

# Board of Economic Inquiry Punjab (Pakistan)

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PUBLICATION No. 111

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*General Editor :*  
**Prof. M. HASSAN**

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## **SOIL EROSION IN THE PUNJAB**

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*Surveyed by*  
**ABDUL AZIZ ANWAR, M.A., LL.B.**

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**Price:- Rs. 1/8/-**

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(The Board of Economic Inquiry, Punjab (Pakistan), does not hold itself responsible for any opinion expressed or conclusions reached by the writer).

## P R E F A C E

Soil erosion is called the 'creeping death' of the soil. It is a world-wide problem, but it is much more assertive in under-developed countries where the modern discoveries in scientific knowledge have not been applied commensurate with their needs in agriculture. It works out its serious effects through this process : loss of surface soil, plant-food and sub-soil water, silting up of water channels, disruption of communications, reduction in productivity of land and ultimately lowering the already low standard of living of the peasantry.

Soil erosion has affected vast areas of our fertile land, rendering them completely unfit for cultivation. In Rawalpindi Division alone about 5 lakh acres of productive land have become uncultivable while another 10 lakh acres are seriously affected. The menace of soil erosion is fast spreading. It needs effective measures for combating it.

It need hardly be emphasised that soil is a basic national resource and its conservation is the prime necessity. For, without its due care, we may not be left with enough land to raise food and commercial crops for our growing economy. Some measures have been taken in the past to combat soil erosion, with emphasis on afforestation and terracing. A more effective approach, however, is needed in view of the gravity of the situation existing in the country by taking adequate steps, which involve planned land use, control of running water, contour cultivation, stabilisation of gullies, proper stocking and management of grazing lands, growth of permanent vegetation on steep slopes, digging the diversion ditches, etc. It requires pooling of efforts of various experts working in agriculture like foresters, soil scientists, agronomists, irrigation engineers to plan various control measures so as to check further erosion of the soil and to reclaim land already affected by it.

It was, therefore, decided to survey the problem of soil erosion and the remedial measures that have been taken in this connection. The Survey was under taken by Mr. Abdul Aziz Anwar, M.A., LL.B., of the Research Staff of the Board. Dr. Abdul Moquit, Ph. D. (Wisconsin) assisted me in editing the Report.

The Board is grateful to Mian Mushtaq Ahmad, P. Ft. S. Mr. K.A. Ghafoor, I.S.E., Mr. H.J. Asar, P.S.E., Mian Shamim Ahmad P.S.E., and Dr. Mohammad Abdullah Khan Ph. D., who have gone

through the Report. Their valuable suggestions have been incorporated in it. The help given by the Departments of Forest, P. W. D. Irrigation, Co-operative, Land Records and the Directorate of Erosion Control & Soil Conservation is also acknowledged.

M. HASSAN.

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TABLE 1

*Tehsilwise Population, Area & Density Per Square Mile in the Punjab.*

Tehsils and Districts	Actual Population			Percentage			Area (Sq. miles)	Density per square mile.	
	Urban	Rural	Total	Urban	Rural	Total		Rural	Total
<b>Gujranwala Dist. ...</b>	2,51,057	7,95,975	10,47,032	24	76	100	2301	352	455
Gujranwala ...	1,54,414	4,23,809	5,78,223	27	73	100	930	461	622
Hafizabad ...	36,866	2,14,745	2,51,611	15	85	100	915	235	275
Wazirabad ...	59,777	1,57,421	2,17,198	27	73	100	456	369	476
<b>Lahore Dist. ...</b>	9,80,821	9,14,407	18,95,228	52	48	100	2429	400	780
Lahore ...	8,59,364	2,75,536	11,34,900	75	25	100	679	500	1671
Chunian ...	37,297	4,78,225	5,15,522	27	73	100	1106	436	466
Kasur ...	84,160	1,60,646	2,44,806	5	95	100	644	251	380
<b>Sheikhupura Dist. ...</b>	82,617	8,40,743	9,23,360	22	78	100	2318	370	398
Sheikhupura ...	56,962	3,97,321	4,54,283	13	87	100	877	470	518
Nankana ...	16,599	2,32,023	2,48,622	7	93	100	690	341	360
Shahdara ...	9,056	2,11,399	2,20,455	4	96	100	751	284	294
<b>Sialkot Dist. ...</b>	2,20,396	12,53,857	14,74,253	15	85	100	2071	613	712
Sialkot ...	1,67,543	2,50,850	4,18,393	40	60	100	387	753	1081
Daska ...	20,294	2,71,086	2,91,380	7	93	100	398	685	732
Narowal ...	15,298	2,36,434	2,51,732	6	94	100	416	574	605
Pasrur ...	17,261	2,34,730	2,51,991	7	93	100	381	621	661
Shakargarh ...	...	2,60,757	2,60,757	...	100	100	489	533	533
<b>LAHORE DIV. ...</b>	<b>15,34,891</b>	<b>38,04,982</b>	<b>53,39,873</b>	<b>29</b>	<b>71</b>	<b>100</b>	<b>9,119</b>	<b>429</b>	<b>586</b>

TABLE 1—contd.

D.:G. Khan Dist. ...	74,999	5,55,695	6 30,694	12	88	100	9,271	59	67
D. G. Khan ...	38,932	1,99,215	2,38,147	12	88	100	1,945	103	122
Biloch T. F. Tracts... ..	...	45,016	45,016	...	100	100	3,990	11	11
Jampur ...	16,999	94,956	1,11,955	15	85	100	900	106	124
Rajanpur ...	8,955	1,22,616	1,31,571	7	93	100	1,944	63	68
Sanghar ...	10,113	93,892	1,04,005	10	90	100	592	159	176
<b>Jhang Dist. ...</b>	<b>1,35,307</b>	<b>7,41,454</b>	<b>8,76,761</b>	<b>15</b>	<b>85</b>	<b>100</b>	<b>3,400</b>	<b>220</b>	<b>258</b>
Jhang ...	73,402	2,75,877	3,49,279	21	79	100	1,328	209	263
Chiniot ...	50,111	2,79,983	3,30,094	15	85	100	1,012	277	326
Shorkot ...	11,794	1,85,594	1,97,388	6	94	100	1,060	1271	186
<b>Lyallpur Dist. ...</b>	<b>2,83,039</b>	<b>18,69,824</b>	<b>21,52,863</b>	<b>13</b>	<b>87</b>	<b>100</b>	<b>3,534</b>	<b>532</b>	<b>609</b>
Lyallpur ...	1,87,202	5,14,872	7,02,074	27	73	100	771	677	910
Jaranwala ...	28,068	4,09,919	4,37,987	6	94	100	709	581	618
Samanduri ...	6,637	4,02,267	4,08,904	2	98	100	771	522	530
T. T. Singh ...	61,132	5,42,766	6,03,898	1	99	100	1,283	442	471
<b>Montgomery Dist....</b>	<b>1,54,833</b>	<b>16,61,287</b>	<b>18,16,120</b>	<b>7</b>	<b>93</b>	<b>100</b>	<b>4,208</b>	<b>397</b>	<b>432</b>
Montgomery ...	62,268	5,41,586	6,03,854	10	90	100	1,228	444	492
Dipalpur ...	16,369	2,90,271	3,06,640	5	95	100	965	301	318
Okara ...	40,325	3,83,616	4,23,941	10	90	100	722	536	587
Pakpattan ...	35,871	4,45,814	4,81,685	7	93	100	1,293	347	373
<b>Multan Dist. ...</b>	<b>3,41,307</b>	<b>17,66,296</b>	<b>21,07,603</b>	<b>16</b>	<b>84</b>	<b>100</b>	<b>5,619</b>	<b>317</b>	<b>375</b>
Multan ...	1,90,122	3,16,693	5,06,815	38	62	100	777	415	652
Kabirwala ...	9,485	2,41,749	2,51,234	4	96	100	672	363	374
Khanewal ...	58,002	3,26,396	3,84,398	15	85	100	981	336	392
Lodharan ...	25,998	2,63,090	2,89,088	4	96	100	1,064	248	272
Mailsi ...	10,242	1,74,490	1,84,732	6	94	100	633	276	292
Shujahabad ...	23,089	1,95,303	2,18,392	11	89	100	688	284	317
Vehari ...	24,369	2,48,575	2,72,944	9	91	100	804	310	339



TABLE 1—Contd.

Tehsils and Districts	Actual Population			Percentage			Area (Sq. miles)	Density per square mile	
	Urban	Rural	Total	Urban	Rural	Total		Rural	Total
Muzaffargarh Dist.	54,361	6,96,889	7,51,250	7	93	100	5,601	125	134
Muzaffargarh ...	15,679	2,19,177	2,34,856	7	93	100	750	293	313
Alipur ...	10,677	2,00,505	2,11,182	5	95	100	932	216	227
Kot Adu ...	10,507	1,32,502	1,43,009	7	93	100	1,504	88	95
Leiah ...	17,498	1,44,705	1,62,203	11	89	100	2,415	60	67
<b>MULTAN DIV. ...</b>	<b>10,43,846</b>	<b>72,91,445</b>	<b>83,35,291</b>	<b>13</b>	<b>87</b>	<b>100</b>	<b>31,733</b>	<b>231</b>	<b>263</b>
Campbellpur Dist.	90,075	6,33,049	7,23,124	12	88	100	4,149	153	174
Compbellpur ...	66,036	2,00,181	2,66,217	25	75	100	652	159	408
Fatehjang ...	5,127	1,38,845	1,43,972	4	96	100	853	163	169
Pindi Gheb ...	10,157	1,54,176	1,64,333	6	94	100	1,438	107	114
Talaang ...	8,755	1,39,847	1,48,602	6	94	100	1,206	116	123
Gujrat Dist. ...	1,31,183	10,27,492	11,58,675	11	89	100	2,258	464	513
Gujrat ...	73,962	3,22,668	3,96,630	19	81	100	565	592	702
Kharian ...	30,126	3,16,316	3,46,442	9	91	100	664	481	522
Phalia ...	27,095	3,88,508	4,15,603	7	93	100	1,029	384	404
Jhelum Dist. ...	77,275	6,04,786	6,82,061	11	89	100	2,786	221	245
Jhelum ...	56,617	2,09,153	2,65,770	22	78	100	905	238	294
Chakwal ...	13,319	2,09,019	2,22,338	6	94	100	1,016	207	219
P. D. Khan ...	7,339	1,86,614	1,93,953	4	96	100	865	219	224

TABLE 1—Concl'd.

Tehsils and Districts	Actual Population			Percentage			Area (Sq. miles)	Density per square mile	
	Urban	Rural	Total	Urban	Rural	Total		Rural	Total
Mianwali Dist. ...	58,204	4,92,295	5,50,499	11	89	100	5,389	92	102
Mianwali ...	23,341	2,16,795	2,40,136	10	90	100	1,528	142	157
Bhakar ...	17,974	2,16,498	2,34,472	8	92	100	3,144	69	75
Isakhel ...	16,889	59,002	75,891	22	78	100	717	83	106
Rawalpindi Dist. ...	2,55,128	6,20,376	8,75,504	29	71	100	2,023	312	433
Rawalpindi ...	2,37,219	2,04,949	4,42,168	54	46	100	750	280	590
Gujjar Khan ...	8,503	2,01,344	2,09,847	4	96	100	564	358	372
Kahuta ...	...	1,23,810	1,23,810	...	100	100	454	273	273
Murree ...	9,406	90,273	99,679	9	91	100	255	383	391
Shahpur Dist. ...	2,13,616	9,49,372	11,62,988	18	82	100	4,788	202	243
Shahpur ...	29,019	1,46,378	1,75,397	17	83	100	605	255	290
Bhalwal ...	49,749	2,61,683	3,11,432	16	84	100	826	278	377
Khushab ...	49,168	2,22,197	2,71,365	18	82	100	2,526	88	107
Sargodha ...	85,680	3,19,114	4,04,794	21	79	100	831	387	487
<b>RAWALPINDI DIV.</b>	<b>8,25,481</b>	<b>43,27,370</b>	<b>51,52,851</b>	<b>16</b>	<b>84</b>	<b>100</b>	<b>21,393</b>	<b>205</b>	<b>241</b>

TABLE II

*Circlewise cases of Unauthorised Grazing in the Punjab  
Since 1947-48*

Circle		Lahore	Multan	Rawalpindi	Grand Total
1947-48	A	625	362	2,190	3,177
	B	1,389	2,711	11,621	15,721
	C	157	226	46	429
<b>Total ...</b>		<b>2,171</b>	<b>3,299</b>	<b>13,857</b>	<b>19,327</b>
1948-49	A	946	1,099	2,375	4,420
	B	3,740	4,045	13,156	20,941
	C	145	238	153	536
<b>Total ...</b>		<b>4,831</b>	<b>5,382</b>	<b>15,684</b>	<b>25,897</b>
1949-50	A	908	538	3,318	4,764
	B	665	2,846	11,201	14,712
	C	...	976	148	1,124
<b>Total ...</b>		<b>1,573</b>	<b>4,360</b>	<b>14,667</b>	<b>20,600</b>
1950-51	A	1,691	819	2,608	5,118
	B	3,020	2,056	13,825	18,901
	C	1	252	360	613
<b>Total ...</b>		<b>4,712</b>	<b>3,127</b>	<b>16,793</b>	<b>24,632</b>
1951-52	A	2,081	1,111	5,505	8,697
	B	3,126	2,732	15,147	21,005
	C	729	26	291	1,046
<b>Total ...</b>		<b>5,936</b>	<b>3,869</b>	<b>20,943</b>	<b>30,748</b>
1952-53	A	1,759	2,226	2,521	6,506
	B	2,501	2,201	13,475	18,177
	C	...	15	197	212
<b>Total ...</b>		<b>4,260</b>	<b>4,442</b>	<b>16,193</b>	<b>24,895</b>

A—Means cases taken to court.

B—Means cases disposed of under Section 67 of I.F. Act 1878.

C—Means undetected cases.

TABLE III  
*Hydrological Data Concerning Indus Basin Rivers*

Name of the river:	Catchment area at debouchment in plains in sq. miles	Maximum recorded flood discharge in cusecs	Minimum monthly discharge in cusecs
Ravi ...	3,562	200,000	2,086
Beas ...	5,384	500,000	4,641
Chenab ...	11,399	750,000	6,830
Jhelum ...	12,445	800,000	7,246
Sutlej ...	23,400	400,000	4,325
Indus ...	118,400	1,000,000	26,584

TABLE IV  
*Distribution of Forests in the Hill Catchments of Indus River System*

Name of the river	Hill catchment area in India and Pakistan (sq. miles)	Area still under forest inside the hill catchments (sq. miles)	Forest area ruined by human misuse (sq. miles)
Ravi ...	3,560	2,580	380
Beas ...	5,400	3,740	130
Chenab ...	10,540	2,590	2,010
Jhelum ...	16,280	10,520	1,250
Sutlej ...	12,660	3,110	710
Indus ...	79,440	11,760	10,710
Total ...	127,880	34,300	15,240

Source: The Pakistan Journal of Forestry, October 1954.

TABLE V

*The Indus River System*

Name of the river	Length in miles	Himalayan area included in the catchment basin (sq. miles)	Total discharge of water in one year (estimated*)	Ratio of discharge to area taking that of Ravi to be unity
Ravi ..	420	3,100	1.0	1.0
Beas ...	220	5,600	2.5	1.3
Chenab ...	640	10,500	5.5	1.6
Jhelum ...	430	13,000	5.5	1.3
Sutlej ...	900	18,500	3.5	0.6
Indus ...	1,830	103,800	9.0	0.3
Total ...	4,440	154,500	...	...

(\*Taking the Ravi discharge as unity ; the numbers do not represent any actual units of measure but show the ratio of river discharge to that of the Ravi. These are based on short observations and rough estimates.)

Source : The Pakistan Journal of Forestry, October 1954.

TABLE VI

*Classifications of the Area in the Punjab.*

Quinquennial Average.	Uncultivated Acreage				Cultivated Acreage			Grand Total	% of cultivated area to total area.
	Forest.	N. A. For Cultivation.	Cultivable Waste.	Total.	Current Fallow.	Net Area actually sown.	Total.		
1906-7	18,62,704	59,50,666	1,54,18,170	2,32,31,540	20,93,500	1,16,88,660	1,37,82,160	3,70,13,700	37.24
1911-12	17,72,014	61,81,986	1,44,64,536	2,24,18,536	26,91,254	1,19,76,503	1,46,67,757	3,70,83,293	39.55
1916-17	16,15,133	62,44,220	1,41,56,605	2,20,15,958	22,70,763	1,28,52,441	1,51,23,204	3,71,39,162	40.72
1921-22	14,32,422	63,35,535	1,32,85,322	2,10,53,279	32,92,635	1,28,83,441	1,61,76,076	3,72,29,355	43.45
1926-27	13,70,900	63,41,933	1,30,01,347	2,07,14,180	23,98,204	1,41,15,136	1,65,13,340	3,72,27,520	44.36
1931-32	12,56,310	64,48,089	1,23,31,757	2,00,36,156	24,81,273	1,46,14,097	1,70,95,370	3,71,31,526	46.04
1936-37	12,00,163	66,69,844	1,17,77,279	1,96,47,286	24,14,464	1,50,53,294	1,74,67,758	3,71,15,044	47.06
1941-42	12,00,220	67,66,653	1,13,63,531	1,93,30,404	22,84,816	1,55,03,014	1,77,87,830	3,71,18,234	47.92
*1946-47	11,56,872	66,99,441	1,03,98,146	1,82,54,459	21,76,411	1,66,09,542	1,87,85,953	3,70,40,412	50.72
1951-52	11,46,707	67,61,860	98,79,971	1,77,88,538	27,93,870	1,65,61,180	1,93,55,050	3,71,43,588	52.11

\* Data for the years 1944-45 and 1945-46 is not available. Therefore the figures relate to the trienium average.

N.A.—Not Available.

TABLE  
District wise Rain fall

Year.	Lahore.	Sialkot.	Gujranwala.	Shiekhupura.	Gujrat.	Shahpur.	Jhelum.	Rawalpindi.
1931-32	34.5	30.2	24.9	22.6	23.2	9.4	23.6	34.6
1932-33	13.6	25.4	16.5	13.1	25.3	14.9	26.5	29.9
1933-34	22.6	38.9	32.3	22.6	37.5	22.7	31.7	27.3
1934-35	24.5	37.2	33.3	20.1	28.6	18.3	26.4	43.2
1935-36	12.9	34.7	23.1	15.8	23.5	12.9	30.3	42.8
1936-37	22.5	48.4	20.1	20.7	27.7	18.2	24.4	40.3
1937-38	14.1	24.3	15.6	10.1	19.8	11.8	20.6	25.2
1938-39	12.9	37.4	22.5	10.1	24.1	9.8	28.8	47.9
1939-40	13.6	22.5	16.1	10.6	21.4	9.8	14.9	23.3
1940-41	10.2	33.8	14.5	12.4	19.2	14.4	22.4	29.0
1941-42	16.8	28.4	26.9	17.1	26.8	16.1	35.2	36.1
1942-43	15.8	36.5	21.4	15.7	29.9	10.3	31.5	35.3
1943-44	11.2	22.5	15.3	20.4	23.6	20.3	26.7	32.8
1944-45	16.8	33.0	32.7	18.3	25.6	23.2	32.2	33.3
1945-46	17.7	22.7	19.8	20.1	18.6	15.4	21.7	31.2
1946-47	13.9	39.5	11.1	7.5	16.8	8.6	23.6	34.9
1947-48	16.8	34.5	20.3	14.5	27.9	5.1	33.2	30.2
1948-49	27.3	42.6	39.2	32.8	38.6	14.5	47.2	56.5
1949-50	15.4	34.7	29.9	15.9	30.7	20.5	30.5	33.5
1950-51	28.2	46.3	35.2	30.4	45.1	15.6	27.3	41.8
Average	18.1	33.7	23.0	17.5	26.7	14.5	27.9	35.5

TABLE  
Districtwise acreage under Forests

Year.	Lahore.	Sialkot.	Gujranwala.	Sheikhu-pura.	Gujrat.	Shahpur.	Jhelum.
1931-32	27,522	1,578	884	3,983	50,882	3,64,941	2,20,323
1932-33	27,621	1,578	884	3,952	52,471	3,63,634	2,20,351
1933-34	27,624	1,578	884	3,957	52,870	3,59,539	2,20,355
1934-35	26,998	1,572	884	3,796	54,050	3,57,490	2,20,355
1935-36	28,449	1,572	884	3,895	54,921	3,58,461	2,20,369
1936-37	25,881	1,572	885	3,895	55,190	3,58,466	2,20,369
1937-38	25,158	1,572	885	3,952	55,113	3,58,461	2,20,317
1938-39	25,996	1,572	885	3,952	55,112	3,59,292	2,20,022
1939-40	25,149	1,572	885	3,983	55,112	3,59,293	2,19,850
1940-41	26,303	1,572	885	3,983	55,110	3,57,880	2,20,495
1941-42	25,301	1,572	885	3,983	55,115	3,55,232	2,20,496
1942-43	23,835	1,572	885	3,983	55,115	3,51,860	2,20,496
1943-44	20,011	1,572	885	3,983	55,115	3,49,543	2,20,496
1944-45							
1945-46							
1946-47	18,673	1,734	885	3,983	54,796	3,45,160	2,20,412
1947-48	18,505	1,734	885	3,983	54,797	3,46,314	2,20,412
1948-49	18,408	1,734	885	3,983	54,799	3,46,313	2,20,422
1949-50	18,498	1,734	885	3,983	54,907	3,46,313	2,20,465
1950-51	18,498	14,334	2,003	4,775	54,907	3,46,256	2,20,575
1951-52	18,496	12,563	1,390	4,775	54,907	3,46,248	2,20,575

in the Punjab since 1931-32.

(Figures in acres)

Attock.	Mianwali.	Montgomery.	Lyallpur.	Jhang.	Multan.	Muzaffargarh.	D. G. Khan.	Average.
15.9	10.1	15.2	18.0	10.1	5.4	4.9	3.4	17.9
19.0	14.9	4.0	5.2	13.6	5.8	7.4	9.0	15.3
27.1	13.6	14.6	14.1	10.0	7.3	5.5	9.4	21.1
29.7	9.5	6.2	16.9	9.5	8.6	7.6	8.8	20.5
27.1	18.3	9.9	8.0	8.4	3.5	2.1	2.9	17.3
23.3	16.2	16.6	13.7	9.9	12.9	11.0	13.6	21.2
18.7	8.1	4.5	8.2	4.7	2.9	2.9	4.6	12.2
31.3	13.9	7.8	8.6	6.1	5.7	4.3	4.0	17.2
20.1	9.0	5.8	8.8	6.8	4.7	4.5	3.1	12.2
19.6	11.2	9.3	4.9	5.9	5.2	2.8	7.6	13.9
22.5	11.2	8.4	19.0	19.2	17.4	4.4	4.4	19.4
27.6	9.1	12.4	15.8	9.3	9.9	8.9	5.1	18.4
25.8	11.8	7.8	17.9	9.6	4.2	5.5	5.5	16.3
23.9	16.3	16.3	13.6	12.8	12.3	10.5	10.7	20.7
25.1	11.6	12.4	9.0	9.9	1.9	2.8	1.7	15.1
17.3	6.6	3.6	6.1	2.9	1.4	3.1	1.4	12.4
21.1	10.7	6.5	10.8	7.2	2.6	1.6	1.7	15.3
25.9	11.0	17.5	15.9	12.4	6.2	6.4	2.9	24.8
23.7	8.9	9.0	11.5	7.9	6.2	5.7	7.2	18.2
28.3	12.4	13.6	16.1	11.4	7.2	8.1	9.2	23.5
23.7	11.4	10.0	12.1	9.4	6.6	5.5	5.8	17.6

## VIII

in the Punjab since 1931-32.

(Figures in inches.)

Rawalpindi.	Attock.	Jhang.	Montgomery.	Multan.	Muzaffar Garh.	D. G. Khan.	Total.
2,16,188	2,00,904	359	20,884	40,560	58,223	6,287	12,03,518
2,16,096	2,00,657	359	21,295	40,811	48,216	6,276	12,04,201
2,15,300	2,00,651	3.9	22,811	37,903	48,111	6,858	11,98,800
2,15,059	2,00,651	359	22,659	37,903	48,030	6,858	11,96,644
2,15,149	2,00,659	359	22,035	39,025	48,125	6,858	12,01,761
2,15,280	2,00,659	359	23,034	39,025	48,113	6,858	11,99,586
2,14,980	2,00,602	359	23,044	48,495	46,831	6,148	12,05,917
2,12,066	2,00,771	359	22,982	48,515	42,359	5,793	12,05,676
2,12,066	2,00,771	359	23,282	48,515	48,354	5,793	12,04,989
2,12,066	2,00,989	359	22,282	48,515	48,879	5,792	11,82,437
2,12,066	2,00,988	359	22,193	28,463	47,382	4,371	11,78,411
2,12,066	2,00,978	359	15,706	27,692	47,989	4,371	11,66,907
2,12,066	2,00,976	359	17,842	21,434	46,840	4,371	11,66,493
2,12,066	2,00,443	359	17,841	19,925	47,594	4,344	11,48,215
2,12,066	2,00,443	359	17,832	19,925	57,601	4,344	11,49,200
2,12,066	2,00,443	359	15,155	19,925	47,890	4,344	11,46,806
2,12,066	2,00,443	359	15,155	19,925	23,222	3,472	11,21,427
2,12,066	2,00,443	359	15,155	19,725	34,186	4,344	11,47,626
2,12,066	2,00,392	14,887	15,918	19,725	47,192	4,344	11,73,478



TABLE IX. Cattle Population in the Punjab.

Category	1904	1909	1914	1920	1923	1928	1930	1935	1940	1945
Bulls ...	20,37,375	21,64,733	24,52,388	3,519	5,294	3,273	3,105	3,130	3,900	4,149
Bullocks ...	...	...	...	21,39,316	22,84,873	22,80,063	22,18,732	22,50,027	23,38,132	24,23,076
Cows ...	15,99,575	18,77,043	20,06,502	15,28,584	15,39,502	15,03,257	13,73,781	15,21,209	13,94,591	14,37,848
Youngstock calves	16,96,471*	18,41,815*	19,24,403*	15,78,734	15,11,404	16,12,479	13,78,348	16,76,137	15,85,053	14,89,587
<b>TOTAL</b> ...	<b>53,33,421</b>	<b>58,83,591</b>	<b>63,83,293</b>	<b>52,50,153</b>	<b>53,40,073</b>	<b>53,99,072</b>	<b>49,73,966</b>	<b>54,50,503</b>	<b>53,21,676</b>	<b>53,54,660</b>
Male Buffaloes...	3,43,005	3,86,961	3,37,575	2,69,200	2,60,801	2,42,624	2,31,249	2,87,635	2,79,418	2,36,815
Cow "	5,46,842	10,88,566	13,44,542	13,59,968	14,68,996	15,22,698	15,34,304	16,97,295	17,99,940	19,36,540
Youngstock Buffalo & calves	Included above.	in Young stock	calves	9,02,498	10,62,902	11,21,021	10,99,055	13,33,849	14,78,161	15,45,301
<b>TOTAL</b> ...	<b>11,89,847</b>	<b>14,75,527</b>	<b>16,82,117</b>	<b>25,31,666</b>	<b>27,92,699</b>	<b>28,86,343</b>	<b>28,64,608</b>	<b>33,18,779</b>	<b>35,57,519</b>	<b>37,18,656</b>
Sheep ...	29,53,215	32,61,788	33,79,507	28,73,664	31,31,303	33,15,243	32,65,759	34,84,866	39,09,592	31,87,564
Goats ...	28,42,525	22,29,821	25,14,183	17,25,910	25,81,250	23,47,162	20,92,181	24,25,415	17,45,438	21,29,033
<b>TOTAL</b> ...	<b>57,95,740</b>	<b>54,91,609</b>	<b>58,93,690</b>	<b>45,99,574</b>	<b>57,12,553</b>	<b>56,62,405</b>	<b>53,57,940</b>	<b>59,10,281</b>	<b>56,55,030</b>	<b>53,16,597</b>
Horse ...	...	...	...	74,182	66,618	76,343	77,510	77,550	58,449	51,906
Mares	1,73,871	2,28,381	2,71,083	1,41,624	1,49,873	1,60,281	1,59,011	1,53,750	1,18,109	1,14,394
Youngstock colts & Fillis.	Included	in Horses	and Mares	43,110	44,295	56,473	52,520	44,319	49,043	42,353
Mules ...	13,999	23,211	18,700	19,855	18,512	19,981	21,186	18,183	19,431	21,309
Donkeys ...	3,46,773	4,08,822	4,97,716	4,46,314	4,58,475	4,89,629	4,60,335	4,98,948	4,97,311	4,56,819
Camels ...	1,74,604	1,85,805	2,24,397	1,41,998	1,72,703	1,95,771	1,84,562	2,04,498	1,78,567	1,73,166
<b>TOTAL</b> ...	<b>7,09,247</b>	<b>8,46,219</b>	<b>10,11,896</b>	<b>8,67,083</b>	<b>9,10,476</b>	<b>9,99,478</b>	<b>9,55,124</b>	<b>9,97,248</b>	<b>9,20,910</b>	<b>8,59,947</b>
<b>G. TOTAL</b>	<b>1,30,28,255</b>	<b>1,36,96,946</b>	<b>1,49,70,996</b>	<b>1,32,48,476</b>	<b>1,47,55,801</b>	<b>1,49,47,298</b>	<b>1,41,51,638</b>	<b>1,56,76,811</b>	<b>1,54,55,135</b>	<b>1,52,49,860</b>

\* This includes Youngstock (Buffalo Calves).

## APPENDIX A

*Results of the Experiments Conducted at Nurpur and Banni  
Research Stations Regarding Loss of Soil*

**Nurpur Research Station  
(1939-40)**

Particulars	Grass Cover (Trays 1 & 2)	Grass and Bush (Trays 3 and 4)	Bare Soil Grass Clipp- ed Every 8 Days (Trays 5 and 6)
A.—(i) Percentage of rainfall which ran off on 63 wet days for the total rainfall of 42.26" from 1st April, 1939 to 31st March, 1940	10.3	10.1	59.5
(ii) Weight of soil (in lbs.) lost per acre during 63 storms from 1st April, 1939 to 31st March, 1940	1,343	1,214	24,455
B.—Weight of soil (in lbs) lost per acre during 198 storms from 9th July, 1937 to 31st March, 1940	6,204	6,192	68,630

It is clear that the run-off from bare soil was about six times the run-off from grass or grass-and-bush-covered soil, while the loss of soil from bare land was about 18 times that from grass and 20 times that from grass-and-bush-covered soil. Since the installation of the trays, the bare soil had lost some 68,630 lbs. of soil per acre in about 33 months which is about 11 times the soil lost under grass or grass-and-bush-cover. The bare area has thus lost soil at the rate of 2,000 lbs. per acre per month. This loss was, however, recorded only on one experimental farm.

The run-off and soil-wash data for the year 1940-41 were collected from the date of the installation of the trays which is given below :

Particulars	Grass Cover 80 % (Trays 1 and 2)	Grass and Bush Cover 90 % (Trays 3 and 4)	Bare Soil Grass Clipped Every 3 Days (Trays 5 and 6)
A.—Percentage of rainfall which ran off on 58 wet days for total rainfall of 43.26" from 1st April 1940 to 31st March, 1941,	7.5	8.5	62.5
Weight of soil, (in lbs.) lost per acre during 58 storms from 1st April, 1940 to 31st March, 1941.	1,025	1,560	17,961
B.—Weight of soil (in lbs.) lost per acre during 256 storms from 9th July, 1937 to 31st March, 1941	7,230	7,753	86,590

The run-off from the bare soil was nearly 9 times the run-off from the grass-covered soil. The total soil lost from the bare area was about 12 times the soil lost from the grass-covered soil since the beginning of the experiment. The total loss from the bare soil works out to about 23½ maunds per month per acre.

The run-off and soil data were collected up to June, 1941. Further recording was discontinued as statistically no further data were required. Moreover, soil conditions in two trays had strikingly changed while a considerable part of the soil had been washed away leaving a mantle of pebbles on the surface. The following table summarises the results upto 30th June, 1941 :

Particulars	Grass Cover 80 per cent (Trays 1 and 2)	Grass and Bush Cover 90% (Trays 3 & 4)	Bare Soil Grass Clipped Every 3 Days (Trays 5 and 6)
Percentage of rainfall which ran off on 18 wet days for total rainfall of 9.85" from 1st April to 30th June 1941	5.5	10.1	52.5
Weight of soil (in lbs.) lost per acre during 18 wet storms from 1st April to 30th June, 1941	178	281	5,217
Weight of soil (in lbs.) lost per acre during 274 wet storms from 9th July, 1937 to 30th June, 1941	7408	8,034	91,808

The run-off from the bare soil was again nearly 9 times the run-off from the grass-covered soil. The total soil lost from the bare area was over 12 times the soil lost from the grass-covered soil since the beginning of the experiment. In the course of 4 years, the bare soil lost 1,120 maunds of soil per acre or 280 maunds per year per acre.

### BANNI RESEARCH STATION

A similar battery of erosion trays was installed at Banni in the Pabbi Hills and the data collected for the year 1939-40 is given below :

Particulars	Grass Cover (Trays 1 & 2)	Grass and Bush (Trays 3 & 4)	Bare Soil Grass Clipped Every 8 Days (Trays 5 & 6)	
Percentage of rainfall which ran off on 52 wet days for total rainfall of 21.92" from 1st May, 1939 to 31st March, 1940		20.1	18.1	47.5
Weight of soil (in lbs.) lost per acre during 52 storms from 1st May, 1939 to 31st March, 1940		7,262	6,328	32,752

The above summary reveals that soil loss from bare soil was five times the loss from grass and bush-covered soil and was about 3,000 lb. per acre per month. The data collected for the year 1940-41 from the Banni Experimental Farm is summarised in the table below.

Particular	Grass Cover 80 % (Trays 1 and 2)	Grass and Bush Cover 90 per cent (Trays 3 & 4)	Bare Soil Grass Clipped Every 3 Days (Trays 5 & 6)	
A.—Percentage of rainfall which ran off on 48 wet days for total rainfall of 24.82" from 1st April, 1940 to 31st March, 1941		21	18.5	47
Weight of soil (in lbs.) lost per acre during 48 storms from 1st April, 1940 to 31st March, 1941		9,353	7,194	61,046
B.—Weight of soil (in lbs.) lost per acre during 100 storms from 1st May, 1939 to 31st March, 1941		16,615	13,522	93,798

The soil lost from bare surface was about 7 times the loss from the grass-covered soil. The total loss from the bare soil works out at 49.7 maunds per month per acre. The results of the experiments for the year 1941-42 at Banni are tabulated below.

Particulars	Grass Cover 80 per cent (Trays 1 & 2)	Grass and Bush Cover 90 per cent (Trays 3 and 4)	Bare Soil, Grass clipped Every 3 Days (Trays 5 & 6)
A.—Percentage of rainfall which ran off on 58 wet days for total rainfall of 43.77" from 1st April, 1941 to 31st March, 1942	46.4	20.2	64.5
Weight of soil (in lbs.) lost per acre during 58 wet storms from 1st April, 1941 to 31st March, 1942	29,398	11,372	130,362
B.—Weight of soil (in lbs) lost per acre during 158 wet storms from 1st May, 1939 to 31st March, 1942	46,013	24,894	224,160

The commulative soil loss from bare surface during the year 1941-42 was about 5 times the loss from grass-covered soil. The total loss from the bare soil works out to nearly 911 maunds per acre against 187 maunds for grass-covered and 100 maunds for grass-and-bush-covered soil per year.

## APPENDIX B

*(Extracts from the Report of the Pakistan Agricultural Inquiry Committee, 1951-52.)*

**Control of Erosion**

53. This work is of vital importance. We recommend that the Agricultural Development Council suggested by us should prepare detailed projects for tackling these problems efficiently. At present erosion is gaining ground and though good work is being done with 10 or 12 tractors working at present it only touches the fringe of the problem. The big scheme would require about a thousand tractors of 50 H.P. and above.

54. Besides the large scale problem of anti-erosion in Rawalpindi Division there are several areas in Campbellpur, Attock, and other districts where land affected by erosion is in private hands. In such areas there is room for several projects involving the hiring of tractors. According to the views expressed to us by officers of the Reclamation Department the hiring of tractors would be a paying proposition and of considerable assistance in solving the problem of land erosion. We again stress the importance of a proper survey and initiation of well considered projects in this area. There is work similar to the above required to be done in Baluchistan, Muzaffargarh District (Punjab), and parts of the N.-W.F.P.

**Dry Farming and Moisture Conservation**

55. The rainfall in large tracts of Rawalpindi Division is from 14" to 25" per annum, but owing to partial erosion and uncertainty of rainfall the cattle and cultivator population is sparse. In these areas, rapid cultivation and sowing after the rains would ensure a crop and for this tractors would be invaluable.

56. Where cropping is dependent on rain timely ploughing and sowing of the land is vital and this can be more effectively secured by tractors than by bullocks. In irrigated and flooded areas also timely ploughing and sowing would secure a good crop produced under the best conditions.

**On State Lands and For Anti-Erosion**

92. These are areas where tractors can be introduced at once to help in quick development and as quick method of absorbing surplus labour available in other areas. A programme of mechanisation both for development and cultivation, should, in our opinion, be prepared at once for New Canal Colonies. A programme for anti-erosion work should also be drawn up and a regular annual expenditure provided. From these two measures we could expect a rapid increase in food and cash crops within the next few years.

**Deterioration of Land**

138. Though new land is being brought under cultivation by irrigation scheme and otherwise, land already cultivated is deteriorating. Water-logging and salting have already affected 2.5 million acres and soil erosion continues to be a grave menace. If the lessons of the past and the experience of other countries are not to be forgotten, measures should be adopted to guard against the inherent fertility of the land being lost through its misuse or through the misuse of irrigation water.

One of the main factors causing soil erosion is the destruction of forests. *Pakistan's forest land covers only about 4.5 per cent. of the total area ; this is nearly the lowest percentage in the world. It is estimated that for a properly balanced use of land in dry areas, especially where timber is used for fuel, the land requires nearly 25 per cent. forest cover.*

### Classification of Area

366. The area, according to village records, is classified into 5 heads :—(i) Forests ; (ii) Area not available for cultivation ; (iii) Other cultivated land excluding current fallows ; (iv) Current fallows ; and (v) Net area sown during the year.....Still the classifications are not free from ambiguity. For instance, the maximum period for which the land left uncultivated is treated as 'fallow' varies from province to province according to local conditions and practices. This should be definitely fixed for the sake of uniformity. At the expiry of this period, the land, if still left uncultivated, should be included, for statistical purposes, under the head "Culturable Waste".

367. The total area is also classified into irrigated and unirrigated, the source of irrigation being shown. The number of acres irrigation under different crops is shown, as also the areas sown more than once.

368. *Forest.* "Forest" means any land classed or administered as forest under any enactment dealing with forest. Any province, however, is free to exclude any cultivated area which may exist within such forests and to enter it under the heading "Net area sown during the year". The purpose of this note is evidently to make agricultural returns free from legal or administrative considerations as much as possible. But instead of permissive action in transferring such areas, as suggested, these transfers should be made obligatory in order to secure uniformity in the returns from all provinces/States and to make the returns conform more closely to the actual agricultural position.

369. Uncultivated land may form part of a forest or may be occupied by buildings, water, roads, etc., or may be current fallow. A portion of this area may, however, be definitely known to be cultivable. This is shown in a separate head "A", which reads "Cultivable Area". Areas under bamboos and thatching grass (when not forming parts of forest areas), as also groves not classed in sown area, are included in this head. This appears misleading. The purpose of agricultural process or culture is to grow something useful or something that can have a money-value. Culturable area included in head 3 seems to imply that such land is not profitably utilised, but in point of fact, bamboos, thatching grass or trees may not be necessarily less lucrative than food crops or jute, cotton, etc., grown on it. Moreover, the point arises as to whether ratoon crops, such as sugarcane, in the third year should or should not be included in this category. In a sense, bamboos, tea, thatching grass, and other perennial crops may be regarded as ratoon crops not requiring cultivator's attention every year and the area concerned may properly be included under cultivated area.

## APPENDIX C

*Summary of Erosion Control Methods Classified by Functions*

Functions	Methods
A. To improve existing plant cover on all unploughed land	
(i) through grazing control	1. Reduction of surplus cattle.
(ii) through village organisations	2. Closures, complete and rotational.
(iii) through forest protection and afforestation.	3. Partition of shamlat (common) land.
(iv) for wind erosion measures, see under J below.	4. Co-operative management of grass lands.
B. To build up soil fertility in ploughed land	5. Better management of existing forests.
C. To reduce the exposure of bare soil particularly during monsoon	6. Village plantations.
D. To increase surface storage and infiltration.	7. Manuring and green manuring.
E. To increase infiltration into the deeper layers.	8. Preserve stubble and crop residues.
F. To prevent run-off gaining a cumulative velocity	9. Consolidation of holdings.
(i) by control of field drainage	10. Improve tenancy conditions.
(ii) by control of drainage outside fields	11. Choice of crops and crop rotations.
G. To divert excess water of natural channels.	12. Strip cropping.
	13. Reduce bare fallow.
	14. Restrict cultivation of steep slopes.
	15. Cover crops and mulching.
	16. Contour ploughing.
	17. Contour ridging and watbandi.
	18. Bench terraces.
	19. Subsoiling.
	20. Trenching.
	21. Basin listing.
	22. Grassed ditches.
	23. Masonry outlets in field bunds.
	24. Contour bunds set out with a side slope so that water is led off fields quickly.
	25. Live hedges & contoured hedgerows.
	26. Gully plugging & check dams.
	27. Reclamation of ravined land.
	28. Control of snow melting in high catchments.
	29. Diversion bunds.
	30. Diversion ditches.



- |   |   |
|---|---|
|   | 31. Deliberate water-spreading by flooding of overflow meadows. |
|   | 32. Water tanks.  |
|   | 33. Road drainage control and recovery of land-slips.           |
| H. To head back accumulations of water in the river bed itself. | 34. Small water-holding bunds in multiple along torrent beds.   |
|   | 35. Major reservoirs.   |
| I. To confine the torrent of river to a planned channel.        | 36. Canalising smaller torrents by vegetational control.        |
|   | 37. River bank consolidation in major streams.                  |
| J. To reduce wind erosion                                       | 38. Fixation of sand dunes.                                     |
|   | 39. Shelter-belts and wind-breaks.                              |
|   | 40. Improve dry-farming practice.                               |

Source : "Soil and Water Conservation in the Punjab" by R. MacLagan Gorrie, 1946.

## APPENDIX D

### Erosion Control Proposals Summarized\*

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#### Ploughland

1. Wat-bandi and terracing; improve where already in use and introduce where unknown.
2. Remission of revenue to encourage wat-bandi.
3. Consolidation of holdings to facilitate planning of field layout.
4. Planning and proper terracing of field drains.
5. Co-operative loans for land improvement.
6. Use of live hedge plants and proper alignment of hedges.
7. Capture and use of road run-off.
8. Encourage use of compost manure and use of green-manuring crops.
9. Rotation of crops and strip cropping with soil-binding crops.
10. Find legume or grass crop to sow on fallow.
11. Gully-plugging to stop deep erosion in and between fields.
12. Improve cultivation of wasteful crops such as potatoes.
13. Restriction of cultivation on very steep slopes.
14. Refuse 'nautor' sanctions on vulnerable slopes.
15. Provide fuel supply to eliminate burning of cowdung.
16. Patwaris and district civil staff to be given short courses in erosion control.

#### Livestock and Fodder

1. Encourage voluntary and rotational closures.
2. Legislation to extend application of Chos and Minor Canals Acts to other closures
3. Partition of shamlat (common lands)
4. Panchayat or co-operative management of grass-lands.
5. Replace grazing by grass cutting and stall-feeding
6. Grass-land improvement by wat-bandi and water catching
7. Develop grass and hay markets
8. Green fodder crops and silage
9. Emergency fodder crops—e.g. spineless prickly pear
10. Planting of fodder trees
11. Rotation of lopping fodder trees
12. Control migratory flock movements and reduce percentage of goats in flock
13. Application of cattle or livestock tax to encourage good type of milch and plough cattle and eliminate useless scrub animals
14. Reduction of surplus livestock
15. Grading up of flocks and herds by maintaining stud animals and segregating male goats, castration, etc
16. Determine palatability of local grasses and fodders
17. Feed mineral salts as "licks" to compensate for deficiencies in local fodders
18. Search for improved strains of grasses both local and foreign
19. Improve watering arrangement with dams, tanks, wells, etc
20. Develop market supply and humane killing in slaughter houses
21. Improve grading and marketing of hides.

#### Afforestation and Other Works

1. Reclamation of ravined lands for fuel and fodder production
2. Reclamation of flat lands in torrent beds by stream training
3. Establish shelter-belts where advisable
4. Village plantations for fuel, timber and fodder
5. Planting of fodder trees in grass-land and rotation of lopping
6. Control of 'nautor' grants in village waste and scrub jungle
7. Protection of existing forests
8. Encourage village co-operative society as the unit for organizing forest improvement and protection schemes
9. Special legislation for control of vitally important catchments
10. Run-off control and contour trenching and water-catching bunds in forest land
11. Closure of dangerous landslips and their vicinities

\* "Land Management in the Punjab Foot-hills" by R. MacLagan Gorrie.

## APPENDIX E

*Co-operative Soil Conservation Societies in Rawalpindi Division***(A) Rawalpindi District***Kahuta Tehsil*

1. Abad Pur
2. Arazi Sohail
3. Bhaun
4. Bishandot
5. Balhar
6. Berot
7. Chhaper
8. Chebutra
9. Dhok Mahli
10. Dhok Bengial
11. Dhok Baba Faiz
12. Dahu
13. Ghazan Abad
14. Geder Galla
15. Khenada
16. Luni
17. Manianda
18. Miana Mohra
19. Mirgala Maghral
20. Nadna Jatal
21. Nadna Mangral
22. Pindora Hardu
23. Pandori
24. Samot
25. Ser Sube Shah
26. Sada Khambal
27. Tekal
28. Terail
29. Phalina
30. Mohra Hiran
31. Mohra Murid
32. Sahut Saddar
33. Jochha
34. Choa Khalsa
35. Dhok Baba Baland
36. Nambal
37. Arazi Khas
38. Adwala
39. Baniwala Mohra
40. Basanta
41. Blakher
42. Champa Kirpal
43. Chulo
44. Chaprali Herdu
45. Dhok Dhamial
46. Dhok Jaba
47. Darial
48. Guff
49. Gehdar

50. Kahuta
51. Kamili Sadiq
52. Mohra Nagerial
53. Maira
54. Mohra Dhmaial
55. Mohra Terkhana
56. Numb
57. Nothia
58. Pir Grotha
59. Roper
60. Saljur
61. Sahut Budhal
62. Sahib Dhamial
63. Thanda Pani
64. Mohra Bakhtan
65. Mak
66. Mohra Rupal
67. Maira Sangal
68. Darkali Mamuri
69. Darkali Mamuri Patti Chauderian
70. Dhok Zaman Ali Jaswala
71. Sathwani

*Rawalpindi Tehsil*

1. Arazi Sohail
2. Atial
3. Badia Rustam
4. Bhedana Kalan
5. Bhangril
6. Chuher
7. Chak Madat Khan
8. Chak Pakhral
9. Dhok Saidu
10. Dhok Makhan
11. Dhok Kumaran
12. Dhok Jiwan
13. Dheri Shahan
14. Dadhuchha
15. Dadan Nijjar
16. Dhokheri
17. Golra
18. Gangu Jumma
19. Gider Kotha
20. Jagiot
21. Jodh
22. Kot Hathial
23. Karamwal
24. Kalinjer
25. Katarian
26. Khuram Gujjar

27. Khana Dak
28. Kirpal
29. Lakhu
30. Lakhwal
31. Mohra Jumma
32. Mohra Jafer
33. Mohra Noor
34. Mughal
35. Malka
36. Mal Pur
37. Noon
38. Narela Khurd
39. Nurpur Shahan
40. Ohjerian
41. Phul Geran
42. Pind Begwal
43. Pindora
44. Shah Pur
45. Sihala
46. Sambal Kark
47. Shaker Parian
48. Said Pur
49. Ternaul
50. Tahlian
51. Terlai Kalan
52. Jhamat
53. Jhatha Hathial
54. Rewat
55. Kaliyam Teli
56. Dhok Raja Bostan
57. Mohr Chauderian
58. Mankiala
59. Sagri
60. Jherki
61. Sohan
62. Jasial
63. Dhamial
64. Malukra
65. Takhti

*Gujjar Khan Tehsil*

1. Adra Nagerial
2. Bewal
3. Binjial
4. Berki Budhal
5. Bhatta
6. Bucha
7. Buchial
8. Bajjar
9. Chakri Vakilan
10. Changa Maira
11. Chura
12. Dora Budhal
13. Dhok Gondal
14. Dhok Zaman Ali

15. Dara Kial
16. Dhok Gakhar
17. Dhok Amir Ali
18. Dhok Hayat Bux
19. Darkali Kalan
20. Datta Bhatt
21. Dera Kanial
22. Bagwal Dergahi
23. Guliana
24. Gurah
25. Hedo Jagi
26. Hechiari Dolal
27. Jand Nijjar
28. Karauli
29. Kahli Klhinger
30. Kaliyam Awan
31. Kurzada Maliaran
32. Kurzada Sawan
33. Kuri Dolal
34. Kalial
35. Kala Phida
36. Kariali
37. Kanyat Khalil
38. Laddar
39. Lode
40. Mankila Brahmanan
41. Muhri
42. Muhri Barsal
43. Muhri Karnali
44. Mohra Dhamial
45. Mohra Amin
46. Matua Bangira
47. Machhia
48. Mari Bir
49. Pharwal Saru Khan
50. Pherwal Bangial
51. Paka Khan Pur
52. Rayan Gorsian
53. Rama
54. Sihal Khinger
55. Sangori
56. Satho
57. Soga Datt
58. Suj Bahadur
59. Sukho
60. Tal Khalsa
61. Thurjial
62. Turkwal
63. Darkal
64. Changa Bangial
65. Darhala Khaki
66. Dera Bakhasian
67. Tapiali Khurd
68. Pind Payan
69. Panj Girain Khurd
70. Narali Jabair

- |                       |                             |
|-----------------------|-----------------------------|
| 71. Terhala Kalial    | 34. Bafahid                 |
| 72. Hakim Chhatha     | 35. Dheri Kot               |
| 73. Arjan             | 36. Barazi                  |
| 74. Juliari Bhay Khan | 37. Dhok Ahmed Khan Dekhali |
| 75. Banth             | Jalla Banian                |
| 76. Natha Dolal       | 38. Sagra Brahma            |
| 77. Kajo              | 39. Hissar                  |
| 78. Mohra Muqadam     | 40. Baryar                  |
| 79. Mandra            | 41. Bhedian                 |
| 80. Mohra Roshan Ali  | 42. Golara                  |
| 81. Kund              | 43. Kaccha                  |
| 82. Suhr              | 44. Barotha                 |
| 83. Mothu Khinger     | 45. Jahan Abad              |
| 84. Jhuliari Guljri   | 46. Kamra Kalan             |
| 85. Nur Dolal         | 47. Chechian                |
| 86. Jand Guj r        | 48. Mari                    |
| 87. Malakwal          | 49. Langer                  |
| 88. Rukhia            | 50. Sohail                  |
| 89. Jermot Khurd      | 51. Pirana                  |
| 90. Wasla Bangiai     | 52. Thoha                   |

**(B) Campbellpur District**

1. Dhok Siloo
2. Ratwal
3. Chauntra
4. Langer
5. Bahtar
6. Dhurnal
7. Magian
8. Chohan
9. Khalara Kalan
10. Multan
11. Tarap
12. Kot Sarang
13. Singwala
14. Chinji
15. Mirjan
16. Dhudial
17. Naka Kanut
18. Pira Fatial
19. Shah Muhammadi
20. Chatwal
21. Traggar
22. Wah
23. Salar
24. Islam Garh
25. Malak Mala
26. Ghorghasti
27. Dhok Umra Dekhali Jasian
28. Babarki
29. Labh Thathu
30. Fatullah
31. Ghazi Kohli
32. Kohlian
33. Nikoo

**(C) Gujrat District***Gujrat Tehsil*

1. Khokhar Gharbi
2. Dharowal
3. Khapranwal
4. Kot Bela
5. Tibba Bute Shah
6. Ahli
7. Malikpur Chehra
8. Miana Kot
9. Uggowal
10. Doulat Nagar
11. Lakkanwal Khasa
12. Mota
13. Mongowal Sharqi
14. Jhamat Abad
15. Bhoian
16. Jindar Khurd
17. Malowal

18. Karianwala
19. Sarhali Khurd
20. Ghural
21. Chak Budha
22. Kot Ranjah
23. Santal
24. Handa
25. Jalalpur Soltian

#### *Kharian Tehsil*

1. Chechian
2. Rashidpur
3. Dhoke Murid
4. Bawali Khurd
5. Bawali Kalan
6. Kullewal Gujran
7. Damun Chak
8. Aima Shah Ji
9. Gullian Patti Umar
10. Gullian Patti Gujran
11. Khawaspur
12. Bhag Nagar
13. Dhauro
14. Gill
15. Qasba Karyali
16. Bangial
17. Batur
18. Qazi Baqir
19. Khanpur Gujran
20. Baganwala
21. Dak
22. Maira
23. Bhaddar
24. Sidh
25. Chak Sikandar
26. Kotla Arbab Ali Khan
27. Jagal

#### (D) **Jhelum District**

##### *Jhelum Tehsil*

1. Bajwala Dattan
2. Chakrai Rajgan
3. Chhappar Sayadan
4. Naka Kalan
5. Nakki
6. Phulra Sayadan
7. Dhok Khabbal
8. Khookha
9. Daiwal
10. Darapur
11. Said Hussain
12. Doyan

13. Akra Mohra
14. Jhelum Distt. S/c Socy,

#### *P. D. Khan Tehsil*

1. Dhariale Jalap
2. Makhial
3. Nalli
4. Haranpur
5. Pinnanwal
6. Baghanwala
7. Choa Sadan Shah
8. Waula
9. Dhariale Kahun
10. Badshapur
11. Da'wal
12. Chhappar Saidan Shah
13. Lehri Sultanpur
14. Pidh
15. Chunbi
16. Dandot

#### *Chakwal Tehsil*

1. Dhok Sarang Khan
2. Khai
3. Bhaun
4. Satwal
5. Mohra Thanil
6. Dhudha
7. Chak Maluk
8. Chak Kharak
9. Jangah
10. Shah Pur Sayadan
11. Munde
12. Hattar
13. Khokhar Zer
14. Trimni
15. Kalo Jo
16. Bhalla
17. Chakral
18. Chakwal
19. Chakwal Sharqi
20. Nurwal
21. Kalas
22. Bhikhari Kalan
23. Kajli
24. Chak Naurang
25. Jabbair Pur
26. Sua
27. Murid
28. Chohan
29. Lohaser
30. Adhwal

## APPENDIX F

*Comments on Soil Erosion, its Causes, Effects and control by Mian Shamim Ahmad P.S.E. and Dr. Mohammad Abdullah Khan Ph. D., Directorate of Erosion Control and Soil Conservation Rawalpindi.*

Soil deterioration results from menaces like erosion, water logging, salinity and exhaustion through continuous crop removal. Soil erosion is as old as agriculture. It commenced when, on the virgin land, the pre-historic man made the first furrow and exposed it to the abrasive action of wind and water. It has been going on ever since. It has, thus, been brought about as a result of human interference with the normal equilibrium existing between soil building and soil removal and continued by his apathy to restore this balance or make amends for it. Wherever land surface is bared of protective vegetation as it must be when under cultivation, soil is subjected directly to the action of erosive elements. Transposition processes of an extremely rapid nature are set in motion and the soil is bodily displaced much faster than it can be formed. Unless adequate measures are taken to guard against this abnormal highly accelerated phenomenon of soil removal, it assumes the form of the most potent single factor contributing to the deterioration of productive land.

Soil erosion is one of the most serious problems facing Pakistan. Large areas in all parts of the country have been destroyed and thrown out of cultivation as a result of severe erosion. Areas which are suffering from moderate to slight erosion and whose productivity is on the decline are larger still.

### **Forms of Erosion**

Erosion is caused by wind and water. Both differ in the nature of their action and in their outward manifestation but are similar in the sense that both remove and transport surface soil. Under the action of wind storm the small particles of soil are thrown up in a spinning motion, and subsequently fall at a distance 4 to 5 times the height they were projected. Large particles bounce along the surface and may be carried farther in this creeping motion. Very fine particles are suspended in air and are carried over longer distances. 93% of the total soil moved by wind is known to be on account of saltation and creep and is generally below a height of 12 inches, the rest being through suspension.

The action of water, however, is two-fold. When the drops fall on the exposed land surface, they tend to detach and transport the soil particles. As the water gains in amount and velocity, its cutting and carrying capacity is increased. Theoretically, a doubling of the velocity enables water to move particles 64 times larger, allows to carry 32 times more material in suspension and makes the erosive power in total four times. Thus, if the velocity of a stream increases 10 times, its carrying capacity becomes a million times and the erosion increases 100 times. Water erosion takes three forms-sheet, rill and gully. Two or more of them may occur simultaneously in the same field. One may develop into another. In a way, these in fact represent three stages of the same process.

**Sheet Erosion** :—Sheet erosion is the more or less even removal of soil in thin layers one at a time, over an entire segment of the level or sloping land. It is the least conspicuous and the most extensive and insidious type of erosion. It is frequently accompanied by a gradual change of soil colour from dark to light as the humus laden top soil is replaced by humus deficient subsoil and a consequent decline in crop yield.

In the absence of soil cover and poor physical condition, beating action of rain causes surface sealing. Small particles plug the small openings in the soil. Clods and soil lumps are broken down forming a pasty mass. These hinder free penetration of water and favour runoff. The vulnerability of any field to sheet erosion is conditioned by the inherent erodibility of soil itself. Soils with a shallow layer of surface soil over-lying a dense sub soil of low permeability are particularly susceptible to this form of erosion. It also prevails on soils of high silt content, fragile sandy soils, stiff clays and all soils deficient in organic matter.

**Rill Erosion** :—Rill erosion is characterised by small incisions irregularly dispersed on the land surface by the cutting action of water concentrating in streamlets of sufficient volume and velocity to generate cutting power. This form is more apparent than sheet erosion probably in newly planted or fallow fields. The small incisions are easily obliterated by ordinary tillage operations and are thus under-rated for the damage that it can bring about.

Rill erosion is most common in areas of rather intense precipitation and on lands of low permeability. Soils with high silt content are especially susceptible though the process is apt to occur on all lands having loose soil overlying dense sub-soil.

**Gully Erosion** :—Gully erosion results either from cuts in the land surface caused by concentrated run-off in sufficient volume and velocity or continued cutting of the same incision long and deep enough to develop a gully. Usually gullies follow sheet erosion or arise from neglect of rills. Frequently, they make their beginning in slight depression of the land surface, ruts left by the wheels of wagons driven up and down the hill, livestock trails or furrows made along the slope.

The shape of gullies depends upon the relative stiffness of the soil strata and the underlying rock material. Where the soil strata offers resistance to cutting, U-shaped gullies develop. V-shaped gullies are common in areas where this resistance is present. There may thus be a combination of U-and V-shaped gullies in the same field consequence upon heterogeneity so prevalent in our fields.

### Factors Affecting Erosion

The intensity and rate of erosion depends on specific factors. Those of importance are discussed below :

**Rain Fall** :—Of the two phases, amount of total rainfall and its intensity, the later is usually the more important. A heavy annual precipitation received gently may cause little erosion while a lower annual rain fall received in torrential showers may result in tremendous damage. High intensity rain of short duration will do more damage than low intensity rain of long duration. Drop volume, size of drops and the seasonal



distribution of precipitation are also critical in determining soil erosion losses. Drop size and velocity produce the necessary impact required for detachment, surface sealing and run-off. Rain received at a time when there is no cover is apt to cause more damage. This is why monsoon rains in the upland districts which usually come with heavy intensity and at a time when the soil is almost bare, bring about enormous losses of soil and water.

*Slope and Topography*:—The greater the degree of slope, other conditions remaining constant, the greater the erosion due to increased velocity of water flow. Also more water is likely to run off. Percent slope, however has little effect where detachment is a limiting factor, but, where transportation is limiting, the increase in percent slope will increase soil losses.

The length of slope is of prime importance since greater the extension of the inclined areas, the greater the concentration of the flooding water. Any time there is concentration of water into rills or gullies, soil losses will increase in length. This influence of slope is of course modified by the size and general topography of the drainage area and the physical condition of the soil. Clay in poor physical condition undergoes more loss with increased slope length but, these losses are stabilized when physical condition improves.

*Land Cover*:—Land cover provides protection against beating action of rains through interception, breaking impact force and thus reducing detachment. Forests and grasses are about equal in their effectiveness in this connection. Their influence varies. For instance, a forest with heavy organic matter and dense undergrowth is markedly superior to open woods with little organic accumulation. Again, the kind of grass, the thickness of stand and the vigour of its growth greatly affect erosiveness. Perennial grasses have more soil building and protective value. Field crops also vary in their influence. Close growing crops provide better canopy effect and mechanical check to run off than the intertilled crops. Goodstands of wheat, oats, *chari*, alfalfa, cow peas, *moth* etc., offer considerable obstruction to surface wash. Legumes in pure stand or in mixture with cereals exercise a stabilizing effect on soil building and soil removal.

*Rotations and Management Practices*:—Sequence in which crops are grown has a marked affect on erosion losses. If this sequence reduce the period of fallow and provides cover of desirable quality and amount during rainy season, it reduces soil and water losses. The common rotation in the crop land districts is *rabi-kharif-fallow-fallow*. Thus, half the amount in each holding is kept fallow and continuously tilled for one year thereby aggravating the erosion hazard. This rotation needs a change either in the intensity of cropping or in its management so as to provide complete or partial cover on land when it is most needed.

Faulty cultivation up and down the slope, unscrupulous number of tillage operations regardless of its exposure to erosive elements during the fallow period, sowing across the contour, burning of dung rather than its application to the crop, grazing of stubbles, overgrazing of ranges and pastures and reckless felling of trees are wasteful practices, calculated to enhance the erosion hazard. Management practices should aim at establishing good stand of crops, proper tillage, proper manuring and proper utilization of the product.

**Soil Characteristics** :—Texture, structure, organic matter content and depth of top and sub-soil, surface intake and permeability of the sub-soil greatly affect erosiveness. Generally, light textured soil overlying dense sub-soil or heavy top soil with impeded drainage are easily erodible. Structure exercises a healthy influence. Aggregated light textured top soil will resist erosion like granulated clay. Organic matter not only acts as a sponge for local absorption of rain drops but also supplies binding material for aggregation. Content of colloidal clay, aluminium and iron oxides and calcium exercise binding influence, help granulation and tend to reduce soil losses. A deeper column of light textured top soil overlying dense clay will have a different reaction as compared to a shallow top on similar sub-soil. The latter, other conditions being similar, is more deleterious. Impeded surface intake or permeability of the sub-soil induces run-off and consequent losses.

Soil temperature also has a modifying influence. Higher temperature is conducive to decomposition of organic matter and thus tends to increase soil losses. Low temperature is protective causing freezing of land but heavy intensity rain received after thawing leads to more damage.

### **Effects of Erosion**

**Losses of Plant Food and Water** :—The accelerated erosion of soil taking place with unwise agricultural practices has increasingly deleterious effects on the physical body of land. The magnitude of this problem can be visualized from the fact that together wind and water are known to remove not less than 5 billions tons of soil from the crop land and associated pastures every year throughout Pakistan. This 5 billion tons of waste soil contains the equivalent of 5,250,000 tons of N.P.K. and 269,000,000 tons of calcium and magnesium. The nutrient elements of N.P.K. alone work out to an annual loss from soil equivalent to 17,296,000 tons of commercial fertilizers—400 times more than ammonium sulphate distributed by the Agriculture Department, Punjab, during 1952-53. To give an idea of the enormity of water losses as run-off from unconserved fields, a foot hill deforested and heavily grazed in the Punjab is known to lose 16,000 cubic ft. of water per second per square mile. against 60 cubic ft. from a terraced rice field.

More important than the loss of plant food constituents, however, is the soil itself. Erosion removes the entire physical mass of land, the mineral particles, the microscopic organisms and all other constituents. Crop, on the other hand, extracts only diminutive portions of the soil leaving the bulk of the material which may subsequently be improved. Erosion, if not checked, removes all leaving nothing to be improved. No other process or combination of processes is so destructive of valuable soil, its nutritive constituents and water as erosion.

**Productivity Reduced and Economy Upset** :—It is proverbial that any process which destroys the essential productivity of soil can exercise only an adverse effect on an economy that depends fundamentally upon the soil. Erosion is such a process. Other factors being equal, its adverse effect on agricultural economy is being reflected in the progressive deterioration of productive land and lower farm returns.

Agriculture Departments in various provinces have been actively engaged since inception on increasing the agricultural output per unit area. To achieve this, they have introduced better implements, more effective cultural practices and better yielding crops. Taking Punjab as an example, where persistent endeavours have been made in the past, the goal does not appear to be in sight. Based on total sown area and the total production in the Punjab, co-relation, co-efficients between per acre production and years have been worked out for the period 1942-43 to 1951-52 (Appendix 1). These co-efficients do not present a happy situation. The food crops like barley and maize and cash crops like cotton register a negative relationship. Three years observations made at a model farm of the Forest Department speak of a similar story. It does not, however, negate the good work done by these Departments, but, it only brings to light the fact that the increase in yield brought about by the improved agriculture has been more than offset by the canker ceaselessly eating into the vitals of soil.

With decrease in soil fertility and productivity not only the crop yields are affected, but the quality also suffers. Apart from inherited characters the quality depends upon the absorption of nutrient ions and their availability in soil. Erosion diminishes the latter and thus the former is automatically lowered. This in turn affects animal nutrition which lowers the quality of their products.

Such are the effects on level land which are subject to surface wash alone. The severity of the effect will be alarming on sloping land for which no authentic data is available.

Through the ages soil erosion has exerted a tremendous influence on the course of civilization. Man owes his sustenance to the products of soil and thus, his struggle for existence resolves into wresting land from nature. Man's conquest of land has frequently led to extreme impoverishment or complete destruction of the soil resource on which he himself depends. Unchecked erosion eventually may lead to sub-marginality, abandonment, rural migration, disruption of tax base, general community disintegration and similar maladjustments of an economic and social nature. True, civilization rises and falls when land fails to produce.

*Under-ground Water Supply Impaired* :—When a part or whole of the top soil is eroded taking away with it the organic matter, the land no longer remains spongy and absorptive. Also in the absence of any mechanical check to run off, resultant on the lack of cover, the water flows off as soon as it falls on the soil surface thus minimizing local absorption. Consequently, the replenishment of the sub-soil water does not take place, and the underground water supplies are diminished. These effects have become very prominent in Baluchistan and the upland districts of the Punjab. In the latter the water level is going down and in karezes of the former the water supply is on the decline.

How far soil conservation helps in this direction is obvious from the work done by the Forest Department in Gujjar Khan Tehsil of Rawalpindi District. In certain tracts where terracing and embanking of the ravined fields was undertaken the water level rose many feet.

*Floods Intensified* :—With denudation, the absorptive capacity of the catchment area has been much reduced. Unchecked run off increases flow in water ways which with progressive sedimentation in their beds are reduced in capacity for this flow. The water thus spills over their banks into the adjoining low land. The increasing number of engineering works such as weirs and bridges across the rivers, canals, roads and railway embankments provided with insufficient cross drainage obstruct the flow of this water thus intensifying the flood hazard.

*Communications Damaged* :—Soil erosion undermines the compactness of the ground and often leads to land slides in hilly tracts which block roads and rails. Threat to communication increases manifold in monsoon season when as a result of heavy downpours and greater run-off, the rail and road tracks are submerged. The stream channels are clogged with debris. Road and railway embankments are undermined and highways covered with silt, sand and gravel. Irrigation and drainage channels are choked with mud, water supply, power reservoir, rivers and harbours are silted up and need dredging operations at an enormous subsequent cost.

*Climate and Games Affected* :—Natural vegetation exercises a healthy influence on climate and affords natural protection and nourishment for games. Indiscriminate felling of trees and denudation caused by overgrazing tend to raise the atmospheric temperature. Lower relative humidity and decreased precipitation. With thinning out of forests, the wild animals retreat to remote forest reserves causing shortage of game animals.

*Wind Erosion a Nuisance to Plant and Human Life* :—Low sweeping winds that drive dust and sand before them are more destructive as they attack the land with more regularity. They blow silt and sand over thousands of acres of range and crop land smothering plant life and killing whatever chances there may have been for a harvest or a cover of grass. Often the abrasive force of these wind driven soil particles slices off plants at their roots. In many instances the shifting blowing sand has covered highways and formed troublesome drifts, dunes that are a constant menace to adjoining farm lands. In all its forms wind erosion has become a twofold destructive process in removing fertile soil from fields where it is needed and in depositing relatively infertile soil on lands where it is neither needed nor welcome.

To the people, the process is both economic and a social menace. It is not only impairing or destroying the basis of their major industries, agriculture and grazing, but, also blanketing homes, offices and merchantile establishments with dust, covering sheds and other small buildings with sand and destroying agriculture machinery.

### **Erosion Control and Soil Conservation**

Many individual farmers especially in the rural part of this country-grew conscious of the problem much earlier and some tried remedies of their own. Concern grew with knowledge and the Government through the Forest and Co-operative Departments began to study the process of soil washing and methods looking to its control or prevention. Unfortunately, early efforts to control erosion largely tended to lean on a single method of control. Erratic efforts towards afforestation or terracing were

regarded as complete defence against erosion. Occasionally spillways were made and bigger gullies blocked with huge dams at selected places involving enormous expenditure for ponding up resultant run-off for inducing sedimentation. The upper reaches were kept constantly stirred for accelerating this process. In this way, a few acres were reclaimed at the foot of the dam. Such a process of reclaiming is highly questionable on economic and technical grounds. Vegetative methods of erosion control were given scant attention. The use of mechanical and vegetative measures in support of each other was infrequent. The fallacy of reliance on temporary or piecemeal methods of conservation, haphazardly applied, thus failed to produce the desired effect.

Soil conservation is essentially different from soil reclaiming and involves adoption of a new and conservative system of land use. The modern approach to erosion control through a planned system of land use in the entire catchment area involving the coordinated application of a variety of control measures devised by a team of experts in the fields of Agronomy, Soil Science, Agricultural Engineering and Forestry has proved fruitful in other countries and shows considerable promise under our conditions. The pre-requisite to such an approach is a real recognition of soil erosion as a national problem and its wide understanding by the politician, the legislator, the educator and the cultivator alike. Upon such an understanding will depend not only the incentive to act but the ability to act intelligently. Demonstrations of sound conservation, land use practices carried out in problem areas through the collaboration of Government agencies and the individual cultivator prove of immense educational value. These might ultimately be extended to all vulnerable land. Discussion is given below on soil conservation programme in line with a modern approach.

*A Proper Land Use* :—Like living beings every piece of land is born with a different capability and is thus suited to a specific use. In order to determine this, land capability classification is done keeping in view the characteristics of top and sub-soil, topography, erosion and inhibiting factors like wetness, overflow stoniness, etc. Based on this, the land is separated into two major groups; fit for cultivation and not fit for cultivation. The former group of land is fit for arable farming. These groups can be further subdivided into four classes (I, II, III, IV) each differing in the intensity of limitations, in use and hazards in maintenance and thus requiring a variety of agronomical and engineering practices for conservation use. Likewise, the latter group of land is only fit for permanent vegetation. The character of which may vary with the classes (V, VI, VII, VIII) into which this group may be similarly subdivided. However, land under this category accompanied by certain water spreading and water control devices may support forest stands, ranges, pastures and wild life with advantage. It is thus apparent that the use which can be assigned to a particular piece of land will take into consideration its limitations and hazards in addition to the farmers' requirements and will be according to a certain plan drawn out for the entire catchment. Such a use will not only give the maximum utility of its inherent capability but will also guard it against the inroads of erosion.

**Soil Cover** :—The maintenance of continuous vegetative cover is essential to intercept dashing rain, break impact force and thus check detachment. The cover affords a mechanical check to run-off, thereby increasing infiltration. The plant roots exercise binding influence on soil particles, add organic matter, help aggregation and increase absorptive capacity of soil.

The nature of this cover may vary with land classes. Forest and grasses form the best cover on land not fit for cultivation. Wherever this cover has been removed, it needs to be re-established. On crop land however, a crop cover is preferred. The cover crop should be faster in growth and less hard on soil. Such a cover has to be devised keeping under consideration the environments, farmers' economy and the adaptability of the cover crop.

In the upland districts, the general rotation followed on the crop land areas is *rabi-kharif-fallow-fallow*. This leaves half the holding without a cover of any kind for one year fully exposed to erosive agencies. To aggravate conditions, the bare soil is kept continuously stirred thus making it easier to succumb to abrasive forces. In order to help save the situation, the long period during which the soil remains bare has to be cut down by growing some sort of a cash crop. Ground nut (*Arachis spp.*) *mash* and *mung* (*Phaseolus spp.*) and cow peas (*Vigna spp.*) appear to be promising in this respect.

**Management Practices** :—Tilling up and down the hill, sowing in rows running along the slope, removing the entire growth at harvesting, keeping a long fallow and indiscriminate tillage, are some of the popular, though faulty, practices in vogue. These require to be modified keeping in with the conservation requirements.

In place of indiscriminate number of cultivations it would be highly desirable to cut this down to an extent which will not adversely affect the performance of the following crop. If necessary, breaking sod may be combined with slight application of fertiliser to recoup fertility. During the rainy season, contour tillage is necessary. On slope, contour listing which essentially consists in making a ditch and a ridge should be resorted to. Each ditch and ridge will check run-off and aid local absorption. This should be followed by sowing on the contour and if possible the fields should be subdivided into small compartments by making contour levees. The check to run-off by the crop stand entailed by levees will enable the crop up and down the slope to benefit equally from subsequent rains.

Our soils are very deficient in organic matter. This deficiency has not only told upon the physical condition of the soil, but also the absorptive and water holding capacity and plant performance. As a result of low capacity for water absorption and holding, the water runs off in larger volumes and causes more losses. In order to remedy this state of affairs the following steps may be suggested :—

1. Addition of farmyard manure.
2. Green manuring,

3. Provision of legume crops in the cropping system,
4. Leaving a part of the matured stalk at harvesting as stubble mulch.

Farmyard manure supply with zamindars of upland districts is very limited. For want of other fuel, a part out of this has to be burnt for meeting household needs. This quantity can be saved by growing green hedges of *arhar* (*Cajanus* spp), *jantar* (*Sesbania* spp), *sankukra* (*Hibiscus* spp.) around the field. These plants, to a certain extent, will serve their fuel, fibre, and vegetable needs.

Due to moisture problem caused by erratic rainfall in the upland districts, the scope of green manuring is limited unless the land after burying green manure is left fallow for one season or some technique to hasten decomposition of organic matter is found out. The provision of a legume crop in the cropping system and leaving a part of the mature stalk as stubbles are practical anti-erosion measures meriting consideration.

In areas subject to erosion, overgrazing is common. This is partially due to low fodder supplies. In order to divert the pressure on grazing, fodder crops have to be raised, pastures and ranges improved and controlled grazing introduced.

**Engineering Devices** :—It is, some how, maintained in certain quarters, that levelling of sloping land is essential for arable farming. It is not only expensive and laborious but uneconomical and non-practicable enterprise. Without it, arable farming is possible if suitable engineering practices are undertaken on sloping land.

Suitable engineering devices supplementing the programme are very essential. For efficient and quick results they have to be necessarily combined with agronomical practices. Terraces correctly laid out and combined with contour sowing cut off the run-off very efficiently. There are a number of terrace designs available. Different designs are meant for meeting different situations but all aim at cutting the length of slope and affording a regular check to run-off.

While laying out a terrace, the capacity of water shed has to be assessed and a diversion ditch provided for conducting the surplus water safely into the water-way. Waterways for an individual holding or a number of holdings in the catchment area have to be carefully designed. This design will depend upon the amount and velocity of run-off. In case of a smaller run-off of non-erosive velocity, a grass water way would be adequate. A grass which grows prolifically withstands drought and overflow, and forms a thick mat which be highly desirable. A spur may be needed if the velocity of run-off increases. Construction of spillways will become essential if the velocity or amount are otherwise uncontrollable. The spillways, however, should be carefully designed keeping in view the run-off requirements.

To stop further damage, gully plugging is very essential. The velocity of the run-off has to be reduced. To achieve this, cross-bands of a bunch type, quick and tall growing grasses, drought resistant and

not susceptible to overflow should be planted at regular intervals along the gully and its fingers. *Sarkanda* (*Saccharum* spp.) *nara* (*Arundo-dona* spp.) and *Ipomia* species meet this requirement under different conditions. The same plants can be used for stabilizing gully banks. Suitable tree species should be planted in the gully beds and banks by a suitable technique to ensure success. Protection of the existing grass vegetation in the entire gully area will exercise a healthy stabilizing influence. In certain places, where absolutely necessary, small check dams of a suitable design may be built.

*Wind Erosion* :—In controlling wind erosion, the stabilization of sand with a vegetative cover and growing of shelter belts are needed. Regular shelter belts of the type desired for fighting this menace dispersed throughout the wind borne area may not be a practical proposition in view of the scattered holding and tenancy. However, if the borders of each field are provided with a green hedge of *sarkanda* or *nara* and strips of tall growing crops like *chari*, and *bajra* systematically laid out against the prevailing wind direction in summer when blowing is optimum, it will check wind velocity and reduce the hazard. To add to efficiency strips of stubbles at least 2-4 ft. high should be left at the time of harvesting. Listing sandy areas, when bare, against the prevailing wind direction will prove of a definite avail.



## APPENDIX

*Coefficients of correlation between years and crop yield in the Punjab.*

Name of crop	Coefficient of correlation	Sr.	Required for significance at		Significant or non-significant
			5%	1%	
Wheat	+ 0.078	0.377	0.666	0.798	0
Barley	- 0.394	0.346			0
Maize	- 0.615	0.299			0
Gram	+ 0.276	0.363			0
Cotton	- 0.019	0.378			0
Sugarcane ( <i>gur</i> )	+ 0.233	0.348			0

\* Punjab Season and Crop Reports, 1942-43 to 1952-53.

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## GLOSSARY OF TERMS

ANNA	...	One-sixteenth of a rupee (Abbrev. A. or As.)
BANJAR	...	Land which has gone out of cultivation. Unproductive cultivable land.
BARANI	...	Depending on rainfall.
BUND	...	An embankment built of stone or earth.
CANAL	...	The name given to a large area brought under
COLONIES	...	cultivation as a result of canal projects.
CHO	...	A torrent of sand or boulders.
DARRAR	...	A ravine.
DISTRICT	...	The most important administrative unit of area in Pakistan.
GULLY- PLUGGING	...	Dams or obstructions erected in a stream bed or rivulet in the hills.
GUZARAS	...	Village forests.
KACHCHA	...	In case of weights applied to local as distinguished from standard ones; for wells the term denotes those which are unlined by bricks and for houses those made of mud only; for roads denotes unmetalled conditions.
KAS	...	Sandy torrent outflow bed.
KHAL	...	Water channel.
KHARKHANA		A variety of long grass with small prickly surface.
KHARIF	...	Autumn harvest, monsoon or summer crops.
LAKH or LAC		A hundred thousand.
MAUND	...	A standard weight of 40 seers used in Indo-Pakistan sub-continent: equals to 82-2/7 lbs. (Abbrev. Md.)
NARA	...	A long tropical grass with thick and hard stem.
PARTITION	...	The division of Indian sub-continent into Bharat and Pakistan under the Indian Independence Act of 1947. The provinces of Punjab and Bengal were also partitioned by the Radcliffe Award in August 1947 under the same Act.
PUCCA	...	Sound; perfect; complete; fixed; applied to weights and measures it denotes those recognised by Government as distinguished from those

having local sanction; for wells and houses implies the use of kiln-baked bricks in their construction, for roads those which are metalled.

- RABI ... Spring harvest or winter crops.  
 RAKH ... Forest.  
 RUPEE ... A standard coin of Pakistan. (Abbrev. Re. or Rs.)  
 SEER .. One-fortieth of a maund, equals to 32.9 oz. or 933.1 grammes (Abbrev. Sr.)  
 SHAMLAT ... Village common pasture.  
 TEHSIL ... Revenue sub-division of a district with a separate administrative staff.  
 WATBANDI ... Contour ridging in plough land, the practice of erecting embankments around fields.  
 WATT ... An embankment round a field built to pond up rainwater.

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