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IS LAND LEVELLING IN VALLEY FLOORS A VIABLE OPTION FOR INCREASING CROP PRODUCTION UNDER RAINFED CONDITIONS OF POTHWAR PUNJAB, PAKISTAN

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ABSTRACT

Population pressure on limited land resources pushed farmers to bring non-cultivated area of the rainfed Pothwar under arable farming. Land leveling options -are used by farmers extensively to bridge land resources inadequacy to ensure even a subsistence level of farming. The use of land leveling as a single solution is not endorsed by the soil and water conservation experts as against the development oriented public departments. The expensive and low paying nature of existing land leveling practices is criticized at certain foras. This study was planned to analyze the cost and benefit of leveling uncultivated lands, status of erosion and production gains at new-leveled lands. Cross section data was collected to provide empirical evidence on the problems and prospects of land leveling. Result shows that leveling of uncultivated land is profitable under many situations. This is particularly valid when land is subject to severe erosion and un-recoverable damages. It was estimated that incremental land value of leveled increased 3-5 times than uncultivated lands. The pay back period of the investment that include cost of bulldozer leveling, additional tractor hours used, structure cost, erosion management was estimated about 5 years. It is concluded that land leveling decisions need to be Inade in consultation with the technical departments and considering different production packages compatible to the physical resource base and socio-economic circumstances.

I. INTRODUCTION

The Rainfed areas commonly known as the Barani tract account for about one quarter of the total cropped area of the Punjab, Pakistan. This tract is one of the poorest areas of the province, unlike the irrigated areas. Soil in the region is generally medium textured with a fair proportion of clay soils. Low and erratic rainfall, erosion hazard and inadequate soil depth are the main limitations which adversely affecting the production potential of the cultivated area. Ansar et al (2004) reported that the area confronted with dual concern of soil erosion and water stress, resulting low productivity of these potential soils. It is estimated that about 5.000 ha of Barani land is being affected by erosion to various degrees every year. Chaudhry (2000), has reported that erosion affects fertility degradation and crop productivity. It also causes deterioration of soil structure, decrease rooting depth and available soil water. Due to the

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steep slopes, the upper fertile layers of the soils are removed by the runoff, top soil eroded from surface showed relatively low AM inoculums potential whereas that of captured soil collected from the foot-hills revealed high potential (Rashid and Ghufran (1999). Bhushan et al (1984), also observed as much as 32 Mg per hectare soil loss on 2 percent slopping cultivated fallow land, which ultimately enhances the erosion. The loss of soil is enormous and happened during torrential rains. The fields left fallow for many years until bushes re-emerged. Erosion causes depletion in micronutrients and organic matter. Bari et al., (1995) have proved that standing phytomass was the most variable affecting erosion with foliar cover and basal cover also highly correlated to erosion. Erosion is widespread throughout the area. The natural vegetation is sparsely and poorly available in the Pothwar area. Poor quality scanty grass and scrub vegetation exist on steep eroded soils and mountainsides but extensive grazing doesn't permit this vegetation to thrive. On leveled well-bounded lands chances of soil erosion reduced considerably. Almost 80 percent of the area in rainfed Pothwar is cultivated. There is scope for land improvement as around 20 percent uncultivated area can be brought under cultivation through land improvement (Khan *et al*, 1999). The main problems of the Pothwar tract related to land and water resources are as follow: Unleveled and fragmented land holdings, soil erosion, loss of surface run-off, formation of gullies, lack of proper vegetation in fallow system, poor management and conservation of rain water. The above problems were realized even during the British era and for the first time soil conservation work in rainfed areas of Pothwar was taken up in 1939 by the Forest Department. After this the government of Punjab without sufficient research support created a separate department of Erosion Control and Soil Conservation. These activities are mainly confined to gully plugging and land leveling with bulldozers on 50 percent subsidy basis.

Proper research on alternative methods of soil and water conservation is critical to increase their productivity and economic returns. The expensive nature of existing methods used for land leveling is criticized at different technical levels. A detailed study was conducted to resolve certain conflicts on the socio-economic efficiency of prevailing land leveling approaches. The objectives of the study reported here were threefold: to analyze the tradeoffs of different land use options of uncultivated lands, to analyze the cost and benefits of adopting land leveling, and opportunities for land development and to determine the status of erosion on newly leveled lands and cost of erosion management.

II. METHODOLOGY

The nature of the project requires a detailed investigation both from the primary as well as secondary sources. Gujar Khan was selected as the study area because it is well known for the large extent of land leveling efforts made historically. The list of the farmers who availed the opportunity of land leveling was obtained from Soil conservation department of Gujar Khan. In order to achieve the objectives, primary and secondary sources of information were collected.

The topography of this area requires heavy land leveling of uncultivated particularly gullied land to bring these under cultivation. The land of this area ranges from less steep to

highly steep. Moreover the study was confined to only one tehsil so that similar type of lands and situations could be found to evaluate the economics of investment made on land leveling.

A set of questionnaires was developed to collect information in a sequential way. After pre-screening the questionnaires and incorporating some necessary changes the data about the status of soil erosion, value of the leveled land, yield difference at new leveled land and old land, present value of uncultivated land and reclaimed land etc were collected through formal interviews with farmers. In total sixty farmers from Gujar Khan tehsil were interviewed in a formal manner. Farmers were interviewed through objective oriented questionnaire. Checklist was used to take detailed information from the key informants.

The Annual returns of land leveling were estimated as:

$$IB = \sum NRT_{oi} - \sum NRT_{ni}$$

Where

IB = Incremental benefits of land leveling

NRT_{oi} = Net returns from *i*th crop on old leveled land

NRT_{ni} = Net returns from *i*th crop on newly leveled land

The net returns were estimated after treating various costs like maintenance of newly leveled lands, cost of erosion management and other costs of crop management on these lands. The pay back period of the land leveling cost incurred was estimated as follows:

$$PB = LC / IB$$

Where

PB = Pay back period land leveling cost / acre

LC = Land leveling cost / acre

IB = Incremental benefit / acre

Farmer's socio-economic problems for land development were also investigated and subjected to both qualitative and quantitative analysis. The gross margins of individual crop enterprises and net returns for specific crop rotations followed on newly leveled lands were also estimated. Although the results were generalized on over all bases yet efforts were made to have a representative sample of small, medium and large farmers. The farm size was categorized in small having less than 6 acres of operational land holding, medium from 6 to 12.5 acres and large having more than 12.5 acres of land. There were 30 percent farmers having small, 35 percent medium and 35 percent farmers having large land holdings.

III. RESULTS AND DISCUSSION

Socio-economic Characteristics of Farmer and Value of Land

The level of human capital formation in Pothwar was low as reflected from the average number of schooling years. The average age of sample respondent was 57 years and the average schooling years were 8 years because majority of the farmers were illiterate (87%) as only 13 percent were literate. Family size was generally very large (12 persons). About 33.33 percent of a family member were less than 16 years of age, 25 percent were in the range of 16-60 years and 8.33 percent was older than 60 years which showed higher dependency ratios both in children and old age category (Shah et al, 2003). The average rainfed farm size was 13.46 acres, where the average own cultivated and non-cultivated area was 14.25 acres (66%) and 7.32 acres (34%) respectively (table 1). The area rented in and rented out was found very small, Farmer's access to irrigation resources was limited as 3 percent area was found irrigated at sample farms (Shah et al, 2003).

Table 1. Land resources availability in sample farms

Particulars	Area (acre)	Percent area
Own cultivated	14.25	66
Own non-cultivated	07.32	34
Total Land	21.56	100
Operational rainfed land holding	13.46	97
Operational irrigated land holding	00.38	3
Total Operated Land	13.84	100

Source: Shah at al, 2003

Shah et al, (2003), have further reported that most of the farmers had developed new land which was found at the ratio of 2:1 in the sample area. The average old and additional (new leveled land) cultivated area of the sample respondents was 9.37.acres (65%) and 4.88 acres (35%-) respectively. The soils were clay loam, clay and sandy types. The colour of most of the soils was reported white, which indicates low organic matter present in the soil. The Bullied lands mainly adjacent to cultivated area were leveled. The piles of clay existed in between leveled lands was mainly moved to fill nearby eroded lands. The places where this soil was spread prove more productive than old cultivated land for the first two years. These soft deposits serve to conserve moisture for better crop production in patches. Majority of the farmers leveled Qullied (60%) or plain lands (36%). Only 4% farmers have got gravel land leveled mainly for forest tree plantation. The value of plain land was 29 percent higher than Bullied and 79 percent higher than gravel lands. The irrigated land value was estimated 3 times higher than rainfed lands.

Table 2. Value of cultivated and uncultivated land in the study area

Land type	Land value (Rs/acre)	Std. Deviation
Cultivated rainfed	110104	56304
Cultivated irrigated	280000	144224
Uncultivated plain	38000	16576
Uncultivated gravel	21144	11480
Uncultivated gullied	29400	13128

Source: Shah at al, 2003

Uncultivated Land Uses and Availability of Bulldozer

Use of uncultivated lands for arable farming was very limited. Animal grazing and fuel wood collection were the main uses of these lands. The plantation in these lands was natural. Only two farmers have experimented eucalyptus plantation but failed. Free grazing and fuel wood collection were the major uses of communal lands. Only few farmers reported to practice controlled grazing or fuel wood collection from their own uncultivated lands. In some cases farmers' were found growing crops on unleveled lands for some marginal production gains. Farmers could not put uncultivated lands under more productive uses because of the lack of financial resources and technical know how to manage these lands. Use of these lands for high value crops or orchards production require ensured irrigation resources availability, which is generally beyond the capacity of the individual farmers. The mini dams construction for crop production and fish farming could be another alternatives depending upon the appropriate site of dam, which need larger catchment area for continuous water availability for this enterprise. The timber tree plantation can benefit farmers with a slack period of 10-15 years. The benefit accrued from uncultivated lands before leveling were meager and almost identical on all types of lands. In most of the villages, community was getting no benefit from the uncultivated lands. But there were few villages in which community was getting the benefit of grazing and fetching fuel wood. Leveling is easy and cost effective under moisture conditions therefore, land leveling is mainly performed just after rainy season of the year. The demand for bulldozer increased many folds just after the rainy season. Bulldozers are provided at subsidy only for agricultural land development purposes. Full rates are charged for road construction, dams construction, kiln work etc.

Farmers used to avail the bulldozer services whenever it is available in the vicinity of their farms. Therefore most of the farmers (58%) reported that they got booking directly from driver of bulldozer while the other farmers (42%) got advance booking of about 50 hours while for the additional booking 83 percent reported that they made payments to the driver. Even if the farmers were aware that more time would be consumed to level the planned area, they got advance booking for less time. The reason behind this was that more payment had to be deposited in advance for additional time above 50 hours. On an average the initial booking was made for 43 hrs (37 % response), which was not sufficient time for leveling the planned land, so the farmers had to book bulldozers for additional time to level the planned area, and on an average it was booked for additional 31 hours. It was common practice that payment

for additional booking was made through operator and no cash receipt was given to farmer. There was one case in which the area leveled was equal to the planned area. In all cases farmers increased the booking and on an average 45 percent more time was needed than the estimated time for the planned area to be leveled. All the farmers were of the view that bulldozer was the most suitable and effective method to level uncultivated lands particularly for eroded and steep lands. Tractor is economically feasible for lands where less work is required and lands are less steep.

Bulldozer availability for land leveling is limited and shows gap in supply and demand situations. Lot of machines were reported lying idle because of specific disorders and nonavailability of appropriate repair facilities. Generally bulldozer was provided on first come first serve basis. However, the additional bulldozer services were hired informally by the applicant as well as neighboring farmers. This informal booking practice keeps bulldozers busy for additional hours in a certain village and resulted into late availability of bulldozers to the next applicants.

Farmers Opinion about Profitability in Land Levelling

All the sample farmers were of the view that investment on land development was highly profitable because the value of leveled land increased about 2-3 times. Only few farmers, during informal survey, explained that under prevailing drought conditions and high cost of inputs it was useless to invest on land development.

Area Levelled in Different Time Periods

The preparation of uncultivated land on the rainfed area of the target tehsil represents a low-cost method of land leveling. The highest land leveling (10.05 acres) was performed during 1991-97 (table 3)

Table 3. **Average area leveled in different time periods**

Years	Farmers Number	Education (years)	Tractor Owners	Tractor Rented	Mean Land Levelled T.O (ac)	Mean Land Levelled T.R (ac)
Upto 1960	2	8	I(50)	1 (50)	4.00	1.25
1961-70	12	9.3	7 (58)	5 (42)	2.38	3.55
1971-80	3	7	1(33)	2(G7)	5.00	3.36
1981-90	17	8	3 (18)	14(82)	3.00	1.88
1991-97	23	7.39	9 (39)	14(61)	10.05	1.50
1998-2002	3	10	2(67)	I(33)	3.32	1.71

Out of 60 farmers 23 farmers owned tractor while the remaining 37 farmers used rented tractors for all the field operation, which resulted that the tractor owners levelled more land as compared with the farmers who have rented tractors. Beside this for land levelling not a single farmer had obtained credit from formal sources. The main sources of income for meeting cost of

land levelling were off-farm employment, which was 43 percent while 18 percent farmers met the leveling expenditures from their farm income. About 13 percent reported remittances from abroad while 20 percent reported pension of a retired family member as the main source of finance for land leveling (Shah et al, 2003).It is the matter of prestige to have more land ownership in our society and people like to increase land ownership. With the increase in family size and division of land among family members, farmers were pushed to reclaim uncultivated lands to fulfill subsistence needs. About 76 percent of the farmers were of the view that they leveled the uncultivated land for more productive uses. In rainfed areas most of the people are employed in army and other government/semi government jobs and at retirement they find it as an investment opportunity. Beside this many people from the study area had settled in foreign countries and their families had resources to invest in land leveling.

Erosion Management at Leveled Lands

For land leveling besides cost of bulldozer, some additional costs were also involved. The erosions caused by rains after leveling also resulted into additional costs. The rate of erosion on the leveled land was very high in most of the cases. Mussarat et al, (1999), have mentioned that major causes of erosion is poor land, crop management, slope gradient, erodibility of soils and heavy concentrated rains. The spillways were constructed at newly leveled lands to control erosion. About 61 percent farmers reported erosion damages during initial three years. Erosion problems after three years of leveling generally reduced (15%). Almost 50 percent farmers reported moderate erosion intensity during initial three years while 36 percent reported high and remaining 11 percent reported low erosion problem. After three years although only few farmers faced erosion problem yet the intensity was high as reported by 44 percent farmers. This happened only during the heavy rainy seasons. Farmers try to manage eroded lands immediately to avoid further losses. Farmers for controlling the soil erosion used the following measures: strengthen bunds, cemented outlets are constructed, outlets are formed on that side of the field where compact soil is present, normally the slope is made opposite to that part of field where loose soil was put so that water could not stay at that part and cause erosion and construction of the spillways for the control of the soil erosion. In the case of land levelling additional cost incurred beside bulldozer costs were analyzed separately. About 3.9 bulldozer hours per kanal were reported to use on these farms and the cost was Rs. 4168 per acre. The additional tractors use for leveling was 4 hrs and this cost was Rs. 1232 per acre (Table 4). These additional work on leveled lands helps in a great deal for controlling erosion. The total cost incurred per acre over time was estimated Rs. 12784 which was much higher than the cost incurred on bulldozer hours (Rs. 4168).

Table 4. Cost of land leveling

	Hrs /ac	Rs/ca
Cost of leveling (bulldozer)	31.20	4168
Additional tractor leveling cost (initial years)	4.00	960
Initial Structure cost	-	1232
Erosion management cost	-	-
Average area subjected to erosion initial 3 years (ac)	-	58.40
Labour cost	4.64	56.00
Tractor cost	25.68	6160
Material cost	-	208
Total cost per acre	-	12784

Source: Shah at al. 2003

Costs of Erosion Control Structures

The additional cost of controlling erosion was also estimated in relation to the slope of the lands. These costs were directly related to the slope of the leveled lands. The cost of structures built to control erosion was three time more on very steep lands than moderately steep lands (Table 5).

Table 5. Cost of erosion control structures at different slopes

	Very steep	Steep	Moderately steep	Cultivated sloppy
Structure cost (Rs)	4163	2203	3176	-
Area levelled (ac)	2.75	1.86	6.63	2.13
Cost per acre	1544	1152	480	-

Source: Shah at al, 2003

Incremental Land Value

The present value of the unleveled land during 2002/03 was about Rs. 29400, 38000 and 21160 per acre for gullied, plain and gravel land respectively (Table 6). While the land value of leveled lands was reported Rs. 110104 per acre for gullied as well as plain lands where as the value of gravel lands after leveling was Rs. 70000 per acre. At present prices incremental land value with bulldozer leveling was about Rs. 80704, 72104 and 48840 for gullied, plain and gravel lands tespectively. This two to three time increase in the value of the leveled lands induces farmers to make leveling decisions.

Table 6. Incremental land values at sample farms

Land type	Waste Land value	Leveled land	Incremental land value
	Value of land Rs. Per acre		
Gul lied	29400	110104	80704
Plain	38000	110104	72104
Gravel	21160	70000	48840

Source: Shah at al, 2003

Possibilities for future Adoption of Land Levelling

A Major change has occurred in the incremental value of land after reclamation with bulldozer levelling both with and without subsidy. As the levelling cases were from different years starting from 1955 to 2002 therefore cost and value of land was discounted for 1975 prices to eliminated the effect of inflation. The percentage increase in the value of land also varies with the type of uncultivated land levelled. The highest increase was obtained in gravel land both with subsidy (469%) and with out subsidy (421%) due to less cost and low prices of the land before levelling. In the case of gullied land, the cost of levelling was highest due to more time consumed while the value of plain uncultivated land was the highest. The value of gullied land increases upto 88% even without subsidy and for plain it increases upto 134%. The increase in land value is followed by the continuous benefits from crops to be grown on new reclaimed land. The results of the study as summarised in Table 7 depicts the clear possibility for adoption of land levelling in future. It is therefore concluded that land levelling has positive effects on agriculture land development of the Pothawar and significant impacts on the land value after land levelling.

Table 7. **Possibilities for future adoption of land leveling**

Land Types	Land Value before Levelling Rs/ac	Level Cost Rs/ac	Land Value with Levelling Rs/ac	Discounted Present Value Rs/ac	Incremental Percentage	Incremental at no Subsidy
Gullied	5336	1024	6360	12144	118.7	87.7
Plain	5592	320	5904	12952	147.6	134.0
Gravel	4296	224	4528	19208	468.6	420.6

Source: Shah at al, 2003

Farmers' Perception About the Yield at Newly Levelled Lands

In semi-arid areas of India private investments on irrigation resources were accompanied by land leveling and organic matter applications. On rainfed lands the land leveling successes are less dramatic, but evidence shows that private tree planting has grown steadily in recent years (Chambers et al 1994). In many cases, farmers invest in indigenous soil and water conservation measures independently of special project efforts (Kerr and Sanghi 1992).

Farmers were asked to provide estimates on production of different crops grown on newly leveled lands during the initial years. They were also asked whether the yield was low, high or normal during the initial years. Farmers' experiences are that about 79 percent farmers reported that in initial 4 to 5 years yield level of different crops is low and start increasing during the subsequent years. Asif (2003) has reported that land leveling gave significantly higher grain yields and save irrigation water than the unleveled land , however, few farmers indicated production at newly leveled lands was normal from the very beginning. But general consensus was that normal production level achieved after 8 years of leveling.

Farmers were asked to inform about the potential benefits *they* might have got in case if these lands would not have been leveled. All the sample farmers were of the view that these lands would have further deteriorated and could have costed much more to reclaim at later stages. The leveling might have been impossible in certain situations with further delays. Some other lands, which were less steep and gave low production would be eroded and after 2-3 years would have becothe unsuitable for cultivation.

Crops Grown During Initial Year

Less fertile patchy germination occurs on those parts of newly developed lands from where soil is removed. The lower exposed part of the field is less fertile but where soil is buried/spread over the field on low lying places give better yields. Due to loose and deep soil structure at these parts, rainwater could penetrate deep and hence provide better production due to high moisture conservation characteristics of these lands.

Crops like wheat, lentil, sorghum, millet, groundout, *tararneera*, and oat were grown during initial years at newly leveled lands. Most of these crops were used for fodder purposes. The grain yield on these lands during "low production" year ranged from 32 kgs to 323.2 kgs per acre. The yield ranges from 89.60 to 624 kgs per acre during normal production years. The yield of grain crops during high production years was estimated 528 to 1113.60 kgs per acre. Farmers those reported high yield during the initial years used to grow major crops like wheat, groundnut and sorghum. The crops grown on low yielding farms include minor crops like moth, ***tarameera*** beside area allocation to major crops (table 8).

Table 8. Crop grown during initial year at new leveled lands

Crops grown during initial years	Yield kgs/acre		
	Low	High	Normal
Wheat	323.20	1104.00	579.20
Lentil	320.00	-	-
Sorghum	172.80	528.00	352.00
Millet	96.00	-	480.00
Groundnut	272.00	640.00	624
Tarameera	51.20	-	89.60
Moth	32.00	-	-

Source: Shah at al, 2003

Net Returns form Crops at New Lands

The area allocation to different crops over the last two years was taken and average of these areas were used to find the general cropping pattern and allocation to different crops. The averages of last and current year yields were taken and extrapolated for long period. Individual crop budgets were prepared to estimate economic returns per unit area. Net returns per farm were estimated by multiplying average area allocation to different crops with respective individual enterprise returns.

Table 9. Area allocation and net returns from crops (2001-03)

Rabi Crops	Area (ac	% Area	Net returns (Rs/acre)	Net returns per farm
Wheat	1.75	47.5	1409 4	2466
Mustard	0	0.2		0
Lentil	0.13	3.4	6677	835
Tarameera	0.11	' 2.7	511	55
Oat	0.09	2.4	1200	105
Fallow area	1.57	43.7		
Average farm area	_ 3.60	100		3460
Returns per unit area during rabi (Rs/ac)				961.76
Kharif Crops				
Sorghum	0.87	24.5	1706	1492
Millet	0.10	3.0	1551	155
Sorghum+millet	0.12	3.5	1628	199
Maize	0.03	0.5	1849	54
Groundnut	0.39	11.0	8129	3186
Mash	0.04	1.0	194	7
Mung	0.002	0.0	1021	1
Fallow	2.03	56.5		0
Average farm area	3.59			5095
Returns per unit area during rabi (Rs/ac)				1418.87
Returns per unit area per year kharif (Rs/ac)				2381.36

Source: Shah at al, 2003

The net returns from wheat were Rs. 1409 per ac while it was Rs. 6677 per acre from lentil. Groundnut returns were highest as Rs. 8129 per acre. The net returns per acrel during Rabi season were Rs. 961.76 and kharif Rs. 1418.87. The returns per acre per year from the existing cropping pattern and crop rotation were about Rs. 2381.36 per acre. These returns per unit are could be used to estimates the returns to investment for land leveling by assuming static cropping systems on new or old lands (Table 9).

Payback Period on Land Levelling Investments

The average cost of leveling, along with other expenditures was estimated at Rs. 12784 per acre. The return from crops came out to be Rs. 2381.36 per acre per year. Without considering the benefits of incremental land value due to land reclamation the payback period of the leveling the net returns and total expenditures was estimated at about 5.3 years. These cost benefit analysis shows that the total leveling cost per acre could be recovered within almost 5 years of investment.

IV. CONCLUSION

It become evident from the discussion above that there is need for research in the barani (rainfed) areas of Pakistan to diagnose factors limiting productivity and to develop recommendations that can be adopted by farmers to improve productivity. Most important factors behind land degradation or low productivity are soil erosion, water shortage, and less efficient use of uncultivated lands. Land leveling options provide vertical as well horizontal increase in production. Government provides subsidies to the farmers who are interested to level their unleveled or uncultivated lands. Land leveling is a way to compensate from dwindling land resources availabilities with more than 90 percent of the rainfed farm households. The small farmers perform land leveling to sustain or manage basic needs.

Land Leveling is one option for putting uncultivated land into more productive uses. Land leveling decisions need to be made in consultation with the technical departments and considering different production packages compatible to the physical resource base and socioeconomic circumstances. Although it is very clear from the results of the study that leveling of uncultivated land is a profitable investment as the incremental land value was 3-5 times higher than the value of uncultivated lands, much higher than the cost of land reclamation. The payback period from crops was nearly 5 years yet the indiscriminate land leveling may be avoided. Before land leveling operations, the depth and nature of the soil required to be analyzed. If the sub-soil is rocky, stony and gravelly then the surface soil should not be disturbed. Natural vegetation such as grasses, forest or orchard trees need to be grown on such soils to prevent their erosion. Where sub-soil is good, land leveling could be undertaken followed by the required agricultural practices to maintain soil fertility and control soil erosion.

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