Drainage Basin Management

BY

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ABSTRACT

Three essential aims :

1. Preserve plant cover wherever in reasonable condition and ecologically stable ; where cover already deteriorated or naturally inefficient, runoff control needs engineering devices (contouring to aid afforestation, check dams in gullies, complete terracing of ploughland).

2. Deal with the whole of each small catchment as a unit. Sounds obvious but often prevented by administrative difficulties, e.g., smallness of individual holdings interferes with contouring ; consolidation of holdings is lengthy legal routine ; government averse to coerce unwilling owners ; common land is nobody's business : common grazing rights hinder herd reduction ; allotment of funds often cut in emergency ; co-operative organization for improving waste land produces " pepper-pot " scattering of effort ; land revenue (tax) department averse to changes in field boundaries.

3. Control the water and the soil will look after itself.

I shall try to show in this paper how local experience in extreme climates and amongst primitive people may possibly be applied to the more equable climates and more advanced types of farming, particularly by comparing the relative efficiency of soil-moving machinery as compared with the indigenous methods of digging and moving soil.

PRESERVING AND IMPROVING PLANT COVER FOR WATER CONTROL

Under this heading the main activities must obviously fall into two groups (*a*) afforestation and grazing control on the one hand, and (*b*) the water use in plough land on the other. In some topographies it may be feasible to separate these completely so that the forester and the cultivator can each be left to do his own work without interfering with the others but Punjab experience tends to show that in our badly gullied uplands the fringe of down-at-heel lands which has passed, or is passing, out of cultivation makes a most intricate pattern around the head of each small catchment and that once land has reached a badly gullied condition with steep flanks sloping into the local main water channel, economical reclamation is essentially a job for a team. The forester or the farmer alone is equally helpless.

METHOD OF RECLAMATION

Experience has shown that the most profitable way to use Caterpillar bulldozers is to combine them with hand labour. If each cultivator who owns land in a narrow gully or nala bed builds a stout masonry dam, the machines can be used subsequently to build up wing walls and raise the height of the structure, thus giving a bigger field behind and quicker silting and levelling. This type of work will give land of higher crop value than the terracing of the more level plateau land. The forest department is already making subsidies to individual owners towards approved masonry bund projects. Some 15,000 acres of nala-bottom cultivation have been reclaimed by means of masonry bunds, and this reclamation has cost Rs. 80 to 150 per acre. Such nala-bottom dams can only be made safe and permanent if the whole of the catchment above the dam has been brought under a flood control regime, the ploughland being fully terraced and the uncultivated land either afforested or under strict grazing control so that grass lands are kept fully absorptive.

COST OF MACHINE WORKING PER HOUR

All costing figures are based upon (*a*) actuals—consisting of all running expenses plus operator's pay, (*b*) overhead expenses which include writing-off the costs of the machine over 10,000 hours, plus ½ that figure for major repairs, plus interest on capital investment at 4 per cent. For machines at present available all-in costs of D-7 are Rs. 17 per hour and for a D-4 Rs. 9 per hour, and the working charges account for roughly half of each. These figures correspond closely with Caterpillar Company's own published data, which for Punjab conditions are : cost per hour, in rupees (Rs. 13 to £1, or roughly 3 rupees per dollar) :

	D 8	*D 7*	*D 6*	*D 4*	*D 2*
Actual running costs ..	9·22	6·90	6·11	4·74	4·40
Overheads	11·11	8·29	6·25	4·15	3·24
Total ..	20·33	15·19	12·36	8·89	7·64

CASH RECOVERIES

D-7s have only recently become available and the recovery in their case at present is a flat rate of Rs. 14 per hour in cash from the owner of the land. This is very nearly the full cost including interest and depreciation for the D-7 when working alone, though the introduction of a scraper attachment costing Rs. 23,000 pushes up the total to somewhere around Rs. 17 by increasing depreciation and interest charges. Although this Rs. 14 charge puts this machine beyond the reach of the poorer classes of owner, this type of work is exceedingly popular and a very large waiting list of applicants for the use of these machines exists in all districts where the machines have worked.

MACHINE COSTINGS ON AN ACREAGE BASIS

There are so many factors affecting the cost per acre that it is dangerous to give a firm estimate for a given area until some work has been done for these or identical conditions. The main factors affecting cost per acre are :

(1) slope ; see below ;

(2) hardness or toughness of ground surface ;

(3) proximity of rock strata, pebble beds or red marl beds ;

(4) experience of operators, the cost coming down steadily with practice ;

(5) size of individual fields, very small fields being a nuisance for any machine but being worst for the larger machines which have not room to manoeuvre, or if they can do so, they waste fuel in frequent stops and gear changes ;

(6) for nala-bottom reclamation the cost of the bund has to be offset against the acreage of the silted bed behind the bund.

EFFECT OF SLOPE ON COSTS

Over a period of 6 months' work in the deeply gullied plateau lands of the Ojhri Catchment near Rawalpindi, the following data were produced with a D-4 pulling a 5-tine scraper :—

Slope class	*Cost per acre*		
	2nd 3 months	*3rd 3 months*	*Round figure average*
Per cent.			
0–2	102	88	90
2–4	108	102	105
4–6	174	121	150
6–8	192	205	200
Over 8	264	251	250

This shows clearly that costs rise steeply as a function of the slope and above 8 per cent. the cost mounts so quickly that it soon becomes uneconomic to terrace for fields. Somewhere around 8 per cent., therefore, is the margin between reclaiming for fields and for afforestation. Steeper slopes can however be profitably worked by machines to produce a contour ditch and ridge or *gradoni* (Italian for shelf or platform) on which tree or coconut planting or grass cultivation will still pay a good profit through the quicker and better growth which will result as compared with planting on an unimproved slope. (An 8% slope is 1 in 12 or 4 degrees, 34 minutes.)

RECLAMATION AS AN INVESTMENT

To define the position for agricultural land, the above gives a clear indication of the cost for plateau land completely levelled between field boundaries. Unimproved land of this type near Rawalpindi can be purchased for 600 to 800 rupees an acre, so allowing a further Rs. 150 per acre for terracing, and with wheat at its present price, the whole cost can be recovered in the first four wheat harvests.

In the case of more ambitious nala-bottom bunds, which are now becoming so popular with the larger Attock and Mianwali landlords, it pays to build big soil-saving bunds with donkeys and head-loads, so it must obviously pay even better with bull dozers which can do this work cheaper and quicker and can extend the crop area by filling up the torrent bed and breaking down hillocks in the reclaimed area. The cost of such reclamation works out at from 80 to 150 rupees per reclaimed acre.

THE PRINCIPLE OF THE CATCHMENT AS A UNIT

In our anxiety to recover as much as possible of the costs for government it is very easy to be sidetracked away from the principle of the catchment. No matter how successful or popular our land reclamation is proving, it will fail if we do not insist upon each unit catchment being dealt with as completely and as comprehensively as possible for water conservation and flood control. This is the only justification for our thrusting into the reclamation of agricultural land. The endless and ragged fringe of bad cultivation retreating before each advancing gully-head has got to be mastered and it can only be made safe and profitable by adopting every possible type of land use and adapting our machine attack towards easy afforestation, fodder production, village tanks and ponds as well as plough land.

FURTHER DEVELOPMENT

The disadvantage of applying any hard and fast rule for recovery of costs is that it precludes us from attempting further experimental work. The building of dams in broad shallow nalas and the terracing of fields on the easier slopes are safely past the experimental stage and we have a long waiting list of applicants clamouring for the use of our machines on such land. But a great deal of pioneering and experiment still remains to be done on the partial terracing of steeper land for afforestation and on the type of earth dams and masonry escape needed to store floods in the deeper and narrower nalas. To insist upon a cent per cent return of government's investment would, therefore, be a serious mistake. We must be allowed freedom to experiment as and when required in order to make as complete a job as possible of each catchment.

OTHER ADMINISTRATIVE DIFFICULTIES IN APPLYING SOIL CONSERVATION PRINCIPLES

Many other difficulties have arisen in the course of Punjab work and some of them should be of general significance even in more fully developed countries, so short notes are given on the following points :—

(*a*) the smallness of individual holdings and the continued fractionizing due to laws of succession to property interfere with any attempt at scientific contouring through rendering the shape and size of each field awkward for terracing and even in extreme cases too small for the use of a plough.

(*b*) one answer is in the consolidation of holdings but this is a lengthy legal routine which takes some years to make operative through a separate branch of the civil administration which deals with it. The consolidation of scattered shares into one holding and the stopping of further fractionization are essential if field boundaries are ever to be brought under modern concepts of run-off control, but in the meanwhile much work is being done on the contour ridging of fields on the existing and often unsatisfactory boundaries.

(*c*) the land revenue authorities are responsible for the records of individual field boundaries and in India and Pakistan the main work of the revenue *patwari* is to record all changes in ownership. His record of field boundaries is an elaborate affair and he holds the whole village economy in his hand ; so he is a power in the land. He does not welcome any proposals which are likely to upset his precious record and so the whole moral force of the revenue subordinates is against any idea of contouring or revision of boundaries. (In Ceylon the revenue records of fields are fragmentary, but there is a general opposition by the owners to any alteration in boundaries.)

(*d*) most governments are averse to using any force or coercion in order to persuade unwilling owners, even when the number of objectors is small. In some cases one may even find that sound legislative measures have been passed and could be applied but local action is withheld because it will be too unpopular. The answer is of course in basic education because an informed public opinion will do more than anything else to coerce the objectors, once the *bona fides* of government and the soundness of the local proposals have been accepted. With primitive populations some form of regimentation is desirable because if the average landowner or tenant is illiterate and ignorant he cannot be expected to know what is really best for his own interest and those of his community. In the case of the contouring of fields the average peasant proprietor knows what water conservation is needed to grow his crops for his peculiar climate, but few indeed have any realization of the harm done by overgrazing and overfelling. The gradualness of deterioration which brings desiccation and gullying as its ultimate end cannot be understood by the countryman whose memory is seldom accurate. Any sort of co-ordination of effort therefore comes easier for ploughland than for waste or grazing land, and so we often find our downstream reclamation for cultivation out-distancing the control of the partially cultivated uplands, which ought of course to come first in priority.

(*e*) common-land is nobody's business. The commons in almost every country are in poorer condition than they ought to be in terms of their natural ecological climax type of vegetation. In India early revenue settlements insisted upon 25 per cent. of the village land being left unploughed in order to guarantee the poor men's grazing rights on the common land, but generally speaking the more grazing provided, the worse are the livestock raised on it, for the less attention is paid to the quality of the stock and breeding control. The districts that have practically no common grazing produce the best plough cattle and milk buffaloes, because every animal is stall-fed and no surplus animals are tolerated. The answer is obviously to organize the remaining common-land so that it becomes some individual's responsibility. This can best be done by forming a co-operative society which can act as if it were a single owner for the common and put it to the best use, either for plough land, rotational grazing, the growing of fuel trees, timber, fruit or fodder-grass, or for water-catching, or all of these combined.

(*f*) the allocation of funds by government to their subordinate departments recalls the Biblical story of the servants' talents, for in times of shortage the revenue-producing activities obviously must be kept going whereas the beneficent activities are the first to be closed down. The best guarantee against this is a periodic plan, for which 5 years is as good a period as any. Once a government has committed itself to supporting such a plan for the development of beneficent activities, it is always a little harder for it to jettison the work. Such a plan also is an essential in the calculation of recruitments and the various grades of technical staff, and the higher the standard of training, as in the officers and rangers' grades, the longer it takes to produce the trained bodies.

(*g*) the voluntary principle for the organization of co-operative societies is an excellent one and should have government's full support in terms of loans on a low interest and an inspection staff to ensure proper organization of each society and the conduct of its business and records. The tendency, however, is for the departmental cadre of inspectors to feel that they can tackle any technical problems themselves rather than call in the appropriate technical department to deal with afforestation, animal husbandry, flood control, public health, or what have you. Another snag is the wide scattering of effort. When a society can be formed on an application of a majority of owners in one village, the tendency is for societies to

spring up as if scattered from a pepper pot. This may suit the co-operative inspectors who like to travel but is the antithesis of what we need in flood control in organizing the whole of one catchment.

(*h*) the natural ability of the cultivator in building his terraced fields is inversely proportional to the average rainfall. Where the rainfall is 8–15 inches, the standard of terracing is exceedingly high because it is only by trapping all of the rain that a wheat crop can be ripened. Where nature is more bountiful the standard is definitely poorer, and it is only in the 20 to 25 inches belt and over that draining off excess moisture becomes a serious problem and elaborate field drainage systems have to be worked out.