FARM LAND SHAPING FOR IRRIGATION

Kisan Laxman Bidkar [1]*Professor, Civil Engg Dept ,SNJB's Late Sau Kantabai Bhavarlalji Jain College of Engineering Chandwad Dist ,NASHIK 423101*

Prasad R. Baviskar[2], *Professor, Mechanical Engg Dept ,SNJB's Late Sau Kantabai Bhavarlalji Jain College of Engineering Chandwad Dist ,NASHIK 423101*

Rajendra C. Patil [3] *Associate Professor, Mechanical Engg Dept ,SNJB's Late Sau Kantabai Bhavarlalji Jain College of Engineering Chandwad Dist ,NASHIK 423101*

Vishal B Shinde [4]*Assistant Professor , KKEIEE&R,Nashik*

ABSTRACT : The mainly practical and environmentally way of creating irrigation assets in the coastal area is through harvesting of excess rain water that goes waste as runoff into the sea. It can be done effectively through suitable shaping of the farm land, which involves in modifying the surface of the farm land for harvesting of excess rain water as well as making the land surface suitably shaped for adoption of improved cultivation of diversified crops. The most important intention of these land shaping is for creating irrigation resources through harvesting excess rain water, diversification and multiple crop cultivation encompassing the year Employing innovative land management practices will not only serve the land degradation concerns but also enable to harvest rainwater and diversification of agriculture. A comprehensive study conducted on fertility indicated that the cutting in slope group of 1.5 to 3 % reduced nitrogen content appreciably. It is also seen that in the first two years removal of surface soil created a problem in zinc deficiency. It is therefore, necessary to augment fertility with a higher dose to tune of 1.25 times greater than usual dose.

***KEY WORDS**: Land shaping, land grading, Cropping Pattern, depth of cut-fill, Water Retention Capacity of Soil*

1.0 INTRODUCTION

Most of the natural lands, barring few exceptions, have uneven surfaces having grades in different directions. If water application is made to this land, it travels to the low-lying areas easily, by passing the high spots. The distribution is not therefore even resulting in pondage of water depressions and dry areas on elevated portion. It also means interruption of drainage on one hand and acceleration of soil erosion on the other. [1] The other effects are the non-uniformity of crop growth difficulties in farming operations.

The nitrogen loss increases as slope and rainfall intensities increase. This is based on the assumptions that when slope and rainfall intensities rise, runoff and sediment production rise, nitrogen loss rises, and runoff are the primary mechanism for nitrogen loss. In the rainy and warm seasons, a lower slope enhanced the availability of soil nutrients like accessible nitrogen, phosphate, and potassium. Plant diversity and AMF colonization were impacted by slope position. In particular, lower and medium slopes have more plant diversity than top slopes.

Soil nutrient loss not only reduces soil productivity but also causes non-point source pollution and accelerates the eutrophication of surface water. [2]

https://doi.org/10.5281/zenodo.14584125

Land shaping is required to be done to overcome these hazards. It is an asset in dry farming and almost a prerequisite for modern irrigated farming.

Land shaping is also known as land farming means reconstruction of land surface to a plane surface either level or with a predetermined grades longitudinal and cross slope. The terms land shaping, land leveling, land grading, land smoothening are many a times used synonymously, though each term has a specific meaning.[3]

2.0 OBJECTIVES OF LAND SHAPING

The basic objective is to enable the farmer to have a better control on distribution and application of available water over his field. It helps farmers in

-The uniform distribution of water over the field.

-Economic use of water

-Draining of excess water, either from rains or from excess irrigation without damage to the crops or soils.[4]

-uniform distribution of fertilizers along with irrigation water if necessary. [5]

-Increasing the yields and quality of crops incidentally

-Bringing some un-commanded portion under irrigation by moving soil to the lower elevations.[6]

- Effective saving of labors in all farming operations.

3.0 DATA COLLECTION

3.1 Soil Depth: It is necessary to ensure during planning that the soil strata remaining after the land shaping is adequate and suitable for crop cultivation. The trial pits shall be at the four corners of the field and one at the center, to cause minimum disturbance. The samples from each 50 cm depth should be collected.

3.2 Nature of Soil: For land shaping purposes it is enough to know the textural classification of the soil. It should be done for each 50 cm depth of soil. The classification is usually done by the mechanical analysis of the soil sample or it can be done by field method. [7]

3.3: Soil Texture: It refers to the relative proportion and the carious size below 2 mm in dia. The widely used distribution systems are

(a)International Soil Science Society (ISSS)

(b) U.S. Department of Agriculture (USDA)

Here ISSS Method is used and the soil texture is given in table 1

Sr. No.	**Soil Separate Range(mm)**	**Diameter Range (mm)**
1	Coarse Sand	2.0-0.20
2	Fine Sand	0.2-0.02
3	Silt	0.02-0.002
4	Clay	Less than 0.002

 https://doi.org/10.5281/zenodo.14584125

4.0 DESIGN CONSIDERATIONS FOR LAND SHAPING

4.1 Soil Profile: For good cultivation, about 1.0 m of soil depth is desirable. If the depth of soil strata is limited, this limits the depth of cut of soil that can be removed. For these cases, contour benching or terracing is practiced, and grading is done within the benches or terraces. The depth of cutting is limited so that after shaping, enough soil layer is left in position. The soil texture along with the irrigation methods to be used, is usually govern the maximum gradients.[8][9]

4.2 Minimum Soil Cover: The soil cover should satisfy

(a) It should be able to accommodate the root system of the contemplated crop

(b) It should be able to hold the irrigation water supplied for the rotation

4.3 Root Zone Depth: It varies according to crops, which is tabulated in table 2

Table 1: Root Zone Depths of Different Crops

Sr. No	Name of Crop	Root Zone Depth in cm
1	Cotton, Grapes, Maize, Wheat, Sunflower	100 to 120
2	Banana, Groundnut, Gram, Beet	50 to 100
3	Potato, Leafy Vegetables, Onion, Cabbages	25 to 50

For commonly grown crops in Maharashtra, the root zone depth is about 1m. It would appear that the minimum soil cover should be 1m. Figure 1 shows the moisture extraction pattern of the crops. This shows that about 70% of the moisture used in extracted from 50 % of the root zone depth and 90% is extracted from 75% of the root zone depth. From above it can be concluded that the maximum necessary soil cover is 100cm, desirable 70cm and the minimum necessary is 50cm.

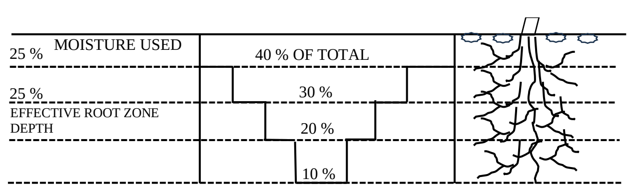


Figure 1: Moisture Extraction Pattern in Root Zone

4.4 Water Retention Capacity of Soil: The second consideration for the minimum soil cover will be water retention capacity of the soil. The minimum soil cover should be able to hold the irrigation water

 https://doi.org/10.5281/zenodo.14584125

necessary during the rotation period. Table 3 gives the depth of soil required to hold 160 mm of water. For all soils except loamy sand, silt and sand the desired soil cover after land shaping may be 75cm, while the minimum soil cover shall not be less than 50cm. In Maharashtra state most of the soil are covered by the above 9 groups. The soils under classification of loamy sand, silt and sand are rarely encountered are not very suitable for irrigation purpose.

Table 2: Values of Available Water Capacity for Different Soil Texture Classes and Soil Depth required to hold 160 mm of Water

Sr.No	Soil Class	Awc In Mm/M Depth	Depth of Soil Cover Required in Cm
1	Clay	190	84
2	Silt Clay	210	75
3	Sandy Clay	180	88
4	Clay Loam	220	73
5	Silt Clay Loam	240	67
6	Sandy Clay Loam	200	80
7	Loam	200	80
8	Silty Loam	235	68
9	Sandy Loam	85	86
10	Loamy Sand	120	130
11	Silt	80	200
12	Sand	60	270

4.5 Irrigation Method Adopted: The irrigation method likely to be used has a great influence on land shaping. Basin irrigation, border irrigation, furrow irrigation are the different gravity methods of irrigation. Each method has its own demands on planning for land shaping. Hence the nature, adaptability and limitations of each method are very important.

4.6 Natural Topography of the Land: The final requirement of the land shaping is to have a uniform acceptable grade in the direction of irrigation and a minimum (or nil in case of basin) slope in the cross direction. As a general rule, the irrigation would be preferable along the gentler slope and the compartments along the steeper slope.

https://doi.org/10.5281/zenodo.14584125

4.7 Cropping Pattern: The land shaping must be suitable for the irrigation method to be adopted in the particular piece of land. This in turn depends upon the crops likely to be grown, the value of the crops and cropping intensity e.g., for paddy, vegetables of orchards basin irrigation is necessary and the investment required for zero slope land shaping can be investment. Most of the land, where no specific crop is contemplated, can be shaped to the requirement of border irrigation which is the most popular method in Maharashtra state.

4.8 Climate and Rainfall Pattern: In the regions of high rainfall intensity maximum non-erodable gradient should be provided. The gradient can be gentler as the maximum intensity of rainfall decreases.

4.9 Un-commanded Patches: The patches near the turnout are sometimes un-commanded by the water level in the field channel. Special attention may be paid to see if these patches can be brought under command by having some extra excavations in these patches.

4.10 Maximum Cut: It can be decided by

(a) The depth of soil (b) Nature of soil (c) Economy in the movement of earth

5 LAND SHAPING DESIGN [3], [4]

Methods: (a) Plane or centroid method (b) Profile method (c) Plane inspection method (d)Contour adjustment method

5.1 Topographical Survey: Land shaping (Figure 4) is to be planned in consonance with the overall layout of the chak alignment and levels of the field channels and field drains. From the contour map for the chak, the individual land holding for which land shaping is separated out and blown up if necessary. It is convenient to take scale of 1:1000 for the map. The position of the water source i.e. the turnout is marked on this map along with the bed level of the turnout and water depth. The irrigation direction and the alignments of field drains are also indicated on this map. [9]

The actual survey to be carried out, in addition to the above map consists of grid leveling of the holding on a 10m*10m grid. The benchmark uses for chak survey should be used for this leveling. This grid map shall be to the scale of 1:500. The ground levels are marked in the left-hand bottom space at each point as indicated.

Formation level	Fill
Ground level	Cut

5.2Execution of Land Grading Work:

The field procedure adopted during execution of land grading work [10]

1)Locate the compartment and verify its dimension.

2)Transfer alignment of null line from the compartment sheet to the field by line marking or burrowing.

 https://doi.org/10.5281/zenodo.14584125

3)Fix wooden pegs (5cm*5cm*100cm) at each grid points of the compartment.

4) Find out maximum depth of cut for compartment and prepare one reference stick of a length little longer than the maximum depth of cut e.g. if maximum depth of cut in a given compartment is 24 cm, prepare reference stick of say 30cm.

5)To fix the depth of cut at the cut grid point, deduct the depth of cut at the given grid point from the reference stick height and tie a red ribbon at the resultant height. If the depth of cut is 14 cm, then measure 16cm up (30cm-14cm) from the ground level and tie red ribbon at that point of peg. (Figure 2 and 3)

6)At null point the height of the red ribbon will be equal to the height of the reference stick i.e. in this case it is 30cm.

7)To fix the height of fill at the fill grid point is quite simple, simply measure the height of fill from the ground level and tie a blue ribbon at that level.

8)When using machine for land grading works, start cutting in layers in between two grid pegs and carry the excavated soil stuff towards null line. To check the adequacy of depth of cut at each cut peg and also the desired grade in between pegs, tie a nylon rope along the cut peg at the ribbon height and try to move vertically the reference stick between the rope and the formation level (Figure 5.2).The cutting should be continued till the reference stick fits exactly at any point between the rope and the finished ground profile. By this method, it is possible to control grades in both, cross and irrigation direction when execution work still going on. Thus, irregularities if any can be corrected at the site itself.

9)The cut soil can conveniently and rather quickly be spread by using wheel tractor.

10)In case of fill pegs, the excavated soil should be filled up to the ribbon heights. Here to the desired ground profile between two fill pegs can be achieved by simply teeing a nylon rope at the ribbon height along the fill pegs. (tie one end of the rope at the bottom of the null point peg and another end at the last fill peg.) And see that the full plane of formation touches the rope. This will be achieved only when the soil is filled to the desired formation level in the fill zone.

11)Care should be taken not to disturb the grid point pegs till the major land grading operation is completed.

12) Compartment bund of the desired cross section (0.18 m2 of 0.45 m^2) is also prepared by using the cut soil staff. The provision of the extra soil needed for bund construction should be already made available during the design of the compartment itself.

13)Pegs should be removed and land smoothening should be subsequently carried out to remove mounds around the pegs and other irregular surface relief created by machine movements or labour during major match-line operation. Use either bullock drawn or tractor drawn float /leveler for smoothening purpose.

The above procedure can be explained by the following example;

 https://doi.org/10.5281/zenodo.14584125

Data given

1) Soil: Medium Textured
2) Cut/Fill ratio: 1.1 to 1.25
3) Crops to be grown: Wheat, Sugarcane, Cotton, Groundnut
4) Soil Depth: 0.6m
5) Water Source: Canal water with discharge 30 lps
6) Method of irrigation: Border and furrow

Steps

I Locate the field in the chak plan (Figure 5). Fix the turnout position and the field channel alignment.

II Determine the land slope along the field channel/ equalizer and slope perpendicular to the field channel (Figure 6)

Average elevation at the centroid = 8.27m

Compartment Number 1(Area =0.27 ha=2700 m^2)

First trial Cut/Fill= 77/78=0.987

Lower the plane at the centroid by 1cm

Cut/fill= (77+6)/(78-6)= 83/72= 1.15

Cut/fill ratio on volumetric basis Average depth of cutting =83/6= 0.138

Average depth of filling =72/6=0.12

Cutting area = 57*25= 1425m^2

Filling area= 51*25=1275m^2

Cut of ratio Volume of cutting / volume of filling

= (1425*0.138)/ (1275* 0,12) = 1.28

I Fix the direction of irrigation and fix the alignment of equalizer

II Sub-divide the field using the criterion under consideration

III Consider sub-field compartment as an independent field for the purpose of land leveling and determine the centroid of the field.

IV Add all the elevations and divide the sum by number of elevations in the field

Design elevation at the centroid = All elevation / Number of elevation in the field =99.24 /12=8.27m

Calculate the designed elevation at each grid point according to the slope designed for irrigation and the cross slope.

Elevation difference per m length

Opposite the direction of irrigation = (0.4/100) *100=0.4cm

Add 0.4cm for each m length if we run opposite the irrigation slope

For 15 m the elevation difference =15*0.4=6.0 cm

The designated elevation at centroid =8.27m

If we run perpendicular to the irrigation slope, the designed cross slope should be used for determining the elevation. Add 0.2 cm for each m length if we run opposite the cross slope. For 15m the elevation at the grid points is calculated.

 https://doi.org/10.5281/zenodo.14584125

I The elevation difference between the designed and the ground elevation will give the depth of cutting or filling. Designed elevation – Ground elevation= Cutting or filling If the elevation difference in the above equation is negative then it is cutting depth.

I Calculate the cut fill ratios Cut/Fill=77/78=0.987<1.15

If this is within the specified limit, then it is ok., otherwise, raise or lower the plane at the centroid to achieve the designed cut/ fill ratio. The ratio is not within the limit. Therefore, lower the plane by 1cm

Cut=73

Fill=72

c/f=83/72=1.15 which lies in between 1.1 to 1.25

II Correct the designed elevations accordingly. Draw the zero cut-fill contour and calculate

Volume of cutting/ Volume of filling = cut/fill ratio

Volume of cutting = Cutting area * average depth of cutting

Volume of filling = Filling area * average depth of filling

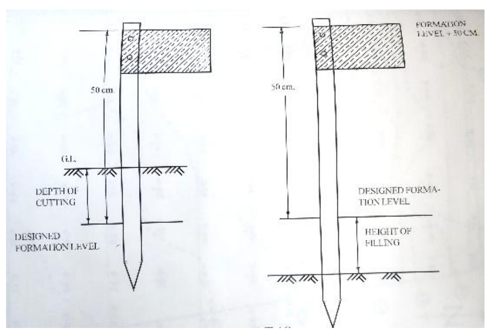


Figure 2: Typical Stake and Flag

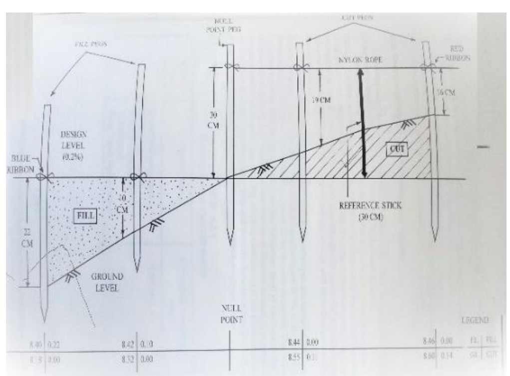


Figure 3: Fixing Depth of Cut and Height of Fill by Tieing Ribbons Using Reference Stick Method

https://doi.org/10.5281/zenodo.14584125

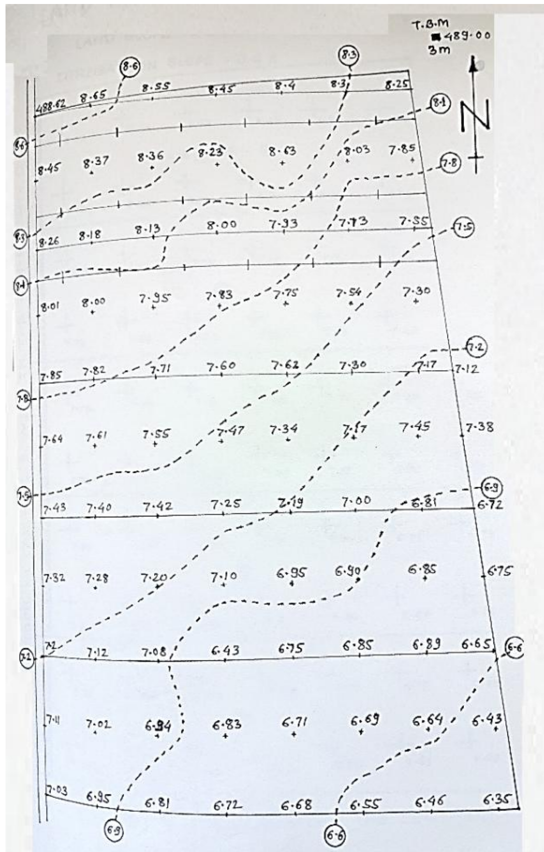
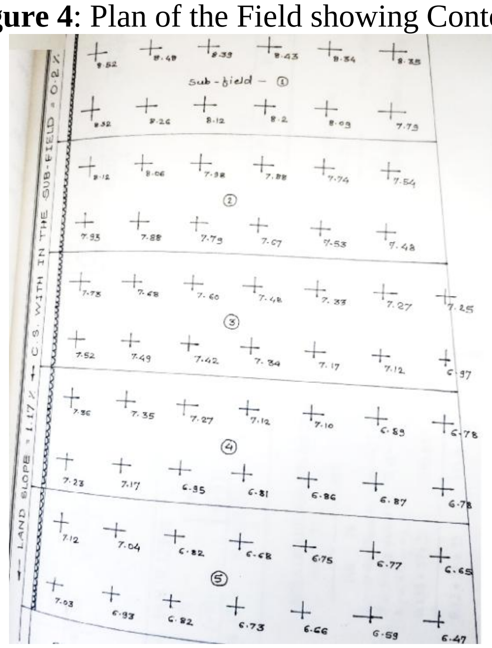


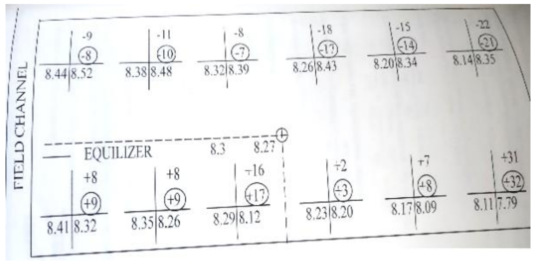
Figure 4: Plan of the Field showing Contours



Land Slope = 0.54 %, Irrigation Slope = 0.4 %

Figure 5: Plan of the Field Showing the Central Elevation of the Grids

https://doi.org/10.5281/zenodo.14584125



Design cross slope 0.2 %, Design Irrigation Slope = 0.4 %

Figure 6: Determination of cut-fill ratio

Area of the sub-field 0.27 ha =2700m^2

Cut/Fill=77/78=0.987

Lower the plane by 1 cm =-77-6=-83

The filling would be: 78-6=72

c/f=83/72=1.15

(0.138*57*25)/ (0.12*51*25)=196.65/153.0=1.28

6.0 Conclusion and Remarks:

The present study took slope length, vegetation cover as variable factors, and investigated the mechanism of these factors affected runoff volume, sediments yield and Nitrogen loss, phosphorous loss.

A comprehensive study conducted on fertility indicated that the cutting in slope group of 1.5 to 3 % reduced nitrogen content appreciably, there being not so much changes in phosphorous. It is also seen that in the first two years removal of surface soil created a problem in zinc deficiency. It is therefore, necessary to augment fertility with a higher dose to tune of 1.25 times greater than usual dose. Experiments on wheat, gram as influenced by cutting and filling indicated that the yields of these crops decreased in cut portion as compared to fill area.

References

1) *S. S. S. National Engineering Handbook*, section 15 : Chapter 12, Land Leveling, United States soil Conservation Service, Washington [D. C.] U. S. A.
2) *The effect of Slope Length and Coverage Ratio on Nitrogen and Phosphorus Loss in Red Soil Regions of Southern China* ,Quin Jing ,Zhang Liping , E3S WEB OF Conferences 136,07028(2019)
3) *Manual of Design for On-farm Development Works, Irrigation Department, Govt. of Maharashtra, Bombay*, October.
4) *Specification, Cost Norms and type Design of O. F. D. Works*, Maharashtra Land Development Corporation, Pune.
5) *Design and Operation of Farm Irrigation System*, Editor: M. E. Jensen. ASAE Mono graph No. 3
6) *Small Hydraulic Structures*. D. B. Kraatz and I. K. Mahajan, Irrigation and Drainage Paper No 26/1 and 26/11, FAO, Rome.
7) *Manual on irrigation Water Management*, Ministry of Agriculture, Govt. of India, New Delhi.
8) *Manual on Irrigation Works in Maharashtra State*, Irrigation Department. Govt. of Maharashtra, Bombay.
9) *Diagnostic Analysis of Irrigation system*. Vol. I & 2, Editors : C. A. Podmore and D. G. Eynon, Water Management Synthesis Project, Colorado State University, Fort Collins, Colorado, U. S. A., October.
10) *Lecture Notes of Professors of WALMI*, Aurangabad.

 https://doi.org/10.5281/zenodo.14584125