertain only to the number of questionnaires where these questions are answered

[6.2] Main reasons for resource conservation		
logistical	29	52%
economic	42	75%
ecological	43	77%
political	15	27%
other	1	2%

[7] Activities in resource conservation		
erosion control	31	55%
tree integration, agroforestry	29	51%
traditional afforestation	22	39%
partial afforestation	14	25%
afforestation with local tree-species	23	41%
animal integration	21	38%
compost and mulch farming	20	36%
mixed cropping	23	41%
rotation	20	36%
green manuring	17	30%
biological plant protection	27	48%
other	0	0%
no entry	2	4%

[8] Priority of resource conservation [4]		
0	3	5%
1	13	23%
2	9	16%
3	6	11%
4	17	30%
no entry	8	14%

[9] More emphasis on resource conservation		
yes		47%
no		7%
by whom?		
donor organizations	6	11%
international organizations	5	9%
local organizations	6	11%
all organizations	1	2%
GTZ	1	2%
research institutions	3	5%
media	1	2%
public authorities	2	4%
extension services	1	2%

4 On a scale of -4 to +4

[10] Who is eligible to execute resource conservation measures?		
governments	2	4%
international organizations	16	29%
local organizations	3	5%
FAO	11	20%
GTZ	22	39%
World Bank	9	16%
research institutions	3	5%
local authorities	3	5%
EU	2	4%
WWF	3	5%
KfW	2	4%
PNUD	6	11%
UNO	2	4%

[11] Awareness of executing agency		
sufficient	21	38%
insufficient	32	57%
Deficiencies		
economic constraints	8	
integration of target group	5	
training/information	4	
implementation of measures	4	
lack of method	3	
workload	2	
political will	2	
motivation	1	

[12] Awareness of target group		
sufficient	16	29%
insufficient	39	70%
Deficiencies		
training/information	10	
economic constraints	8	
customs/habits	2	
integration of target group	2	
motivation	1	
animal protection	1	

[13.1] Preferred technical assistance		
specialist literature	27	48%
individual consultancy	15	27%
communication with other projects/institutions	33	59%
others	2	4%

[13.2] Technical assistance from

Germany	35	63%
Europe	25	45%
North America	14	25%
local	25	45%

[14] How long have you been working in resource conservation?

0	13	23%
1	3	5%
2	0	0 %
3	4	7%
several years	34	61%
no entry	2	4%

[15] How many projects are engaged in resource conservation?[5]
Main organizations cited:

GTZ	28
FAO	23
PNUD	10
World Bank	7
WWF	5
EU	4
USAID	4
UNESCO	3

[16] Crucial problems in resource conservation
(only 49 answers !!)

threat to forests	22
erosion	15
soil fertility	12
plant protection	9
water	8
desertification	7
animals	6
environmental protection	5
air pollution	2

5 Practically no figures cited

Appendix 3

Sustainable agriculture to conserve resources in international agricultural research (IAR)

Ekkehard Kürschner, Arbeitsgemeinschaft für tropische und subtropische Agrarforschung (Council for Tropical and Subtropical Agricultural Research – ATSAF), Bonn, March 1994

Inception of IAR

The prime aim of IAR when the first centres were founded in the 60s was to avert the threat of food shortages in developing countries. Via applied research the idea was to provide improved varieties and cropping technologies for widespread use. Organized since 1971 in the Consultative Group on International Agricultural Research (CGIAR) under the auspices of the World Bank, UNDP and FAO, the donor community has since founded some centres, mostly concerned with crop research, partly with a global and partly regional mandate.

Growing importance of sustainable land use in IAR

With increasing concern for ecology, the conservation and management of natural resources began to receive greater attention in programmes in the 80s. As a result, sustainability was formally declared a CGIAR goal in 1985. Then in 1988 in Berlin CGIAR made the far-reaching decision to systematically enlarge the overall programme by instigating new initiatives and founding new centres. The outcome of subsequent discussions was the adoption in 1990 of a dual strategy with the main aim of raising food supply to the poor and raise their general standard of living by:

- improving the productivity of production systems and
- at the same time enhancing sustainability by conserving and managing natural resources.

Developing the sustainability approach in IAR

Concentrating on suitable sites enabled research to make a substantial contribution to food security. Initially, the broader issues of farming systems and sustainability were only brought into direct relation with food production. Experience gained in implementing and disseminating varieties and technologies revealed the need to account for localized farming systems. As a consequence, greater attention was paid to sites with unfavourbale production conditions. Basically, though, research was still organized along "commodity" lines. Although a multidisciplinary approach was increasingly adopted toward issues under the heading, farming systems, in the 80s, research projects with an ecological focus remained marginal. Some donors however were quick to recognize the need for resource research. Some initiatives were instigated outside CGIAR (e.g. IBSRAM, ICIMOD, ICRAF) with the express aim of dealing with soil conservation and land management issues.

Realignment of the CGIAR system toward natural resource management

Incorporating resource research as an integral component IAR brought about three changes:

[1] Enlargement of CGIAR to embrace new fields of activity, mainly in resources. Centres already in existence were admitted to CGIAR: ICLARM (aquatic eco-systems), ICRAF (agroforestry), IIMI (irrigation management) and INIBAP (banana network). An international forestry centre was founded – CIFOR.

[2] With 10% of the total programme, eco-system research was allotted a much higher priority, supplemented by 29% for the development and management of sustainable production systems. Particular stress is placed on integrated and biological plant protection systems. This does not include bio-diversity, collection and conservation of genetic material (including on-site), which accounts for an additional 8% of the programme. At the same time socio-economics and agricultural policy, major components for an integrated sustainablility approach, were upgraded.

[3] The eco-regional approach redesigned applied resource research methodology. The aim was to take a broad approach by determining the sustainability problems specific to a region. The concept combines both biological and physical aspects (such as climate, soil, topography) with human factors (such as population density, prevalent production techniques, land management and national agricultural policy). Socio-economic and policy parameters in the region concerned are an integral part of this approach. By combining the agro-ecological (zones classified by FAO) and regional reference systems, the eco-region was demarcated as the organizational framework for research. Six priority eco-regions were chosen and one centre appointed as research coordinator: warm and sub-humid tropics in Asia (IRRI), Latin America (CIAT), and in Sub-Saharan Africa (IITA), warm semi-arid and arid tropics in Africa and Asia (ICRISAT) and the cool winter-rain sub-tropics of the WANA region (ICARDA). Activities are also foreseen for the highlands of East Africa (ICRAF) and the Andes (CIP). Research networks are being set up in which the centres can plan and implement research jointly with national programmes. In a complemtary job-sharing approach, the centres work above all on methodological and strategic issues at key sites, whereas national agricultural research institutions (NARS) deal with the more localized questions of implementation.

How do the centers operate?

In line with their mandates, the individual centres have developed different fields of activity. Examples of recent activities in resource research are:

[1] Integrating animal production systems – research by the ILCA since 1985 on vertisol sites in the East African highlands has developed a soil tillage tool for animal traction to conserve soil and water resources in particular. ILCA's research, focussed from the outset on production systems in ecological zones in Africa, was conducive to this approach.

[2] Erosion control – erosion can be reduced from 100 t/ha to 10 t/ha by using improved cropping methods. This was the result of investigations by IBSRAM in the highlands of Thailand. IBSRAM is an international soil science network outside the CG system concentrating on developing soil conservation measures for selected sites in Africa and Asia.

[3] Raising productivity by appropriate farming systems – improved sustainable pasture farming combined with integrated rice growing, can raise land productivity fortyfold. This has been demonstrated since the 80s by CIAT with its research into production systems on acidic soils as part of its regional mandate for Latin America.

Changes in research content and organization

[1] Organization of the core programme

Research has been reorganized in line with the mandate of the respective centre. Centres such as ICARDA and ICRISAT, whose titles imply a regional mandate, already have a suitable basic structure. They focus their programmes and extend existing programmes. Centres concerned with crops can explore different avenues. WARDA, entrusted with rice research in West Africa, is developing a joint resource research programme with IITA in inland eco-systems and their production systems. WARDA's mandate for crops and IITA's mandate, largely concentrated on eco-systems in humid and sub-humid zones in the region, complement each other. Proceeding from studies on the conservation and use of Andean root and tuber crops initially intended to complement its worldwide research on potatoes and sweet-potatoes, CIP chose another path: it started a broad-based eco-regional programme for the Andean highlands. CIMMYT, in contrast, has confined itself to contributing its expertise in crop resarch to eco-regional programmes, coordinated by centres such as CIAT. In addition to its crop programme, CIAT itself has established an independent resource management programme for eco-systems in the Andean foohills, forest outskirts and savannas with higher level land-use components. It was able to draw on experience gained from measures in erosion control and sustainable pasture performed as part of the regional Latin America mandate. IRRI, the global rice research centre, had in turn already fully incorporated the resource side in research at the end of the 80s when drafting comprehensive programmes for individual rice eco-systems (irrigated, rainfed, dry and deep water rice).

[2] Contents of the programmes

Due to their specific mandates in resource research, the new centres have injected new contents: ICLARM responsible for aquatic resource management, ICRAF and CIFOR for agroforestry and forest resources, IIMI for irrigation management to conserve resources. Eco-regional centres pay more attention to land management for water conservation in arid areas, soil erosion and interaction between bio-diversity and sustainable land management. Socio-economics and political factors influencing resource use are gaining in importance. Activities with worldwide environmental relevance are carried out, such as the impact of changes in the ozone layer on rice productivity and the effects of irrigated rice production on the greenhouse gas methane. As part of their present mandates, ISNAR, IFPRI and IIMI have turned their attention more to resource management. Higher priority is accorded issues that affect policy decisions and the management of agricultural and resource research.

3. Approaches in research

An example of a global initiative is the consortium on alternatives to burn-and-slash headed by ICRAF. Applied and strategic research covering a number of ecosystems is conducted on sustainable land management systems and technologies, policy and strengthening of national capabilities. There are 17 national and international institutions involved. As part of eco-regional programmes some regional initiatives are being run with a different approach. These are organized as research associations in consortiums or networks. IRRI, for example, has established an association for the Southeast Asian upland rice region, where the integration of national programmes from the region is exemplary. In keeping with their strength, national partners make a major contribution to the consortium. Similarly, CIAT has established a consortium with national programmes to deal with sites with acidic problem soils. This association includes two German and two American universities studying strategic issues. A steering committee with all partners takes decisions and is in charge of coordination in this association. A feature of these associations is the cooperative involvement of national agricultural research institutions in planning and conducting research. Via participatory methods, target groups and non-governmental organizations are becoming increasingly involved in conducting research.

Appendix 4

Research projects of German institutes in sustainable soil management

Sustainable soil management only plays a minor role in tropical and subtropical agricultural research in German research institutes. Of 539 research projects in 1992, only 29 dealt with problems of sustainable soil management, of which 5 included socio-economic factors.

Most research projects are directly financed by BMZ via the Arbeitsgemeinschaft für tropische und subtropische Agrarforschung (Council for Tropical and Subtropical Agricultural Research – ATSAF), the German-Israeli Agricultural Research Agreement for Developing Countries (GIARA), or by GTZ with funds from international agricultural research or bilateral projects. Research projects are mostly carried out in collaboration with international agricultural research centres, whereas collaboration with national research institutions is the exception.

Since 1993, some of the research projects financed by GTZ's Flanking Programme for Tropical Ecology from BMZ funds are in sustainable soil management. Of 39 projects in 1993, 9 were in sustainable soil management (total volume: 1.02 million DM).

- Total number of research projects (1992): 539
- Of which in sustainable soil management: 29
- Donors: diverse, e.g. BMZ, GTZ, DFG, VW

no.	university / institute	research topic, timespan
1	Universität Göttingen: Inst. f. Pflanzenbau u. Tierhygiene i.d. Tropen u. Subtropen	Design of sustainable crop management systems through simulation crop modelling of cereal based cropping systems of West Africa 1991 ongoing.
2	Technische Universität Berlin (jetzt Humboldt Universität): Inst. f. Sozialökonomie d. Agrarentwicklung	Economic models for optimal resource use in developing countries with special reference to critical inputs 1978 ongoing
3	Universität Hohenheim: Inst. f. Agrar- u. Sozialökonomie i.d. Tropen u. Subtropen	Dynamics of intensification in traditional farming systems and the economics of innovations in crop production in semi-humid areas of Benin 1989 -1993
4	Universität Hohenheim: Inst. f. Agrar- u. Sozialökonomie i.d. Tropen u. Subtropen	Micro-economic potentials and limits to the introduction of alley cropping systems in traditional farming systems in South Benin 1991 -1993
5	Universität Hohenheim: Inst. f. Agrar- u. Sozialökonomie i.d. Tropen u. Subtropen	Economic evaluation of the environmental damages. A case study on soil erosion in Zimbabwe 1990 -1993
6	Bundesforschungsanstalt für Landwirtschaft: Institut für Betriebswirtschaft	Factor input decisions and innovation behaviour in smallholder families – Africa 1988 -1991
7	Universität Giessen: Inst. für Agrarsoziologie	Ecofarming: Strained relations between technology and politics. A sociological contribution shown by an example of Brazil 1987 -1990

no.	university / institute	research topic, timespan
8	Universität Bonn: Agrikulturchemisches Institut	Interactions between P fertilising and organic manuring as well as particularities of the P-dynamics of two P-fixing latosols in South Brazil 1988 -1992
9	Universität Hohenheim: Inst. f. Pflanzenernährung	Influence of different fertilization on growth of pearl millet and groundnut in Niger 1989 -1991
10	Fachhochschule Hildesheim/Holzminden: Fachbereich Forstwirtschaft	Productivity and sustainability of agroforestry systems for the humid tropics 1980 -1992
11	Universität Hohenheim: Inst. f. Pflanzenproduktion i. d. Tropen u. Subtropen	Growth and productivity of simultaneous fallow-cropping-systems in Southern Benin 1991 -1993
12	Universität Hohenheim: Inst. f. Pflanzenproduktion i. d. Tropen u. Subtropen	Influence of different cropping systems on the productivity and reliability of yields as well as soil fertility and efficiency of water use 1986 -1992
13	Universität Hohenheim: Inst. f. Pflanzenproduktion i. d. Tropen u. Subtropen	Development of agroforestry production systems compatible to the utilization of the rainforest ecosystem in the Valle del Sacta, Region of Cochabamba, Bolivia 1989 -1992
14	Universität Hohenheim: Inst. f. Pflanzenproduktion i. d. Tropen u. Subtropen	Genetic resources and management of Sesbania sesban and Sesbania goezel in the semi-arid and semi-humid high altitudes of Ethiopia 1989 -1991

no.	university / institute	research topic, timespan
15	Universität Karlsruhe: Inst. f. Wasserbau und Kulturtechnik, Versuchsanstalt für Wasserbau, mit "Theodor-Rehbock-Laboratorium"	Investigations of runoff and soil erosion in small catchment areas of the pilot zone Taassalet/Project Mina/ Algeria 1988 -1991
16	Universität Bayreuth: Lehrstuhl f. Bodenkunde	Influence of soil properties and fertilizer application on the yield of different food crops in Rwanda 1989 ongoing
17	Universität Bayreuth: Lehrstuhl f. Bodenkunde u. Bodengeographie	Soil and ecological studies of the Kazaboua agroforestry system in the Central region of Togo 1988 ongoing.
18	Deutsche Gesellschaft für Technische Zusammenarbeit,	Central Plateau soil management project (Burkina Faso) 1991 -1994
19	Universität Bielefeld: Lehrstuhl f. Genetik, Fakultät f. Biologie	Nitrogen fixation process: Genetic analysis of the nitrogen fixation process in the Rhizobium meliloti/ alfalfa and the Rhizobium leguminosarum/Vicia faba system 1980 ongoing.
20	Universität Giessen: Inst. f. Mikrobiologie und Landeskultur	Improvement of Sesbania/Aeschynomene rhizobium symbiosis for green manuring of wetland rice 1990 -1993
21	Universität Giessen: Inst. f. Mikrobiologie und Landeskultur	Effects of VA-micorrhizae and liming on phosphate uptake by upland rice (Oryza sativa L.) and soybeans (Glycine max. L.) from acid soils in Java/ Indonesia 1989 -1991
22	Universität Göttingen: Inst. f. Pflanzenbau u. Tierhygiene i.d. Tropen u. Subtropen	The role of VA mycorrhiza in maintaining soil productivity on intensively cropped savannah soils 1991 ongoing.
23	Universität Göttingen: Inst. f. Pflanzenbau i.d. Tropen u. Subtropen	Mycorrhiza on marginal soils: Utilization of vesicular-arbuscular (VA) mycorrhiza for increasing the production of food and fodder crops especially on marginal soils in tropical and subtropical countries 1989 -1992
24	Universität Hohenheim: Inst. f. Bodenkunde u. Standortslehre	Importance of soil organic matter in view of maintaining the soil fertility at different sites of Southern Benin 1987 -1994
25	Landwirtschaftliche Büntehof der Kali und Salz AG, Hannover	Nutrient dynamics in tropical soils under different typical cropping systems in West Africa 1983 -1991
26	Universität Hannover: Inst. f. Wasserwirtschaft, Hydrologie und Landwirtschaftlichen Wasserbau	Hydrological and soi erosion study of a tropical catchment 1991 -1993
27	Universität Hannover: Inst. f. Wasserwirtschaft, Hydrologie und Landwirtschaftlichen Wasserbau, Abt. Tropenwasserwirtschaft	Study on regional erosion caused by heavy tropical rainfalls – Rio Chixoy/Guatemala 1988 -1991
28	Technische Universität München, Weihenstephan: Lehrstuhl für Bodenkunde	Erodibility of soils in Cameroon 1989 ongoing.
29	Technische Universität München, Weihenstephan: Lehrstuhl für Bodenkunde	On soil erosion in the humid tropics of West Africa 1988 ongoing.

Sources: Agricultural Research for the Tropics and Subtropics. Current Projects of Research Institutes in the Federal Republic of Germany. Centre for Agricultural Documentation and Information (ZADI) & Council for Tropical and Subtropical Agricultural Research (ATSAF). 1992.

Topics in research projects in sustainable soil management:

▶ soil erosion	5 (1)*
▶ cropping systems and soil fertility	4
▶ organic and inorganic fertilizer	3
▶ N-fixation	2
▶ phosphate dynamics	2
▶ mykorrhiza	3
▶ agroforestry	4 (1)*
▶ economics	6

* with economics as second major topic

Appendix 5

German finanzial contribution (BMZ) to international agricultural research on sustainable soil management

institution research region	programmes/ projects duration	research activities on sustainable soil management	contribution in thousand DM	percentage for sustainable soil-management
IBSRAM Africa	developing a network for land development with a view to sustainable land management 01/92-12/94	developing appropriate measures of soil management measures and technologies	2 571	100%
ICIMOD Nepal	developing and distributing appropriate integrated programmes focussing on sustainable management of natural resources 01/93-12/95	mountain farming systems programme mountain environmental management programme	3 720	20%
ICRAF	strategic research on genetic im-provement and management of multipurpose trees in agroforestry systems 06/92-05/95	improving sustainable productivity of arable land	5 145	100%
AVRDC	integrated vegetable production in paddy rice fields 09/92-08/95	using legume green manure to protect against erosion and leaching	158	< 50%

institution research region	programmes/ projects duration	research activities on sustainable soil management	contribution in thousand DM	percentage for sustainable soil-management
CIAT South Colombia	research on erosion and soil conservation on agricultural plots on slopes in South Columbia 04/90-03/93	- identifying and developing cropping systems to conserve resources - developing forecasting models for soil erosion	891	100%
CIAT Tropical America	identifying projects and developing strategic resource management research in tropical America 04/92-03/94	identifying, planning and implementing research projects for optimum resource management	(150$ US) (env. 240 DM)	no figures
IITA Cameroon Nigeria	research on erosion forms in different soils in Cameroon and Nigeria 04/85-10/88	identifiying influences of different cropping systems on erosion and infiltration capacity, basic research on soil erodibility, erosivity of tropical rainfall and infiltration capacity of tropical soils	485	33%
IITA Cameroon	research on soil erosion in the humid tropics 08/88-02/92	determining influence of mulch layers of various intensities on erosion and run-off, research on erosivity of rainfall, infiltration rates, run-off and erosion	464	50%

institution research region	programmes/ projects duration	research activities on sustainable soil management	contribution in thousand DM	percentage for sustainable soil-management
IITA humid and sub-humid tropics	influence of fallow management systems and intensity of agricultural use on nutrient movement, groundwater and surface water quality on the tropical site 04/92-03/95	identifying optimum fallow management systems	822	100%
IITA humid tropics	water and nutrient dynamics in alley and monocropping systems in the humid tropics 06/87-03/91	modifying and adapting existing alley cropping systems to acidic soils conditions using suitable tree species	474	no figures
CIAT Latin America	phosphate dynamics in the rhizosphere of grasses and legumes adapted to acidic soils in Latin America 10/91-09/94	groundwork for selecting and breeding plant species amenable to acidic soils	250,4	no figures
ICLARM/IAB Ghana	research for future development of aqua-culture in Ghana 06/91-05/93	developing integrated and sustainable agricultural aqua-culture systems	700	no figures
ICRISAT India	decomposition of organic matter in soils on semi-arid tropical sites 10/84-12/88	basic research on quantitative and qualitative decomposition of C and N in semi-arid areas, under various farming systems	200	no figures

institution research region	programmes/ projects duration	research activities on sustainable soil management	contribution in thousand DM	percentage for sustainable soil-management
ICRISAT semi-arid tropics	Decomposition of 14C peanut straw, dynamics of organic matter and CO_2 evolution in soils in the semi-arid tropics 03/89-09/92	basic research on influence of farming systems on decomposition speed of organic matter in the soil	233	no figures
IITA North Cameroon	research on soil conservation in the Sudan-Sahel savanna of North Cameroon 03/91-02/93	basic research on mechanisms in hardsetting soils	125	no figures
ILCA Ethiopia	agroforestry research on multipurpose trees in Ethiopia 04/88-12/92	introducing quick-growing multipurpose trees to provide fuel-wood and increase use of animal manure to maintain soil fertility	960	no figures
ILCA sub-humid West Africa	evaluation of tropical forage legumes for sub-humid West Africa 01/88-12/92	introducing forage legumes to raise soil fertility	1 030	no figures
ISNAR developing countries	setting priorities for national agricultural research in developing countries with a view to sustainability 11/90-10/93	promoting the application of methods to identify priorities for sustainable agricultural productivity	246	no figures

Source: Annual Report 1992. Restricted-Core-Programme. GTZ, July 1993 Annual Reports 1988 - 1992. Special Projects. GTZ, July 1989/90/91/92/93 International Centre for Integrated Mountain Development 1990: ICIMOD Towards 2000. An Indicative Strategic Plan. Katmandou, Népal.

Appendix 6

BMZ promotion of national/regional research institutions in developing countries in sustainable soil management

Institution / research region	programmes / projects and duration	research activities on sustainable soil management	contribution in thousand DM	percentage for sustainable soil management
AGRITEX, Department of Rural Extension Services Zimbabwe	Conservation tillage 12/89 - 06/96	developing cropping systems to conserve soil	5 000	100%
CATIE Costa Rica and other Central American countries	agroforestry extension of CATIE • research • extension • training 1980 - 1995	basic research on nutrient cycles, identification, research and development of agroforestry systems	17 000	75%
Crops Research Institute Nyankpala Agricultural Experimentation Station Ghana	• farming systems research programme 1992 - 1995 • role of soil fertility in agriculture	rotation, alley cropping, organic and mineral fertilizers, on-farm trials	9 700	20%
Directorate for Agricultural Extension, Soil Conservation Department Paraguay	developing and disseminating land-management systems for soil conservation 1993 - 1995	developing direct sowing, green manuring, rotation, agroforestry systems and cropping methods to conserve soil	3 000	50%

Institution / research region	programmes / projects and duration	research activities on sustainable soil management	contribution in thousand DM	percentage for sustainable soil management
IICA Costa Rica	promoting sustainable development 1990 - 1995	no direct research but support of research in the field of sustainable land use	5 000	no figures
Institut de la Recherche Agronomique (ISAR) Rwanda	farming systems and soil conservation 1990 - 1993	organic fertilization, erosion control, participatory technology development	3 900	80%
Institut National de la Recherche Agronomique Maroc	• forage plant research • seed-legumes research 5/92 - 6/95		10-12000 2 000	30-40% 15%
Agricultural Research Station Central Chaco Paraguay	developing soil and water conservation methods, improved rotations, methods of pasturage and forage production systems and of agro-silvo-pastoral systems 1992 - 1997		7 100	100%
KARI, National Agricultural Research Laboratories Kenya	fertilizer trials on 70 sites 1987 - 1992	identifying typical sites depending on climate and soil, long-term effects of (non-)use of fertilizers, observing the decomposition of organic matter	10 000	100%
Provincial Delegation of Agriculture for the North West Province Cameroun	role of soil fertility and crop rotation in sustainable agriculture		150	100%

Institution / research region	programmes / projects and duration	research activities on sustainable soil management	contribution in thousand DM	percentage for sustainable soil management
SACCAR / ICRISAT Zimbabwe	sorghum and millet improvement programme 1989 - 1992		2 760	20%
SACCAR / ICRISAT Malawi	groundnut and legume improvement programme 1992 - 1994		5 000	20%

Appendix 7

GTZ projects with activities in sustainable soil management

In 1993, the GTZ carried out about 2,500 projects including about one third staff projects. 119 projects were concerned with sustainable soil management. These include the research projects mentioned in Appendices 5 and 6, which focus on developing sustainable soil management methods.

Soil conservation and sustainable agricultural production are accorded increasing importance in nearly all rural development projects.
The following table has been taken from the Resource Management Project Register (GTZ 1993) and lists the activities of 145 projects by continent and region. 78 projects are involved in measures to conserve and improve soil fertility, and 80 projects in developing cropping methods to conserve soil. Most of them are the same projects. About half are located in Sub-Saharan Africa.

AS = Asia; **LA** = Latin America; **AN** = North Africa; **AW** = West Africa; **AO** = East/ Southern Africa; **AZ** = Central Africa; **Ges** = total

Activity in	AS	LA	AN	AW	AO	AZ	Ges
Agricultural production systems							
Agroforestry	16	26	4	17	19	5	87
Ecological oriented farm systems	6	4	2	1	3	0	16
Traditional land use system	3	1	1	5	3	1	14
Silvo-pastoral land use	12	9	4	5	3	1	34
Training / Extension							
On-farm demonstration	13	10	2	10	15	3	53
Fertilisation recommendations	5	5	1	2	3	1	17
Plant Species (Plant groups)							
Autochthonous shrubs	3	3	2	3	4	1	16
Autochthonous trees	9	15	2	7	7	2	42
Fodder shrubs	8	3	2	2	7	1	23
Fodder trees	11	4	2	5	7	1	30

Activity in	AS	LA	AN	AW	AO	AZ	Ges
Resource management and plant production techniques							
Crop rotation ▶	12	11	3	18	6	1	51
Mixed cropping ▶	14	18	2	15	10	1	60
Strip growing ▶	6	2	0	2	3	0	13
Contour strip farming ▶	6	2	1	2	3	1	15
Measures against overgrazing ▶	5	0	1	2	3	0	11
Alley cropping ▶	6	3	0	6	4	0	19
Intercropping ▶	9	4	0	3	7	2	25
Tree integration ▶	6	7	1	4	10	4	32
Shade trees ▶	4	1	0	3	4	1	13
Trees on contour bunds ▶	5	4	1	1	6	2	19
Mixed cropping + intercropping ▶	14	18	2	15	11	2	62
Alley cropping + tree integration + trees on contour bunds + site adapted tree and crop species ▶	8	9	2	8	12	4	43
Improving soil fertility ▶	10	2	1	8	9	1	31
Organic manuring ▶	14	13	3	14	11	2	57
Nitrogen fixation ▶	9	11	0	8	7	1	36
Compost and mulch management ▶	10	16	0	14	12	2	54
Composting stable manure ▶	5	2	1	2	4	0	14
Improving soil fertility + organic manuring + Nitrogen fixation + compost and mulch management + composting stable manure ▶	16	20	3	21	16	2	78
No tillage ▶	1	1	0	1	0	0	3
Minimum tillage ▶	5	3	0	1	2	1	12
Improvement of water infiltration ▶	4	3	1	0	4	2	14
Water management ▶	9	7	3	9	7	3	38
Watercatchment systems ▶	5	1	4	7	3	4	24
Erosion control ▶	16	23	4	15	16	5	79
Terracing ▶	3	7	1	0	5	1	17
Wind breaks ▶	5	4	1	3	3	0	16
Living fences ▶	6	5	1	10	9	2	33
Rehabilitation of fallow lands ▶	7	2	1	1	2	1	14
River stabilising ▶	4	1	1	0	2	0	8
Erosion control + contour strip farming + strip growing ▶	16	23	4	15	17	5	80
Erosion control + trees on contour bunds ▶	16	23	4	15	17	5	80
Erosion control + trees on contour bunds + contour strip farming + strip growing ▶	16	23	4	15	17	5	80
Erosion control + terracing ▶	16	23	4	15	16	5	79

Activity in	AS	LA	AN	AW	AO	AZ	Ges
Erosion control + water management + water catchment systems ▶	18	23	5	20	16	5	87
No tillage + minimum tillage ▶	5	3	0	1	2	1	12
Improvement of water infiltration + water management + watercatchment systems ▶	9	9	4	12	10	5	49
Forestry							
Afforestation + Reforestation ▶	14	22	4	14	10	3	67
Afforestation + Reforestation + all following keywords ▶	20	26	6	24	18	5	99
Multipurpose trees ▶	8	2	1	4	6	0	21
Forest pastures ▶	4	2	1	1	1	0	9
Local inputs							
Raw phosphate ▶	1	1	0	4	2	0	8
Lime ▶	2	0	0	1	5	0	8
Pesticides (locally produced) ▶	2	1	0	2	1	0	6
Research + Development							
On-farm experimentation ▶	14	18	4	17	17	2	72
Farming systems research ▶	6	5	2	8	10	1	32
Site adapted land use systems ▶	7	6	2	5	5	0	25
Research on erosion control ▶	4	2	1	3	4	1	15
Soil/plant analysis ▶	7	3	1	4	4	0	19
Economical studies ▶	12	11	1	12	5	1	42
Socio-economic analysis ▶	18	13	5	16	18	5	75
Constraint analysis ▶	6	3	1	4	5	1	20
Economical analysis of trials ▶	6	2	1	2	4	0	15
On-farm experimentation + farming systems research ▶	16	20	5	19	21	3	84
On-farm experimentation + farming systems research + socio-economic analysis + constraint analysis ▶	21	25	7	23	23	5	104
On-farm experimentation + farming systems research + economical analysis of trials ▶	16	20	5	19	21	3	84
Traditional cultivation/land use techniques ▶	6	8	3	6	8	0	31
Regional rural development							
Land use planning/forest use planning ▶	8	11	2	13	9	2	45
Resource management programme ▶	5	6	0	1	3	1	16

Activity in	AS	LA	AN	AW	AO	AZ	Ges
Socio economics							
Self-help organization	16	9	1	14	11	3	54
Self-help organization + village community projects	18	11	1	15	11	4	60
Participation of target group	14	11	4	13	14	2	58
Testing of acceptance	10	5	1	6	8	2	32
Participation of target group + testing of acceptance	-	-	-	-	-	-	-
Decision process of farmers	16	13	4	15	16	3	67
Promotion of women	11	13	4	14	11	3	56
Animal husbandry							
Integration of animal husbandry	11	15	6	13	13	1	59
Improved fodder basis	9	7	2	0	10	0	28
Pasture management	8	7	2	3	4	4	24

Appendix 8

Databases

[1] Literature on sustainable soil management

Databases are useful for obtaining a list of the available literature and selecting relevant publications. A number of databases store data on soil. Particularly good sources for literature on soil management in farming systems is available from the database of the Commonwealth Agricultural Bureau (CAB) and the Royal Tropical Institute (KIT).

priority	organization	database name
sustainable agriculture	AGRECOL Langenbruck, Switzerland	
sustainable agriculture, participatory technology development	ILEIA Leusden, The Netherlands	
sustainable agriculture, organic farming	IFOAM Tholey-Theley, Germany	
resource management, farming systems R&D	OXFAM Oxford, U.K.	
resource management, agroforestry	ICRAF Nairobi, Kenya	
resource management, farming systems R&D	Royal Tropical Institute Amsterdam, The Netherlands	TROPAG
resource management, farming systems R&D	CAB International	CAB
soils	CAB International	SOILCD
resource management, soil and water conservation, farming systems R&D	FAO	AGRIS

Additional databases, including national ones, can be be found in the GATE publication: Information Sources on Sustainable Agriculture in the Third World.

[2] Databases with information on Technical Cooperation and research projects in soil management to conserve

contents	database name	provider
FAO projects	CARIS	FAO[1]
research projects in Africa	SPAAR	eg. ATSAF[1]
EU programmes in research and development (R&D)	CORDIS RTD programmes	ECHO
GTZ projects	REGIS	Pilotproject Sustainable Soil Management (GTZ)

[1] Also available in the Pilotproject Sustainable Soil Management

Appendix 9

Case studies: Projects for sustainable soil management

To illustrate project activities in sustainable soil management, two examples from GTZ projects are appended. They show the variety of experience gained in this field. The reports were prepared by project staff and kindly provided for this state-of-the-art-report.

Case study: Conservation Tillage for Sustainable Crop Production Systems

(PN 88.2511.9-01.100)

[1] Project brief

Since 1988, the BMZ has been supporting the project, Conservation Tillage for Sustainable Crop Production Systems. The aim of the project is sustainable resource management on Zimbabwe's smallholder cropland via appropriate tillage methods to conserve soil. The project runs two stations for agro-technical and soil-science research in two representative ecological zones in north and south Zimbabwe and agro-economic trials on a total of 64 smallholder farms. The measurements at the stations are to test sustainability and the trials on the smallholder farms are intended to assess acceptance and adaptation of the tillage and cropping methods. Based on the project data mathematical models are currently being developed to forecast soil erosion, for example.

In addition to technical activities, the project also concentrates on counterpart training and upgrading. Three counterparts completed a university course (MSc) to obtain the qualification of agricultural engineer with project fellowships, and another member of staff was reassimilated into the project after qualifying at the University of Leipzig. Immediately following this a project-linked doctorate programme for Zimbabwean counterpart staff was started in October 1993 at the University of Zimbabwe.

The target group are the counterpart staff at the project executing agency AGRITEX, (Department of Agricultural Technical and Extension Service) and the smallholders in the so-called Communal Areas of Zimbabwe.

[2] Project regions

Project activities are equally distributed between the sub-humid North (900 mm annual rainfall) and the semi-arid South (600 mm annual rainfall) of Zimbabwe.

The soils are coarse-granular granitic sands almost throughout. A hallmark is the low clay (< 5% in the topsoil) and organic matter content (< 1% in arable land) and the resulting low water retention capacity (about 9 volume per cent in the topsoil). The cation exchange capacity is equally low (< 4 cmol kg^{-1}). Because of high density (up to 1.7 Mg m^{-3}) and the high penetration resistance (up to 3,000 kPa), the available root space is very limited (50-max. 75 cm). The topography is mostly hilly with gentle slopes averaging 2 to max. 10% inclines.

The smallholder farming systems comprise small areas of 2-5 ha land with poor capital equipment. Due to rural exodus from almost all households many families receive money from the men working elswhere. About 75% of the households, often managed by women, have traction animals and turnover ploughs. The other households work their fields with rented animal traction or manually (less common).

[3] Soil problems

Soil erosion due to inappropriate tillage methods causes irreversible degradation of smallholder land in Zimbabwe. Traditional root crop shifting cultivation with a low population density was eminently suited to the fragile ecological balance in the extreme tropics. However, European settlers introduced the turnover plough developed for temperate climates and ousted the indigenous population onto marginal land.

Even during the colonial era, high population growth in these reservations resulted in the degradation of soil resources. Government schemes attempted to counter this problem by building an extensive system of catchment drains, contour banks and water outlet ditches. This effectively halted the massive gully erosion, but not the slower sheet erosion between the contour banks. Using turnover ploughs to turn and hence expose the soil to the heavy tropical rains can cause huge sheet erosion. As soil erosion and the attendant nutrient leaching threaten even the medium-term carrying capacity of arable land in these regions, there is an urgent need to improve tillage technologies on the one hand and to fit these into smallholder farming systems.

[4] Project activities

In addition to the research activities proper in tillage methods to conserve soil, improved agronomic techniques are tested and adapted to local cropping conditions, such as agroforestry, mixed cropping, strip cropping etc. Donkeys as traction animals, have been introduced and new tillage tools developed for teams of oxen and donkeys (disk ridger, grubber) which are tested along with other tools (sowing tools, harrows, hoes etc.) in collaboration with the University of Zimbabwe (Dept. of Soil Science & Agricultural Engineering) and by farmers working on their own.

Extension services to smallholders, who make up the majority of the population, is of central political importance in Zimbabwe, as indicated by the high recruitment to AGRITEX, which also ensures the comprehensive involvement of the target group. With AGRITEX's agreement, the project, however, aims at improving relations with the target group, because extension work has so far proceeded "top down", i.e. the farmers are not genuinely involved from the outset. Since starting trials on farmers' land in 1990-91, the project has altered the focus in the area. In collaboration with a Zimbabwean NGO (Silveira House), which had already cooperated sucessfully with another GTZ-sponsored project (Rural Artisan Training and Establishment), a Training-for-Transformation Programme was introduced. This programme aims at early and full participation of farmers and extension workers (AGRITEX). All family members (i.e. men, women, working children) are invited to annual one week seminars in the local language Shona. These seminars also give participants the opportunity to meet farmers from other project regions, which has proved very useful for direct exchange of information between "project" farmers. The programme is supplemented by excursions during growth periods to other project regions with alternating participation of all farmers. In addition, field days are organized on farmers' fields as well as at the two stations. So far, this comprehensive involvement of farmers has fostered a high degree of initiative and commitment: farmers have organized their own field days, for example.

[5] Approaches

Tied ridging favoured by the project is proving to be the best tillage technique to avoid soil erosion and increase maize yield, both at the two stations and on the farmers' fields. Ridging reduces the annual erosion generally to less than 0.5 t/ha^{-1}, compared to something more than 10 t/ha^{-1} erosion in conventional ploughing. At the same time furrowing produces with statistical significance the highest maize yield. Comparable results have been achieved with mixed cropping (strip cropping with inter-row cropping) and mulching (in the South of the country). Mixed cropping is particularly promising, because it is a traditional cropping system (e.g. maize with beans and pumpkins). A constraint is still the extension service staff (AGRITEX), most of whom prefer to promote monocropping. As part of the Training-for-Transformation Programme, the project is trying to effect change here and has already gained endorsement and support at provincial level as well as from those in charge of AGRITEX. However, this process needs time, because extension workers cannot be persuaded to alter their long-established practices overnight.

A recent economic project study shows that long-term labour input is lower for the furrow system than for traditional ploughing. The first year, however, is critical because the construction of the semi-permanent tied ridges (remain in place for 5 to 6 years) requires more labour than ploughing and hilling up. Socio-economic studies in the project environment have, however, demonstrated that even farmers without traction animals have installed the system on their fields, which is a promising sign considering how recent these trials are, all the more as the project offers no subsidies at all and financial incentives have been confined to interest-free annual micro-loans to finance tools and donkeys (in the past).

Soil management to conserve resources – the case of the rural development project Matelile/Lesotho

(PN. 85.2515.6)

[1] Project brief

Purpose

The target groups increase agricultural production on the basis of sustainable management methods to conserve resources with increasing self-help participation

One of the 6 results: Agroforestry concept developed and selected resource conservation measures implemented by target groups

Executing agency or institutional attachment of project

In legal terms, the official executing agency is the Ministry of Agriculture (MoA), which has entrusted the implementation to the head of the agricultural authority (DAO) at district level.

Target groups for the dissemination of selected measures are male and female inhabitants of the project area Matelile Ward and to an increasing extent of the neighbouring areas of Mafeteng District.

[2] Project region

Climate, soils, topography

Summer rain area; 600-900 mm annual rainfall; heavy rain; cold, dry winter (May-September) and humid-warm summer (October-April).

For the most part soils highly endangered by erosion; under 1900 m above sea-level: karoo-sandstone beds, forming light, low-nutrient soils, frequently with duplex profiles; over 1900 m tertiary basaltic with initially fertile, mostly loamy to clay-rich soils.

The project region lies in the foothills of the Maluti highlands of Lesotho at 1600 - 2200 m above sea level. Steep slopes predominate.

Farming systems

Mostly smallholder subsistence farming; major groups: rural population with access to land, households with land and livestock, landless households with livestock and landless households without livestock; no ethnic diversity – all inhabitants of the region belong to the southern Sotho (Basotho).

On average, 1.5 ha/family, but 29% of the population already has no access to land resources; tillage mainly with animal traction; in summer half-year cropping of maize,

sorghum and beans, hardly any mixed cropping; in winter: wheat, pea, oats, only one cropping season/year due to tillage bottlenecks and labour shortage; about 30% fallowing/year also because of migrant labour; subsistence farming is subsidized by migrant labour.

90% of the arable land was terraced between 1934 and 1957, but the terraces are often in disrepair. Livestock is kept in the project region on for the most part heavily degraded communal pastureland and is fed increasingly with harvest residues, terrace and field border vegetation and from meagre forage cropping. The animals suffer from hunger 8 months of the year.

[3] Soil problems

Causes, e.g. erosion, nutrient loss, C shortage

Due to a combination of steep slopes, heavy rain incidence, extensively destroyed ground cover and soils prone to erosion, the erosion rate is high. 3-5% of the land area is taken up by erosion gullies, rills and badlands. Of the land on steep slopes, till now used as communal pastureland with no controls, up to 50% is naked rock. Trees and shrubs, which only occur naturally in valleys and on humid sites, have been heavily reduced due to felling/gathering for fuelwood and timber.

The run-off rate is increasing continuously due to progressive degradation. Serious nutrient loss occurs because the A horizon of the soil is being washed away. Moreover, the gathering and burning of manure for cooking and heating impairs nutrient replenishment and the vegetation cover is increasingly depleted by continuous grazing. Soils are impoverished, lose their structure and are exposed to further run-off. Large expanses of lowland (sandstone soils), overused and misused in this way for a hundred years, now lie fallow. The organic matter in these soils is at a minimum and biological activity has been permanently damaged, as clearly demonstrated for example in trials with mulching and organic fertilizer: no bio-chemical decomposition or integration of organic matter takes place, and it is no longer possible to raise yield in the short term.

Magnitude, land affected as percentage of all arable land

On communal pastureland in Lesotho (mostly mountain slopes) annual erosion rates of 40-120 t/ha were measured, on terraced plots depending on slope, crop and structure 1.5-27 t/ha. In the foothills, erosion gullies, locally called "dongas", account for 3% of the land. 75% of arable land is endangered by increased sheet and rill erosion (3 t/ha/a'+). The damage to pastureland in lowlands and foothills due to overgrazing, animal treading and removal of shrubs and bushes for wood is even more advanced (on about 80-85% of the land).

Effects on yield (reduction of yield)

Data on yields has been collected continuously since the 60s. The major indicator is maize yield, because at about 60% it is by far the most important crop. Average maize yields varies greatly between good years and drought years, i.e. in three out of five years extreme yields are recorded. Nevertheless, there is a discernible long-term deterioration in average yield, about 100% in the last 30 years.

Farmer strategies to solve the problems

As the Basotho have only practiced crop farming for 200 years, before which they were livestock farmers and gatherers, they have little experience to draw on for coping with degradation problems themselves. Nor does the population accord subsistence cropping high priority, preferring over the last three generations to pursue alternative strategies (migration, migrant labour), instead of developing their own measures to conserve resources. An adverse climate and the proximity of industry and mining in need of manpower has relegated cropping to a secondary source of livelihood for over a hundred years. Agricultural investments are largely confined to livestock.

National strategies

Beginning during the British protectorate (since 1934), nearly all cropland was terraced using a massive input of machinery and materials. These measures were continued after independence. The rural population views these erosion protection measures, consisting of terraces, grass strips, drainage ditches and green water drainage channels as wasted cropland and as government measures for whose upkeep is not their job. Frequently terraces have been ploughed down and drainages channels destroyed.

Since the early 80s these government-run measures on private or communal land have been stopped. The Conservation Division in the Ministry of Agricultural has since been in the process of redefining its role, but apart from a few pilot and demonstration projects it has not developed a new strategy let alone packages of measures. There are still no instruments to raise motivation and participation amongst target groups in resource conservation, although numerous extension and strategy-development projects have been initiated in the last 4-5 years, partly with donor assistance.

[4] Project activities

In resource protection the project concentrates on finding and testing sets of technical as well socio-cultural measures, promoting participation, self-help and finally disseminating successful approaches via extension and training. Priorities had to be selected from the broad range of degradation processes and countermeasures and worked on intensively.

The priorities chosen for Matelile were above all the rehabilitation of badland and the bracing and biological reinforcement of erosion gullies and rills through self-help and the establishment of communal and small private forest and agroforestry land. Additionally, simple techniques of terrace reconstruction were demonstrated and carried out by the land users themselves. These approaches were aimed at alleviating soil run-off, fuelwood and forage shortage and the lack of land amongst a quarter of the rural population.

First, resource conservation methods and techniques were tried out (either on-farm or on communal land involving the whole community) in a participatory approach, then used as demonstrations for neighbouring communities/individuals and finally offered as an extension package via the 14 agricultural extension workers in the region. Applications for further assistance from the project-tools, construction materials and extension were conveyed in the reverse direction via the extension workers to the resource conservation section. The whole approach was pragmatic, i.e. tailored to the interests and capabilities of the target group. A basic principle was learning by doing.

To provide technical assistance to the farmer applicants in implementing erosion control measures at least one man in each large community (more than 100 households) was trained (2 days intensive training; theory and practice) as a village extension worker in erosion control. Applicants in turn were expected to possess a long-term title of use (form C) issued by the Village Development Committee (VDC) or Village Chief for the land to be rehabilitated. Upon application, communal badland and gullies were frequently given over to individual use. The farmers had to agree to provide enough manpower for the practical implementation of the measures. The new notion of land ownership and the prospect of being able to produce forage and wood on the additional land provided enough incentive for participation in the programme without the need for additional payment or other compensation.

In the four-year project, 900 rural households (total number of households in the project region: 7500) have taken part in reclaiming badland, bracing gullies and reconstructing terraces. More than 1500 planted trees and bushes on private forestland and agroforestry land.

[5] Approaches

This section will look in particular at the technical and biological reinforcement of erosion gullies and rills by the target groups.

During the dry winter months, also a period of underemployment, land heavily damaged by run-off was rehabilitated by the population in self-help measures. A precondition for assistance and extension support by the project was a land title for the land to be tilled. The rills and gullies were mostly situated in the fields, seldom near farms or on pastureland. The private land title helped advance the privatization of these largely unused stretches of village cropland.

Rills and gullies were braced in the dry season with sandbags, cemented or gabions (wire-reinforced stone walls) depending on site, water supply and subsoil. The farmers were given technical guidance by the village extension worker for erosion control. Tools and materials (bags, cement, wire) were furnished by the project.

With the onset of the rains, the barrages filled up very quickly with water and valuable soil sediment. Depending on soil type, water supply and planned use, these were then planted during the humid, warm, rainy season with a mix of grasses, legumes and trees/shrubs. Thanks to conducive conditions at the outset and the retention of many organic components, impressive growth and production rates were achieved.

On the basis of 365 completed rehabilitations and the first yield measurements, the payback on initial outlay in gully reinforcement from forage and fuelwood production takes 18 years. The cost/benefit analyses do not, however, account for maintenance.

As already mentioned, the interest of the rural population of Matelile in resource conservation has picked up enormously in the last four years, largely thanks to prior knowledge of convincing examples of successful rehabilitation measures by farmers. There is hardly any need for the extension workers to raise awareness in this area. Major constraints are still manpower shortage, especially men of working age, due to migrant labour and the delayed issue of land titles to farmers.

The programme is scheduled for expansion to include the whole Mafeteng District (35,000 households) in 1994.

Margraf Verlag

Soil degradation and irreversible destruction of agricultural soils are advancing at an alarming rate. Tropical soils are most affected, due to the nature of the soils and harsh climates. Soil degradation is threatening the food security of an expanding world population, and the decomposition of soil organic matter favors climatic change and loss of an important CO_2-sink.
The state of knowledge-report describes the extent of soil degradation, its bio-physical and socio-economic causes and macro- and micro-economic impacts. The causes behind the failure of soil conservation projects are analyzed. The report proves that it is not just because land users lack efficient technologies that they do not protect the soil better; the major causes are insufficient participation in technology development and the lack of favorable socio-economic, institutional and legal framework conditions.
The last chapter describes approaches for creating more favorable agro-political framework conditions. Economic incentives for farmers and participatory approaches in research and technology development are discussed in detail. The annex gives additional data on the extent of global soil degradation, information on soil-related research in international research centers and German research institutes, and indicates development cooperation projects focusing on soil management.

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