PLANNING OF AN AGRICULTURAL MICRO WATERSHED WITH SPECIAL REFERENCE TO SOIL AND WATER CONSERVATION - A CASE STUDY

THESIS

Submitted to the
Punjabrao Krishi Vidyapeeth, Akola
in partial fulfilment of the requirements
for the Degree of

MASTER OF TECHNOLOGY

IN

AGRICULTURAL ENGINEERING

(SOIL AND WATER CONSERVATION ENGINEERING)

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1987

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the thesis entitled "PLANNING OF AN AGRICULTURAL MICROWATERSHED WITH SPECIAL REFERENCE TO SOIL AND WATER CONSERVATION - A CASE STUDY or part thereof has not been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis/publication of any University or Scientific Organisation. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

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CERTIFICATE

This is to certify that the thesis entitled "PLANNING OF AN AGRICULTURAL MICROWATERSHED WITH SPECIAL REFERENCE TO SOIL AND WATER CONSERVATION- A CASE STUDY submitted in partial fulfilment of the requirements for the degree of Master of Technology in Agricultural Engineering of the Punjabrao Krishi Vidyapeeth,Akola is a record of bonafide research work carried out by Shri Prabhu Lalji Narnaware under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

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ACKNOWLEDGEMENT

The author deems it to be his proud privilege to express his deep sence of gratitudes to his project supervisor Mr. V.B. Dalvi,Associate Professor,Department of Soil and Water Management, P.K.V., Akola for his valuable guidance, constant encouragement and timely suggestions throughout the course of study.

The author is deeply indepted to Dr. B.B.Bhombe, Associate Dean,Post Graduate Institute, Dr.M.N.Pawade, Head,Department of Soil and Water Management and Dr.G.M. Bharad, Professor of Agronomy,Rainfed Farming Project, P.K.V.,Akola for giving freedom of work, encouragement, timely suggestions and providing all facilities for project work.

Thanks are also due to Prof. M.B. Patil,Associate Director of Research, P.K.V.,Akola and Mr.G.U.Satpute, Assistant Professor,College of Agricultural Engineering and Technology, P.K.V.,Akola for their guidance throughout the work.

Author is grateful to Dr.R.M.Bhake,Associate Professor of Agricultural Chemistry and Soil Science, Dry Land Research Project,P.K.V.,Akola for his help in analysis of soil samples and study of profiles.

Special thanks are due to All Staff of Sub-Divisional Soil Conservation Department,Manoli Project, Mangarulpir and Mr.V.S.Patil,Senior Research Assistant,

Meteorological Observatory , P.K.V., Akola for providing necessary data and their encouraging help.

Help rendered in designing of various soil and Water conservation structures by Mr.Mahendra B.Nagdeve, Assistant Professor of Agricultural Engineering,Rainfed Farming Project, Mangarulpir is also gratefully acknowledged.

Author like to remain obliged to his wife, Smruti for her devotion and constant encouragement throughout the studies.

Last but not the least, author acknowledge the con-tribution for all individuals, who have inspired and advised added in different ways during this study.

AKOLA

Dated 18 th December,1987 (PRABHU LALJI NARNAWARE)

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LIST OF ABBREVIATIONS

Agril.	Agricultural
ASAE	American Society of Agricultural Engineers
ASCE	American society of Civil Engineers
Bull.	Bulletin
Cumec	Cubic meter per second
Deptt.	Department
Dn.	Division
ed.	Edition
Engg.	Engineering
et al.	and elsewhere
FAO	Food and Agriculture Organisation
Fig.	Figure
ha.	hectare
hr.	hour
IBH	Indian Book House publishing company
ISAE	Indian Society of Agricultural Engineers
J	Journal
MAU	Maharashtra Agricultural Universities
met.	Meteorological
min.	minute
Proc.	Proceeding
q	quintal
U.N.	United Nation
UNGS	United Nation's Geological Survey
viz.	Namely
vol.	volume.

CHAPTER I

INTRODUCTION

Watershed development is an investment activity in which financial resources are expended to create capital assets those produce benefits over an extended period of time. Watershed planning is a means of making decisions concerning future action. It is an effort that places a high value on retionality and utilization of knowledge. It is a means of achieving social good realizing public interest.

For planning and execution of soil and water conservation works, the watershed is a recognised unit. An agricultural micro-watershed is a small independent hydrologic unit having an area less than 400 hectares and land use in it is predominently for agricultural purposes. The catchment area of any river runs in thousands of square kilometre. It is, therefore, desirable to limit the area of operation so as to achieve the objective within the shortest possible period and with lesser amount of technical personnel available at hand. Therefore, for proper utilization of nation's material resources and man-power to the best advantage, planning for soil and water conservation work on micro-watershed basis is essential.

Soil and water constitute the physical basis of agriculture. Soil is the keystone of our economic structure and wealth, prosperity, freedom and welfare of humanity are entirely based upon this irreplaceable resource. The top soil is the most vital part of the soil lying to an average depth usually 20-25 cm over the underlying ground or rock. This upper layer of the soil is the principal feeding zone of the plants. Under many circumstances, unfortunately, it is one of the most unstable of all major natural resources.

The erosion is the biggest problem. Not only millions of hectares are declining in productivity but also, the loss of soil and water is causing a serious hazard to dams, reservoirs and many public works. There is another aspect of erosion which has been least understood but has acquired greatest importance in recent years, is the pollution hazard. Besides the loss of soil and water, the loss of nutrients particularly nitrate, phosphate, potassium from the soil is enormous. Even the most conservative estimates show that loss of nutrients through erosion is many times larger than all the fertilizers and manures manufactured in our country. It has been estimated that 6000 million tonnes of top soil is eroded every year which carry away about 2.5 million tonnes of nitrogen, 3.3 million tonnes of phosphate and 2.5 million tonnes of potash (78).

In the absence of proper vegetative cover that normally holds soil against the moving force of water or wind, the soil material is frequently transported a thousand times faster than under natural conditions bringing in its wake the utter destruction of watershed.

Country's renewable fresh water resources are represented by annual precipitation in the form of rain or snow. Since the demand for water is not only in excess of its supply but is also growing steadily in all sectors. Loss of productivity of land surfaces are due to inability in optimizing the use of available rain water through conservation and reuse particularly to tide over dry spells and increase yield potential. Therefore planning should involve management of rainfall and resultant runoff.

India has 20 percent of the world's population with only 2.5 percent of the geographical area. If the present trend continues, the population may reach 931 million by the end of 20th century. The total geographical area of our country is 328 million hectares. The net land area available per capita decreased from 0.9 ha to 0.6 ha between 1951 to 1971; by the end of this century, it will get decreased to 0.35 ha (80).

Our plant resources are vast and varied and we have nearly 20,000 plant species, a greater number than those countries having much larger geographical area.

Inspite of the vast human, animal, water and plant resources, it is an established fact that we are not producing enough to provide basic minimal needs of our population and cattle. There is imbalance in land-water-plant-human/animal system and we are moving towards economic insecurity.

The future of Indian agriculture lies in better soil and water management. This is the only way to meet the challenge of the food needs and pollution hazards. Soil and water are the natural resources of the country. As such its conservation should be a national responsibility. If these resources are misused or mismanaged, the entire economic base of the country would be disturbed.

It is, therefore , important to plan the watershed on sound technical knowledge to save the land from erosion and degradation, to conserve water and improve soils for maximum production in the interest of the nation as well as individual farmer.

With these views a case study on development planning with special reference to soil and water conservation, has been undertaken on a micro-watershed basis. A micro-watershed 'Lawana-2" was selected for this purpose. This watershed is situated near Mangarulpir in Akola District.

The objectives of this study are as follows:

1) To investigate the problems of the watershed area and their causes.

2) To propose land use programme according to land capability to increase yield potential of the area

3) To recommend soil and water conservation structures with plan and design specifications.

4) To find out benefit-cost ratio

5) To suggest phasing of the programme.

CHAPTER II

REVIEW OF LITERATURE

A comprehensive review of literature relating to the problem under investigation with special emphasis on project formulation, survey, problems in watershed, climate, physiography, land use, conservation structures, economic evaluation and phasing of the conservation work has been briefly presented inthis chapter.

2.1 Project Formulation

Sharma, V.K.(71) suggested the work plan for the watershed development projects. The plan contained the following chapters. a) The tract dealt with b) Vegetation and factors influencing it. c) Agro-economic and social problems d) Past history and management e)Investigation and analysis of problems f) Basis of proposals g) The engineering structures working circle h) The pasture working circle i) The cropland working circle j) The wood-land working circle k) Miscellaneous regulations. l) Establishment and labour m) Control and records n) Financial forecast and cost of the plan o) Summery of prescriptions and suggestions.

Tamhane, R.V. (79) stated a summary of watershed project as follows. a) Description of watershed:i)Physical data ii) Economic data.
b) Watershed problems : i) Flood water damage ii)sediment damage iii) Erosion damage iv)Problem relating to water

management.

c) Works of improvement to be installed :

i) Land treatment measures

ii) Structural measures

d) Effect of works of improvement

e) Comparison of benefits and costs.

Edward Kuiper (15) suggested the general outline of a feasibility report of the project as given below a) General description of project b)Present development of land and water resources c)Economic and social projection d) Agril. development e)Reclamation works f) Flood control g) Economic and social analysis h) Project financing i) Project implementation j) Conclusion and recommendations.

Wasi Ullah et al. (90) stated that work plan of watershed development should contain the following chapters. a) Watershed characteristics b)land use and cover conditions c) Problems and use e)Recommended soil and water conservation structures f) Costs and benefits g)Phasing of programme and responsibilities in execution h) Appendices.

Gupta,M.P.(25) explained the technique of preparing the working plans for soil conservation in catchments of river valley projects and stated that plan should contain the following items. a) Field surveys of the catchment b) Finding out the problems of the area

c) Preparing the maps (location, contour, soil capability and land use) d) Erosion intensity classes e)Working circles i.e. arable land, grass-land, woodland, roadside slabilization, streams stabilization, live stock development and silt detention working circles f)Cost benefit ratio. It was also stated that detailed working plans were prepared for each of the working circles.

Chinnamani, S. et al.(8) revealed that project formulation on any land-slide control included as i) reconnaissance survey of the area i.e. details of soils, climates, geology, hydrology, vegetation, and present use ii) treatments of different land use areas i.e. specifications for mechanical measures like graded bunds, graded trenches, bench terraces, contour stone walls, gully control structures etc. iii) providing appropriate drainage system for safe disposal of rain water.

2.2 Survey

Subba Raju, V. (77) stated that soil conservation measures always confirmed with the principles of hydrology, engineering and agronomy under varying conditions of topography and drainage. It was opined that there should be at least 50 acres of land to establish any of the scientific farming methods.

Rai, S.R. (55) reported that geological investigation should be undertaken simultaneously

alongwith the soil and land use survey.

Ghumare, N.K. (18) studied on survey and planning in soil conservation and reported that successful planning needed to collect basic data of watershed area as physiographic data, hydrological data, climatological data,soil types, vegetation etc.

Wasi Ullah, et al. (90) reported that field surveys included the reconnaissance survey, preliminary survey and detail construction survey.

Gil, N. (19) revealed that watershed development should start from the top of the drainage basin and go gradually down the slopes and small tributories and finally to a main stream.

2.3 Problem Investigation

2.3.1 Socio-economic enquiry

Sharma,V.K. (71) studied agro-economic and social problems and stated that data were collected from watershed area on human population, agro-economic problems, social customs and aptitudes, crop yields, grazing resources, grazing incidence, fodder, timber, firewood, manure, marketing facility, communications,current rate of labour, inputs and current prices of agricultural produce.

Pillai,G.B.,et al. (51) made study on socio-economic factors influencing adoption of soil conservation

measures and found that the direct and indirect effects of the factors namely farmer's knowledge, education status, age, attitude towards soil conservation,income, simplicity of conservation practices, availability of material for works and the social participation influenced the adoption of conservation works in the watershed.

2.3.2 Conservation problems of watershed

According to Tiwari,K.M.(83),all possible conservation measures were adopted in order to prevent silting up of streams and rivulets.

Gupta, R.K.(26) investigated the problem of silting in the catchment area of rivers Ganga and Yamuna and suggested that measures like pasture management, plantation on area of devoid of vegetation,afforestation, conservation practices for adoption.

Tamhane, R.V.(79) studied on watershed protection in a river valley project and investigated the problems of watershed as flood water damage, sediment damage, erosion, need for drainage and irrigation and need for agricultural and non agricultural water supply.

Murthy,V.V.N.(45)made study on stream bank erosion and suggested stream bank plantations to control erosion by creating a vegetal cover with suitable species on the eroded banks.

Bhatia, K.S. and Choudhari, H.P.(5) investigated the problem of runoff and soil loss from slopy and eroded alluvial soils of Uttar Pradesh and stated that contour farming and fertilization reduced the soil loss by 75%, runoff was reduced by 50% and yield of jowar and barley was increased by 6.34 quintals/ha and 13.04 quintals/ha respectively due to higher efficiency of added fertilizer.

Sharma,S.G. and Panwar,K.S.(70) studied splash erosion problem and indicated that Urid-T9 proved to be best crop for reducing the soil loss closely followed by groundnut plus arhar.

Tejwani, K.G. (81) reviewed the problems of different watersheds in India and suggested conservation problems as over grazing, sediment yield, problems like cultivation up and down the slope, inability of farmer to use a valuable resource like water and waste lands. Waste lands were found having a very great potential of producing fodder, fuel fibre, minor fruits and low quality timber.

Prajapati, M.C. et al. (52) made studies on surface water management problem for grassland and treeland development in a watershed at Kota and revealed that surface runoff was managed through continuous contour furrows of 10 cm^2 cross section at 1 metre horizontal

interval, the channel flow and checkdams to develop grassland.

2.4 Hydrology

2.4.1 Rainfall

Weibull method according to Dalrymple (12)was used for frequency analysis. The maximum annual values were arranged in descending order irrespective of the year of occurence. The data was plotted on probability paper using the log scale and percent chance of occurence of the rainfall on probability scale. According to this method plotting position in % chance = $\frac{m}{n+1}$

in which,

m = rank number when the data are arranged in descending order with highest event marked as 1

n = Total no.of years for which the data is available.

Chow (9) and Benson (4) stated that weibull method was theoretically suitable for plotting annual maximum series.

Doorenbos et al. (14) suggested a modification of plotting position formula when the precipitation series has some zero values in it.

Vanjari et al.(86)studied on rainfall frequency duration for Vidarbha region. The rainfall intensities for various duration and recurrence intervals at Nagpur is given in Table 2.1.

Table 2.1 Rainfall intensities for various durations and recurrence intervals at Nagpur(M.S.)

Sr. No.	Duration (min)	Rainfall intensities for diff. recurrence intervals (mm/hr)							
		2	5	10	15	20	25	50	100
1.	5	137.0	180.5	207.5	223.5	234.5	242.5	270.0	295.0
2.	10	112.5	147.5	170.0	183.0	192.5	200.0	220.5	242.0
3.	15	100.0	132.5	154.0	166.0	175.0	181.5	201.0	222.0
4.	30	74.5	98.0	113.5	123.0	129.0	133.5	149.0	163.5
5.	60	44.0	58.0	67.5	73.0	76.5	79.0	88.5	96.5
6.	120	28.0	39.0	46.0	50.5	53.5	56.0	62.5	70.0
7.	240	14.5	20.0	24.0	26.0	27.6	29.5	32.3	35.9
8.	480	7.4	10.3	12.3	13.5	14.2	15.0	16.9	18.6
9.	960	4.0	6.4	8.0	8.8	9.4	10.1	11.4	12.8
0.	1440	2.8	4.5	5.5	6.3	6.7	7.0	8.1	9.1

Biswas, B.C. and Maske, S.J. (7) made study on rainfall analysis for use in dryland agriculture and concluded that rainfall was the limiting factor for crop production in the tropics where variation of rainfall was very high and evaporation was more. Rainfall analysis with advanced statistical methods brought out many features which were directly used for dryland crop planning, land use and water management.

2.4.2 Runoff

Rama Rao M.S.V.(56) reported that rational method to calculate rate of runoff in cubic feet per second i.e. (Q= CIA) was not restrictive and was used with considerable success over a large range of watershed conditions.

Gupta, S.K. et al.(28) studied on estimation of peak rate of runoff from small watersheds in India and reported that for designing of various mechanical measures, the estimation of peak rate of runoff was one of the main design criteria.

Michael, A.M. and Ojha, T.P.(42) stated that the rational method to calculate design peak rate (in m^3/sec) was applicable to the watersheds having area less than 1300 hectares. This method was considered sufficiently accurate for designing conservation structures.

Schwab,G.O. et al.(67) reviewed that one of the most widely accepted methods of computing the time of concentration for calculating peak runoff rate, was developed by Kirpich.

2.4.3 Infiltration

Michael,A.M.(41) reported the relation for calculating the average infiltration at any time 't' when 't' is small as,

$$Y = at^{\alpha} + b$$

in which,

Y = accumulated infiltration in time t, cm

t = elapsed time, min

a, α, b = are characteristic constants

2.5 Climate

According to Thampi,C.J. (82) climate of Andaman Islands was tropical. The weather was warm in summer. These Islands were generally windy. Humidity was high throughout the year. This tract was subject to cyclonic disturbences. It was concluded that the major climatic factors influencing runoff and erosion were rainfall, temperature and wind.

Sharma, B.M.(68) studied monthly mean maximum-minimum temperature, mean rainfall, mean wind velocity, mean relative humidity and reported that the climate of the Churu area in Rajasthan was characterised by drought

and high temperature.

Dalvi, V.B.(13) analysed the weekly pan evaporation data for obtaining evapo-transpiration by taking weighted values of crop factor.

2.6 Physiography

2.6.1 Soil

Rai, S.R.(55) reported that physio-chemical properties of the soils with reference to their parent materials were essential to give some definite clues as regards the nature and proper crop planning of the watershed.

Sarkar,A.K. and Pandey,S.N.(63) analysed soil data at the Upper Damodar Valley Project and determined the percentage of sand, silt, clay, organic carbon,organic nitrogen,available phosphorus (P.P.M.),available potash (P.P.M.) and Si_2O_3 of clay.

2.6.2 Topography

Goel K.N. et al. (21) studied the alluvial tracts of Uttar Pradesh and reported that more the slope more were the erosion and nutrient losses.

Mahapatra, G. et al. (38) stated the formula to determine the average watershed slope as

$$S = \frac{D \times L \times 100}{A \times 43560}$$

in which,

S = Average watershed slope (%)

D = Difference in elevation of catchment(ft.)

L = Average length of contour (ft.)

A = Area of the water shed (acres)

It was concluded that more the percentage of slope, more is its erosion. Slopes more than 10%, needed special attention to control erosion on priority basis.

Vandersypen,D.R.et al. (985)reported that while studying the characteristics of the watershed,geometric factors, physical factors,geological condition and channel characteristics should be taken into consideration.

Gurmel Singh et al.(31)opined that physiography of watershed area consisted slope,elevation,drainage pattern,channel morphology and most of this information should be on a good map.

2.7 Vegetation and Land Use

2.7.1 Crop land

Reddi,D.V. (58)revealed that a combination of agronomic and mechanical practices was necessary to derive the maximum benefit. The principle of combined practices was of paramount importance in planning soil and water conservation work.

Verma, T.R.(89) reported that the application of

phosphorus resulted increase in canopy. Moong established a very good early cover and protected the soil from high intensity rains in July. Guar gave the maximum green fodder yield. Guar-barley rotation gave the maximum net returns per hectare.

Sharma, S.G. and Panwar,K.S.(70) reported that Urid T-9 proved to be the best crop for reducing the soil loss closely followed by groundnut + arhar.

Singhal,A.K. et al.(76) studied on intercropping of kharif legumes with jowar under rainfed condition and reported that intercropping of jowar and arhar in alternate lines 30 cms. apart, was found most profitable. Such practice offered the possibility of increasing income per unit area.

Venkateswarlu, J. (87) reported that with simple improved agronomic practices yield was increased by 200 to 400 per cent in dry lands. The most important requirements were improved seed, moderate fertilizer use and better management.

Bhushan, L.S. et al.(6) claimed that among the cropping systems, uniform crop of Bajra permitted maximum runoff(28%) and soil loss (6.34 t/ha). Intercropping of Bajra with Cowpea or Moong reduced the soil loss to 4 tons/ha i.e.a reduction of 40%.

Sachan,S.S.and Suraj Bhan (60) reported that paddy

straw mulch alongwith antitranspirant spray of 6% Kaolin gave 74% more grain yield of Mustard and Safflower crops.

2.7.2 Grass land

Mirchandani, P.M. and Badri Singh (43) studied on renovation of grazing lands in Damodar catchment and found that grazing lands responded to fertilization.

Guha,D.P.and Pandey,S.N. (24) studied on grassland development with a view to supply green feed to the cattle for a prolonged period of time and also to reduce the erosion hazards and found that contour trenching at the distance of 20 ft. showed increase in the forage yield.

Patil,B.D. and Ghosh,R. (49) observed twnentyfour species of grasses for their evaluation and concluded that from practical stand point,species Cenchrus ciliaris and C.setigerus brought out the superiority over the others for their soil conservation values such as prevention of erosion, improvement of soil,root production and soil binding action.

Dabadghao,P.M.(10)reported that in grassland development Themeda anathera species was found the most desirable species from the forage point of view.

Morchan,Y.B.and Mariakulandai(44)revealed that Urochloa and star grass was found having more binding effect than Anjan grass.

Singh,B.N. et al. (73) found that the population per unit area of grass Ischaemum rugosum was more at places having more nitrogen, organic carbon, clay and water holding capacity.

Madhavarao,S. et al. (37) suggested some suitable grasses for drains and sides of water ways as i)Carpet grass(Axonopus cimicinus) ii)Star grass(Cynodon dactylon).

Pandey, S.N. and Singh Teolia, S.P. (47) showed that stylosanthes gracilis grass was one of the best legumes which produced good cover for slopy lands.

Sajwan,S.S.(62) reported that eleven dominent grass species were found suitable in Jamuna tract with the result of 13 years study. These were Apluda arislata, Cenchrus ciliaris, Cymbopogon jwarancusa, Cynodon dactylon, Desmastachya bipinnata, Dichanthinm annulatum, Elensine compressa, Eremopogon strictus, Heteropogon contortus, Panicum antidotale and Saccharum bengalense.

2.7.3 Forest land

According to Roy,A.B.(59) in successful planning of forest trees for the purpose of soil and water conservation following factors were taken into consideration i) The amount of organic matter added annually by such a forest tree ii) The rate of decomposition of such organic matter (iii) Evergreeness or deciduousness of such species, their extent and the period of deciduousness iv)rate of transpiration and v)Socio-economic importance of such

forest tree

Tiwari,K.M. (83) suggested the figures as a role of various types of ground cover for preventing the loss of soil and precipitation in Table 2.2

Table 2.2 Role of different types of ground cover

Kind of cover	Loss of precipitation in proportion of first kind of cover	Annual loss of soil per acre in proportion of first kind
a) Forest with normal ground cover	1	1
b) Forest with poor ground cover	3	20
c) Well managed pasture	3	14
d) Grass land	10	130
e) Completely bare ground	25	3250
f) Agril. crops	25	3250

Murthy,V.N.N.(45) suggested following trees for farm forestry programme.

1) Trees for fuel : Babul(Acacia arabica),Sal(Shorca robusta)

2) Trees for timber purpose : Sisoo (Dalbargia sisso)
Siris (Albezzia labback)
Jamun (Eugenia jambolina)

3) Trees for economic importance : Bamboo,Eucalyptus,Cashew_nut

4) Fruit trees : Mango,guava,pomogranate,jack fruit etc.

It was also stated that planting should be a phased programme.

Agnihotri, Y. et al. (2) revealed that Acacia catechu (Katha) grown using spacing 0.30 M x 0.30 M x 0.30M showed well growth in size and shape. Yield of it was observed as 10.24 tonnes/ha after 5 years. Price of fuel wood was considered as Rs.250 per tonne.

2.8 Soil and Water Conservation Structures

2.8.1 Contour bunds

Saxena,P.N.(66) recommended the contour bunds on gentler slopes upto 6% to serve as a sort of spreader system over a large area and to allow as much as percolation as possible. The design specifications of contour bunds were suggested as in Table 2.3.

Table 2.3 Design specifications of contour bunds according to field slope

Field slope (%)	V.I. (ft.)	H.I. (ft.)	Compact height of bund(ft.)	Top width of the bund(ft)
1.0	1.50	150	1.75	1.0
2.0	2.00	100	2.25	1.5
3.0	2.50	83	2.75	1.5
4.0	3.00	75	3.00	1.5
5.0	3.50	70	3.00	1.5
6.0	4.00	67	3.00	1.5

Sahasrabuddhe,K.R.(61) made studies on contour bunding in Deccan region of Maharashtra. It was concluded that the formation of cracks was much more on bare bunds (8.7%) as against the bunds which were either covered artificially by planting or natural grass.

Bali J.S. (3) stated two dimensionless equations for calculating the height of contour bund for hilly slope and flat slope respectively as

i) $H = \frac{1}{2} St + \sqrt{2(1+ns)\ CR}$

ii) $H = \sqrt{2CR}$

in which,

C = Vertical interval between bunds

H = Height of the bunds measured at the middle of the top width

t = Top width of the bund

s = Slope in % of the land, $\tan = \frac{s}{100}$

n = side slope of the bund as a ratio of horizontal to vertical

R = Rainfall in inches or cms in a day

Rama Rao, M.S.V. (56) recommended the contour bunds for scarcity areas. The design specifications were suggested as in Table 2.4.

Table 2.4. Design specifications for contour bund cross-sections

Sr. No.	Soil type	Top width (ft.)	Bottom width (ft.)	Height (ft.)	Side slope	Section area (sq.ft.)
1.	Full murum or soil layer upto 3"	1.5	6.5	2.50	1:1	10.00
2.	Soil layer from 3" to 9"	1.5	8.5	2.75	1:25:1	13.75
3.	Full soil or soil layer from 9" to 18"	1.75	10.0	2.75	1:50:1	16.00
4.	Full soil from 18" to 36"	2.00	14.00	3.00	2:1	24.00

Gawande,S.P. et al.(17) suggested the design specifications of contour bunding on medium clay loam soil having 2% slope as V.I. 0.90 metre and cross-sectional area 1.11 m^2. It was also stated that murum-stone weirs suited well to heavy rainfall.

Tejwani,K.G. (80) stated that soil erosion,runoff and growth of gullies were checked by contour and peripheral bunding.

According to Prajapati,M.C .et al.(52)levelling with bunding found to be the most successful measure for soil and water conservation.

As per the opinion of Kamannawar,H.K.et al.(35) the settlement of the bund,cracks and passing of water through cleavices,pot holes,ponding of water behind newly

constructed bunds, excess siltation and inadequate provision of outlet were the reasons of failure of bunds.

Michael, A.M. and Ojha, T.P.(42) explained the design procedure of contour and graded bunds. The specifications for contour bund cross-sections were suggested as in Table 2.5.

Table 2.5 Specifications for contour bund cross-sections

Sr. No.	Depth of soil	Base width (M)	Top width (M)	Height (M)	Side slope	Area of cross section (m^2)
1.	Shallow soils (7.5 to 22.5 cm)	2.67	0.38	0.75	1:5.1	1.14
2.	Medium soils (2.25 to 45 cm)	3.12	0.60	0.85	1:5:1	1.56
3.	Medium Deep soils (45 to 90 cm)	4.25	0.60	0.90	2:1	2.18

Mann, H.S. and Ramana Rao, B.V.(39) stated that contour bunding of 75 cm height and 80 cm vertical spacing combined with contour furrowing having 10 to 15 cm depth and 100 to 125 cm vertical spacing seemed to be better for moisture conservation in the arid zone.

2.8.2 Graded bunds

Pandey,S.N.and Rao,V.M. (48) reported that as an alternative to broad based terraces, the narrow based graded bunds having 7.5 sq.ft.cross section were recommended for adoption by the farmers.

According to Gupta, S.K. and Ram Babu (30) graded bunding with contour farming gave 53%, 63% and 74% runoff and 63%, 47% and 25% soil loss respectively as compared to up and down cultivation on 4% slope.

As reported by Michael, A.M. and Ojha, T.P.(42) graded bunds were used in India for safe disposal of excess runoff in high rainfall areas and the regions where the soil was relatively impervious. The minimum side slopes for graded bund at which the saturated soil remained stable suggested as in Table 2.6.

Table 2.6 The specifications of side slope for graded bunds

Sr. No.	Type of soil	Side slope (Horizontal to vertical)
1.	Clay soil	1: 1
2.	Loamy soil	1.5: 1
3.	Sandy soil	2: 1

Radhey Lal and Datta,A.C.(54) reported the design procedure of vegetative waterway through solved examples.

2.8.3 Farm ponds

Gupta, S.K. and Dhruva Narayana,V.V.(29) stated that dugout ponds were recommended all over the world by farm planners for irrigation, for gully control,

sediment retention and in many instances for recreation. It was suggested that for greater economy in construction and in order to reduce the surface evaporation to a minimum, the pond should be constructed to a sufficient depth.

Husenappa, V. et al. (32) reported that seepage loss from a unlined farm pond, was directly related to the hydraulic head available in the pond. Design specifications of the farm pond for the catchment 16.18 ha. were suggested as in Table 2.7.

Table 2.7 Design specifications for a farm pond

Sr. No.	Particulars	Specifications
1.	Average depth of the storage	4.5 M
2.	Height of earth dam	6.5 M
3.	Design storage capacity	1.65 ha-m
4.	Submerged area	0.58 ha
5.	Storage capacity after 18 years of life	1.31 ha-m

Sastry,G. et al. (64) stated that harvested runoff water was recycled successfully for crop management When crop was irrigated at presowing and crown root initiation stage with 5 cms each (total 10 cms),maximum area was covered with marginal rise in yield levels. It was also stated that the limited water available in farm ponds should be utilised at the earliest opportunity

i.e. at presowing stage for optimum yields.

Gajri, P.R. et al.(16) revealed that system consisted of collecting and storing in suitable reservoirs, the excess runoff from catchment and its use as crop-life saving irrigations, helped to increase and stabilize yields in rainfed areas.

According to Mann, H.S.and Rama Rao,B.V.(39),the better rain water utilization by harvesting and recycling increased the efficiency of available land and water resources. The potential productivity of arid regions appeared to be two to three times higher than what was attained by the traditional systems of production.

Singh,R.P. (75) explained the design procedure, cost estimation and economic evaluation of farm pond.

Sastry,G. et al. (65) stated that farm pond retarded the considerable volume and peaks of runoff. The pond was constructed for the capacity of 1.65 ha-m against the catchment area 16.2 ha having slopes 2.3% and 4.7%.

Verma, H.N. et al.(88)stated that it was possible to collect at least 8-10 cm of runoff even during the drought year which was sufficient to provide for one supplemental irrigation to the donar area or its equvalent.

Juyal, G.P. and Gupta, R.K. (34) reported that LDPE film with a thickness of 1000 gauge(250 micron)and

a width of 6.7 m found suitable for controlling the seepage loss.

2.8.4 Nalla bunding

Rama Rao, M.S.V. (56) and Gurmel Singh et al. (31) suggested the formula to calculated the storage in an earthen embankment as,

$$\text{Capacity between two contours} = \frac{\text{Distance between two contours}}{2} \times \text{Sum of the areas of the two contours}$$

Gurmel Singh et al. (31) suggested side slopes for earthen embankment as given in Table 2.8.

Table 2.8 Recommended side slopes for earthen embankments

Sr. No.	Soil classification	Slope	
		Upstream	Downstream
1.	Clayey gravels, silty gravels, gravel-sand-clay mixtures and gravel-sand silt mixtures	2.5:1	2:1
2.	Sandy clays, silty clays, lean clays, inorganic silts and clays	3:1	2:1
3.	Inorganic clays of high plasticity and inorganic silts	3.5:1	2.5 :1

Dahigaonkar, J.G. (11) reported Inglis formula for calculating the runoff yield from the catchment are as :

$$R = \frac{P\ (P-17.74)}{254}$$

in which,

R = runoff yield, cm

P = dependable total rainfall of the year

2.8.5 Vegetative bunding

Greenfield, J.C.and Grimshaw,R.G.(23) reported that vegetative hedges of vetiver grass were utilized to meet the urgent need of soil erosion and water conservation. It was also stated that vegetative system of soil and moisture conservations proved cheaper and more effective when implemented correctly.

2.9 Economic Evaluation

Patil,R.G.and Sohoni, D.K.(50) found out direct and indirect benefits of bunding programme as the age of bunding advanced.

Gupta,S.B.L. et al.(27) evaluated the economics of soil conservation measures i.e. afforestation, grass-land development, gully control,terracing in Varanasi District(U.P.) and found B/C ratio as 4.58 on the basis of annuity factors indicating that investment on the conservation measures was justifible.

Goswamy,K.V.and Singh,S.B.(22) reported the worthiness of investment on afforestation of deep ravines of Vasad in Gujrat and found that cost benefit ratio and I.R.R.were highest in case of Sissoo plantation having less payback period and recommended sissoo

plantation to stabilize the gullies.

Singh,A.(72) suggested a simple method for resource gain assessment in wasteland development projects. The method involved the value of the wasteland, cost of development and final value of developed land. The method proposed was helpful to field engineers and planners for planning a suitable land use programme at the planning stage.

Mathur, H.N. et al.(40) studied economic utilization of waste lands in Doon Valley and found that i) Crysopogan fulvus grass with Dalbergia sisoo tree (9.15 M x 9.15 M) ii) Eulaliopsis binata grass with Acacia catechu tree (4.55 M x 4.55 M) and Crysopogan fulvus grass alone, were economical viable for utilization of wasteland.

Joshi,D. and David Seckler (33) made study on the economics of rainwater harvesting project at Sukhomajri near Chandigarh and found B/C ratio as 1.63 on the basis of present worth which indicated the economical worthiness of the project.

Tejwani,K.G. and Ram Babu (81) discussed the case studies with respect to economics of various soil and water conservation programmes in the country. All the case studies had favourable B/C ratios which justified the economical worthiness of the programmes.

Gitinger,J.P. (20) reported the criteria to

calculate B/C ratio and Internal Rate of Return (IRR) and annual equal instalments for repayment of loan.

Kanwar,R.S. et al. (36) studied the economic potential for drainage improvements in the Des Moines River basin by comparing three drainage levels and found the B/C ratio indicating investment in poorly drained soils was justifiable for corn and soybean production.

Ram Babu et al.(57) evaluated the O.R.P.Project (U.P.) involving conservation structures, repair of guhls and found the project as economically feasible at 10%, 12% and 15% interest rate providing IRR 32%, considering the project life 25 years.

2.10 Phasing of the programme

Gurmel Singh et al. (31) suggested the phasing of soil and water conservation programme in Belan-Jharia sub-watershed project,Distt.Mirzapur (U.P.).

2.11 Critique of Review of Literature

A review of the past work on the 'planning of an Agricultural Micro-watershed with special reference to soil and water conservation' brought out the following salient features.

The success of any project is dependent upon the work plan. The development of a complete and comprehensive plan for a watershed requires the help of various types of technicians. The engineer,forester,agronomist,hydrologist,

geologist and economists must work as a team in developing the best coordinated programme for the watershed.

For the preparation of watershed plan,the work can be divided into two groups viz. assembling the basic data of the watershed and field survey.

The maps attached with the plan should be with the aim of giving useful information and to avoid bulkly report. The maps required usually include location map, land capability map, proposed land use map with proposed measures and detailed plans, layout and design specifications.

The work plan may have contents watershed characteristics, land use and cover conditions,problems and needs of the area, proposed land use, recommended conservation structures, economic evaluation and phasing of the programme.

Keeping in view the above inferences, a case study was conducted to plan a micro-watershed, planning techniques, the observations made and the results of the study are presented in following chapters.

CHAPTER III

PLANNING TECHNIQUES

This chapter presents the techniques adopted in preparing a watershed development plan. Standard techniques were used for different surveys, to estimate the probability of rainfall and evapotranspiration, to find out excess and deficit periods, infiltration rate, physico-chemical analysis of soil, to design conservation structures, economic evaluation and to phase the development works.

3.1 Reconnaissance Survey

Reconnaissance survey and assembling available information were done with the help of base map of the watershed and interviewing the farmers to get the first hand knowledge of the problems of the area and to take tentative decision for detailed planning.

3.2 Socio Economic Survey

Socio economic survey was done by interviewing the local people to know their socio-economic status.

3.3 Soil Survey

Soil survey report on land use capability classes of the area was collected from the office of Sub-D.S.C.O., Mangarulpir.

3.4 Contour Survey

Contour survey of the watershed was carried out at 30 m grid with the help of surveyor from Sub-DIS.C. Office, Mangarulpir, and plan is prepared at 0.30 m contour interval.

3.5 Rainfall Analysis

Daily rainfall data for the period from 1967 to 1986 was collected from Tahsil Office, Mangarulpir. Average annual rainfall was calculated. The data was also reformed into standard meteorological weeks. Average weekly rainfall was determined, to know the weekly normal rainfall.

Annual maximum daily and weekly rainfall were analysed to know the magnitude of rainfall of 24 hour duration and a week duration respectively for 25 years recurrence interval by using Weibull formula suggested by Datrymple (12) as,

$$Fa = \frac{m}{N + 1} \times 100 \qquad (3.1)$$

in which,

Fa = Plotting position

m = order number

N = total number of observations

The weekly rainfall data from 23rd met. week to 44 meteorological week was analysed to predict the

expected rainfall at different probability levels by using Doorenbos (14) formula as,

$$Fa = \frac{K}{N} + (1 - \frac{K}{N}) \times \frac{m}{N-K+1} \times 100 \qquad (3.2)$$

in which,

Fa = plotting position

m = order number

N = number of observations(years)for a particular week

K = number of zeroes in total observations

3.6 Evaporation

Weekly evaporation data for the period from 1977 to 1986 was collected from the Meteorological Observatory,Punjabrao Krishi Vidyapeeth, Akola, as there was no, evaporation data available at Mangarulpir. Climatological data other than rainfall were also collected from Meteorological Observatory,Punjabrao Krishi Vidyapeeth,Akola as the watershed area is near from this place.

Weekly evaporation data from 23rd to 44th week was analysed to predict the expected evaporation at different probability levels using Weibull's formula (eq. 3.1). Evapotranspiration at different levels of probability was obtained by using relation,

Evapotranspiration = Pan evaporation x Crop factor (3.3)

3.7 Excess and Deficit Periods

The period during which rainfall exceed evapotranspiration is called the excess period and vice-versa. Mathematically -

T excess occurs when $ET-P < 0$

T deficit occurs when $ET-P > 0$

in which,

T = time period

ET= evapotranspiration

P = rainfall

3.8 Infiltration

Infiltration characteristics of soil were determined by the use of cylinder infiltrometer. The functional relationship between accumulated infiltration (y) and elapsed time(t) was represented by the equation.

$$Y = at^{\alpha} + b \qquad (3.4)$$

The values of the constants a, α and b were determined by the method of averages reported by Michael (41).

where $$b = \frac{Y_1Y_2 - Y_3^2}{Y_1+Y_2- 2Y_3} \qquad (3.5)$$

in which,

Y_1 = accumulated infiltration (cm) corresponding to first elapsed time (t_1)

Y_2 = accumulated infiltration (cm) corresponding to last elapsed time (t_2)

Y_3 = accumulated infiltration (cm) corresponding to elpsed time $t_3 = \sqrt{t_1 \times t_2}$

3.9 Soil Analysis

Soil samples were analysed to know the physico-chemical properties of the soil using standard methods in the chemistry laboratory of Dryland Research Project,Akola. Mechanical analysis of soil was done by Bouyoucos hydrometer method. Soil pH was determined by Glass electrode pH meter. Olsen's method was used to know the available phosphorus. Available K_2O was determined by Flame Photometer Method. Rapid titration method was used to know organic carbon. Available N was known by Alkaline permangnate method and Bulk density by clod method. $CaCO_3$ was determined by rapid titration method. E.C. was known by using electrical conductivity method. Maximum water holding capacity was determined by Piper method suggested by Singh, R.A.(74).

3.10 Design Criteria of Graded Bunds

Specification of graded bunding include vertical interval, grade of channel and cross-section. Following criteria was used for designing graded bunds.

Vertical interval and horizontal interval were determined according to Gurmel Singh(31) and equation(3.11) respectively.

A design peak runoff rate was predicted by using Ramser's (42) rational formula

$$Q = \frac{CIA}{36} \qquad (3.6)$$

in which,

Q = The design peak runoff rate, cumec.

C = The runoff coefficient

I = rainfall intensity in cm/hr for the design return period and for a duration equal to the time of concentration.

A = Watershed area between two adjacent bunds, ha

The time of concentration was computed by using the most widely accepted method developed by Kirpich suggested by Schwab et al.(67).

$$T_c = 0.0078K^{0.77} \qquad (3.7)$$

in which,

T_c = time of concentration, minutes

$$K = \sqrt{\frac{L3}{H}}$$

in which,

L = maximum length of travel ft.

H = difference in elevation between most remote point and outlet point, ft.

The rainfall intensity for corresponding time of concentration was obtained by refering the Table 2.1 given by Vanjari et al. (86).

The bund channel mean velocity(v) was determined by using Mannings formula,

$$V = \frac{R^{2/3}\, S^{1/2}}{n} \qquad (3.8)$$

in which,

V = mean velocity of flow, m/s

n = roughness coefficient of channel

R = mean hydraulic radius, m

S = hydraulic gradient, m/m

The bund channel discharge capacity was computed by relation

$$Q = av. \qquad (3.9)$$

in which,

Q = discharge capacity of channel, cumec.

a = Total area of channel formed by bund, m^2

v = mean velocity of flow, m/s

Height of bund was considered as 1.5 times the depth of flow of water in the channel. Top width and base width were determined on the basis of side slop and seepage line slope ratios selected.

3.11 Grassed Waterway

The porabolic shaped grassed water way was designed by computing the carrying capacity,percentage slope of the land and using relation.

$$A = 2/3\ td \qquad (3.10)$$

in which,

A = crossed sectional area of parabolic waterway, m^2

t = top width, m

d = depth of flow, m

3.12 Design criteria of contour bunds

For designing the cross section of contour bund. The following criteria was used.

Vertical interval (V.I.)was considered as suggested by Michael and Ojha (42).

Horizontal interval was determined by the relation

$$H.I. = \frac{V.I.}{\text{Slope } \%} \times 100 \qquad (3.11)$$

Maximum runoff to be stored in the bund was calculated as,

$$\text{Maximum runoff to be stored in the bund} = \text{Rainfall- Infiltration} \qquad (3.12$$

Cross section of storage area (A) was determined by the relation,

$$A(m^2) = \text{Runoff (m)} \times \text{H.I. (m)} \qquad (3.13)$$

Top width and base width were determined on the basis of side slope and seepage line slope ratios.

Cross section of the bond was known by the relation,

$$\text{Cross section area of bund} = \frac{\text{Top width + base width}}{2} \times \text{height} \qquad (3.14)$$

3.13 Design of Waste Weir

For designing waste weir as a outlet for graded and contour bund, peak runoff rate was calculated by Ramser's formula and the length of waste weir for depth

of flow over the crest was computed by the relation,

$$L = \frac{Q}{1.711 \times h^{3/2}} \qquad (3.15)$$

in which,

Q = peak runoff rate, m^3/sec

h = depth of flow over the crest m

3.14 Plantation of Vetiver Grass

Three survey numbers 44, 45 and 47 were selected for planning the vegetative contour headges to act as a bund to conserve the soil and moisture in situ. The vertical interval was choosen as 1.2 m and horizontal interval as 85 m. The method of transplantation of vetiver grass was proposed as suggested by Greenfield J.C. (23). The distance between two to three slips along the contour line was kept 10 cm to obtain this hedges in short time for maximum benefits.

3.15 Design Criteria of Nalla Bunding

Waste weir was designed as per the criteria given in contour bunding equation 3.15.

Earthen embankment for nalla bunding was designed by considering reduced level at stream bed and reduced level at high flood level. The slope of upstream and down stream sides were taken as suggested by Gurmal Singh (31).

The height of embankment was calculated by the formula suggested by Gurmel Singh (31) as,

$$H_w = 0.384 \quad F \quad 0.763-0.271F^{0.25} \qquad (3.16)$$

in which,

F = fetch, km

H_w = height of waves

Free-board should not be less than height of waves

Height of dam was calculated using formula,

$$\text{Height of embankment} = (\text{HFL}-\text{SBL}+\text{freeboard}) + 5\% \text{ consolidation} \qquad (3.17)$$

Volume of imponded water was calculated by the formula suggested by Rama Rao (56) and Gurmel Singh (31)as,

$$\text{Capacity between two contours} = \frac{\text{distance between two contour}}{2} \times \text{sum of the areas of two contours} \qquad (3.18)$$

Bottom width of cutoff trench was calculated as suggested by United States Department of the Interior(1) as

$$W = h - d \qquad (3.19)$$

in which,

W = width of cutoff trench

h = height of water upto HFL

d = depth of trench

3.16 Design Criteria of Farm Pond

Designed capacity of dug-out farm pond was calculated by considering water requirement for livestock and irrigation use. Livestock and irrigation water requirement was calculated as suggested by Singh (75).

Assuming height, top dimensions and side slope for farm pond, dimensions at mid depth and bottom were determined.

To check assumed dimensions of farm pond and calculate the volume of excavation, prismoidal formula was used as,

$$V = \frac{(A+4B+C) \times D}{6} \qquad (3.20)$$

in which,

V = Capacity of farm pond, m^3

A = area at top, m^2

B = area at mid-depth, m^2

C = area at bottom, m^2

D = depth, m

Vegetative spillway was designed using the equation 3.15, .

3.17 Benefit Cost Ratio Criteria

The following two criteria, Gittinger(20) were employed to test the economic feasibility of the project

$$\text{B/C ratio} = \frac{\sum_{t=1}^{n} \frac{Bt}{(1+i)^t}}{\sum_{t=1}^{n} \frac{Ct}{(1+i)^t}} \qquad (3.21)$$

in which,

Bt = Benifit in t^{th} year, Rs.

Ct = Cost in t th year, Rs.

i = discount rate in Rs/ha

n = life of Project, years

3.18 Phasing of programme

The project breakdown was done into different activities according to their time of completion, physical and financial aspects as given by Gurmel Singh et al. (31).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents the work plan of the watershed which contains the watershed characteristics, socio-economic description, present land use in the area, problems and needs of the people, proposed land use programme, proposed soil and water conservation measures and their design aspects, economic evaluation of the proposed plan, phasing of the development works and discussion on them.

4.1 Characteristics of Watershed

4.1.1 General

Manoli watershed is divided into five sub-watersheds and further into 144 micro-watersheds. Each micro-watershed has distinct physical characteristics in respect of relief, size, shape, topography, geology and socio-economic situations. Considering all physical and socio-economic aspects of these micro watersheds,the state line departments with the financial assistance of World Bank, have undertaken its development. Punjabrao Krishi Vidyapeeth,Akola is also involved for supportive research to raise the economic returns of the cultivators of the area. One of the micro-watersheds named 'Lawana-2' was selected for the study as it was intended to be developed in an early future.

4.1.2 Location

The micro-watershed Lawana-2 is located 8 Km away, on Mangarulpir-Manora state highway, from Mangarulpir town which is about 65 Km from Akola city. The location of Manoli watershed and thereby Lawana-2 micro-watershed is shown in Fig.4.1 and 4.2. The micro-watershed is adjacent to the village named Lawana. It lies between $20^{o}19'$ N latitude and $77^{o}21'$ E longitude.

4.1.3 Size and shape

Total geographical area of watershed is 68.66 ha. Out of which 55.77 ha is cultivated area and rest constitutes the area of nalla and road. General shape of watershed is like an inverted leaf. Approximate width and length ratio is 1:1.95. The contour map of watershed is presented in Fig. 4.3.

4.1.4 Climate

4.1.4.1 Temperature

weekly average weather data is presented in Table A-1 of Appendix-A and represented in Fig. 4.4. This indicates that the maximum daily temperature ranges from 29.2 to $43.2^{o}C$ and minimum temp. ranges from 10.5 to $27.3^{o}C$ throughout the year. The maximum temp. ranges from 30.0 to $39.2^{o}C$ for rainy season, 29.2 to $33.5^{o}C$ for for winter season and 35.0 to $43.2^{o}C$ for summer season. The minimum temp. ranges from 15.0 to $26.5^{o}C$ for rainy

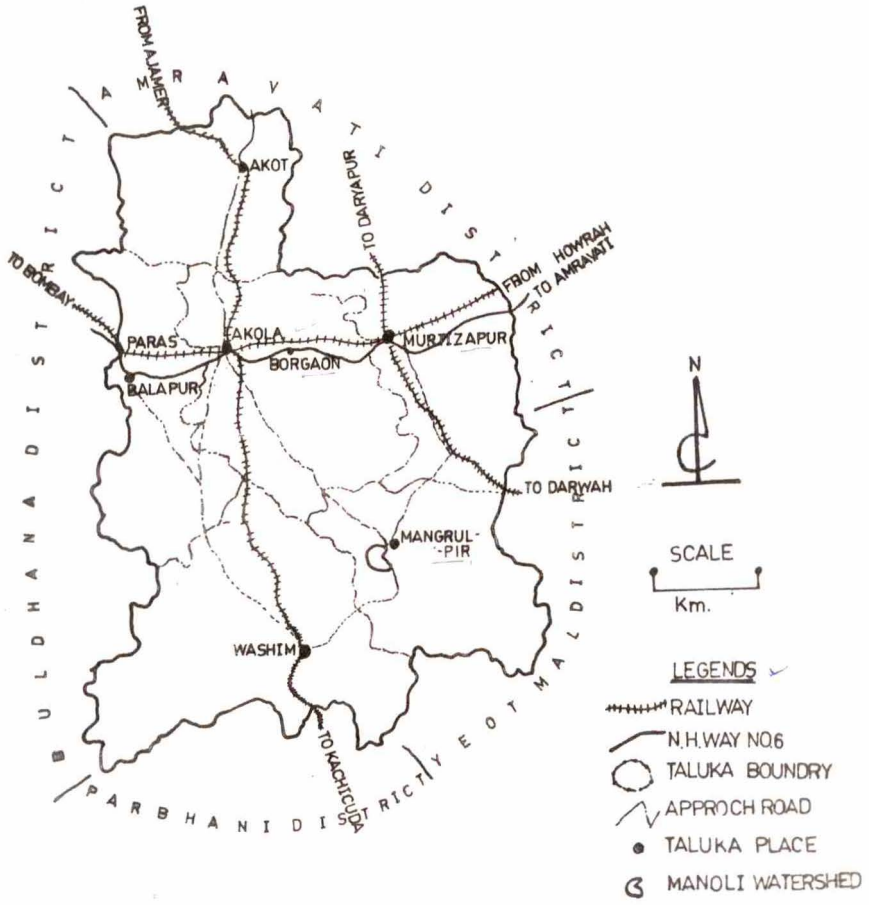


FIG 4·1 LOCATION OF MANOLI WATERSHED IN AKOLA DISTRICT

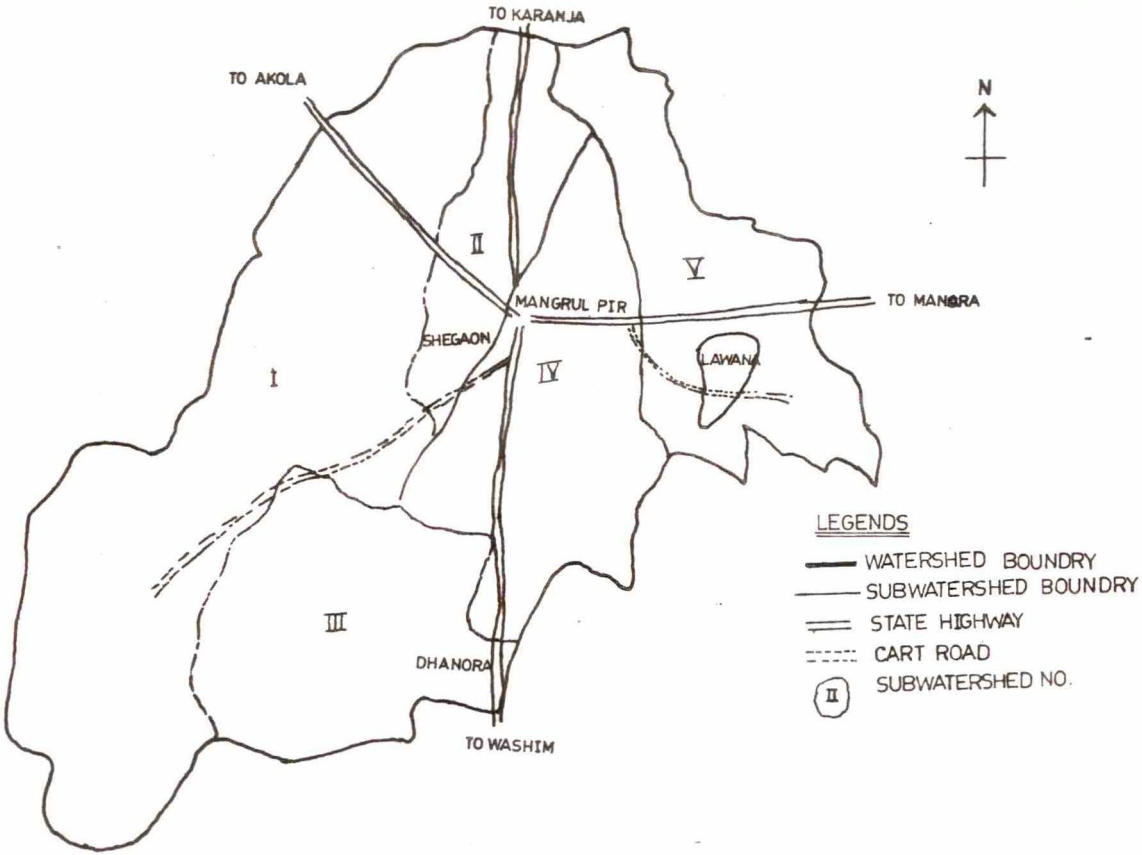


FIG 4·2 LOCATION OF LAWANA 2 MICROWATERSHED IN MANOLI WATERSHED

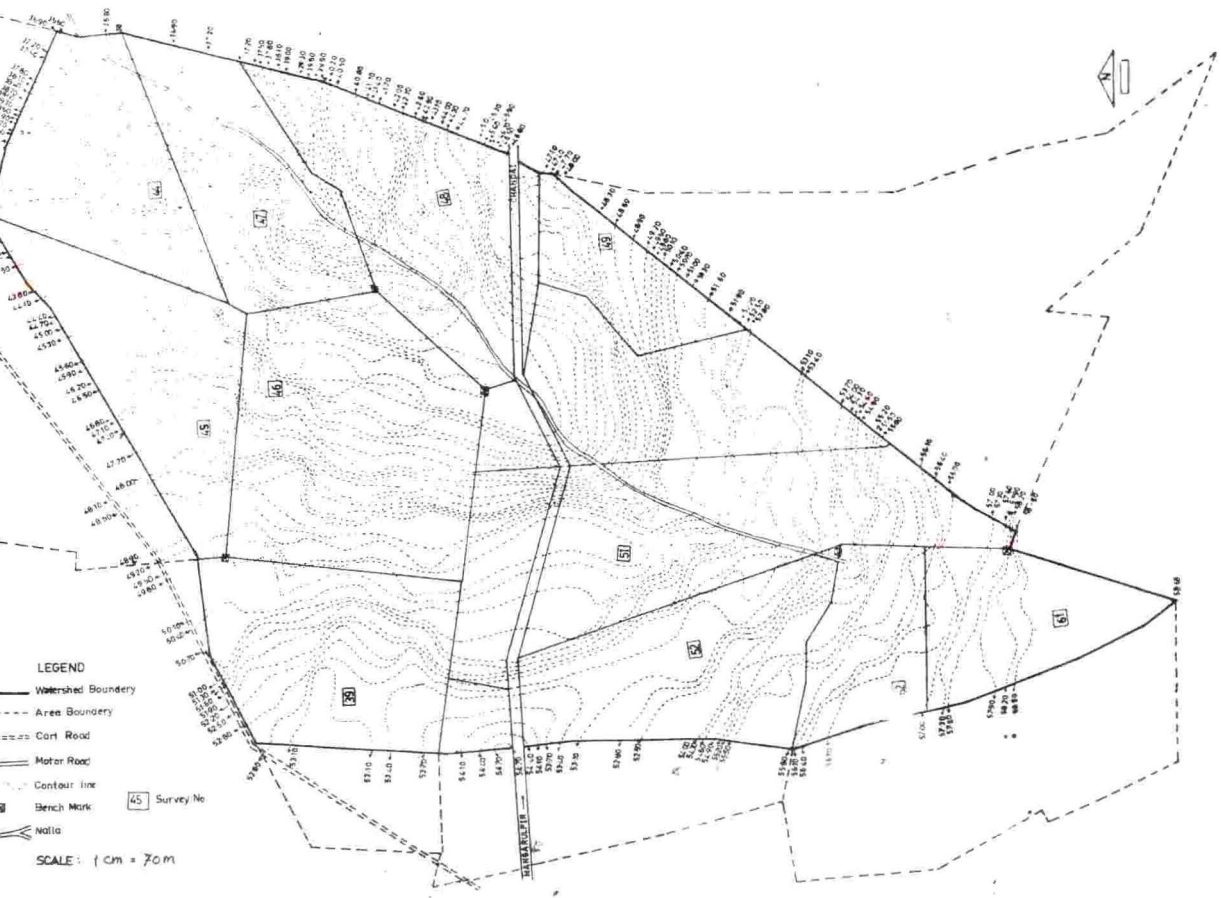


FIG.4.3 CONTOUR MAP OF MICRO WATERSHED LAWANA-2

season, 10.5 to 15°C for winter season and 15.5 to 27.3°C for summer season considering the period from 9 to 22 weeks for summer, 23 to 44 weeks for rainy and 45 to 52 and 1 to 21 weeks for winter season.

4.1.4.2 Evaporation

The average daily pan evaporation ranges from 4.2 to 19.1 mm throughout the year. The mean pan evaporation is 6.85 mm for rainy, 5.77 mm for winter and 14.45 mm for summer season.

4.1.4.3 Relative humidity

Relative humidity in the morning hours ranges from 29 to 88%. Similarly it ranges from 10 to 68% in the evening hours throughout the year. The mean seasonal morning and evening relative humidity is 80.32% and 52.31% for rainy season, 63.93% and 26.87% for winter season and 38.50% and 15.78% for the summer season respectively. Thus, the average daily relative humidity is 66.31% for rainy season, 45.4% for winter season and 27.14% for summer season.

4.1.4.4 Wind

The maximum wind velocity appears in the month of June. The average is 16.5 kg/hr. The direction of wind is from West to East.

4.1.4.5 Sunshine hours

The average daily sunshine hours are 6.05 hrs,

8.87 hrs. and 9.75 hrs. in rainy, winter and summer season respectively.

4.1.4.6 Rainfall

Daily rainfall data for the period from 1967 to 1986 was collected from Mangarulpir station and analysed for average annual rainfall, weekly average rainfall, maximum annual rainfall of 24 hrs. duration and maximum annual rainfall of one week duration to use the values for designing the conservation structures and crop planning.

The average annual rainfall of the area is 860mm which is received nearly in 50 days concentrated over the months June to October.

Weekly average rainfall is presented in Table A-2 and Fig. 4.4 to know the characteristic of the rainfall with other climatological parameters. It shows that there is highest rainfall of 65.24 mm in 35th meteorological week. The maximum part of annual rainfall receives in between 21st and 42nd meteorological week. During the period starting from 1st to 21st week and 42nd to 52nd week, the rainfall is negligible.

The maximum annual rainfall of 24 hrs. duration is presented in Table A-3. Probability analysis was done to know the magnitude of the maximum annual rainfall for different recurrence intervals. Graphical representation of frequency analysis is presented in Fig. 4.5. It

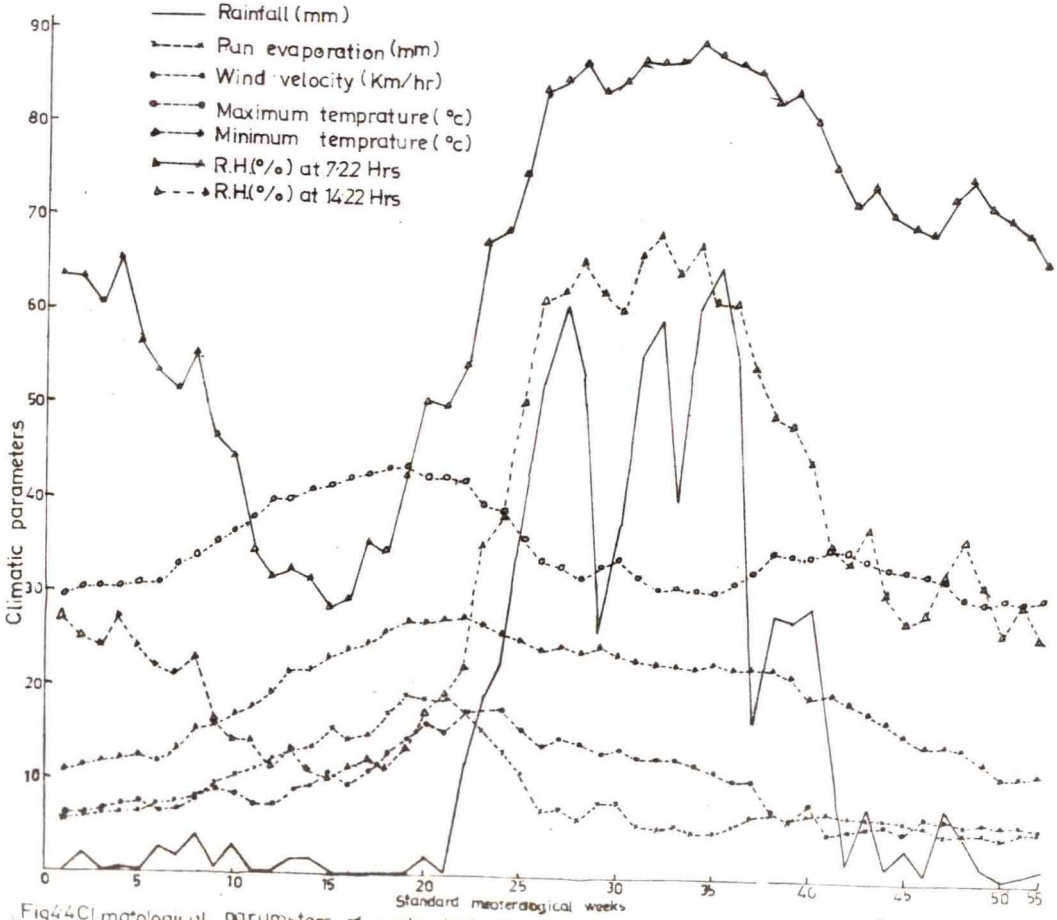


Fig44 Climatological parameters of watershed area.

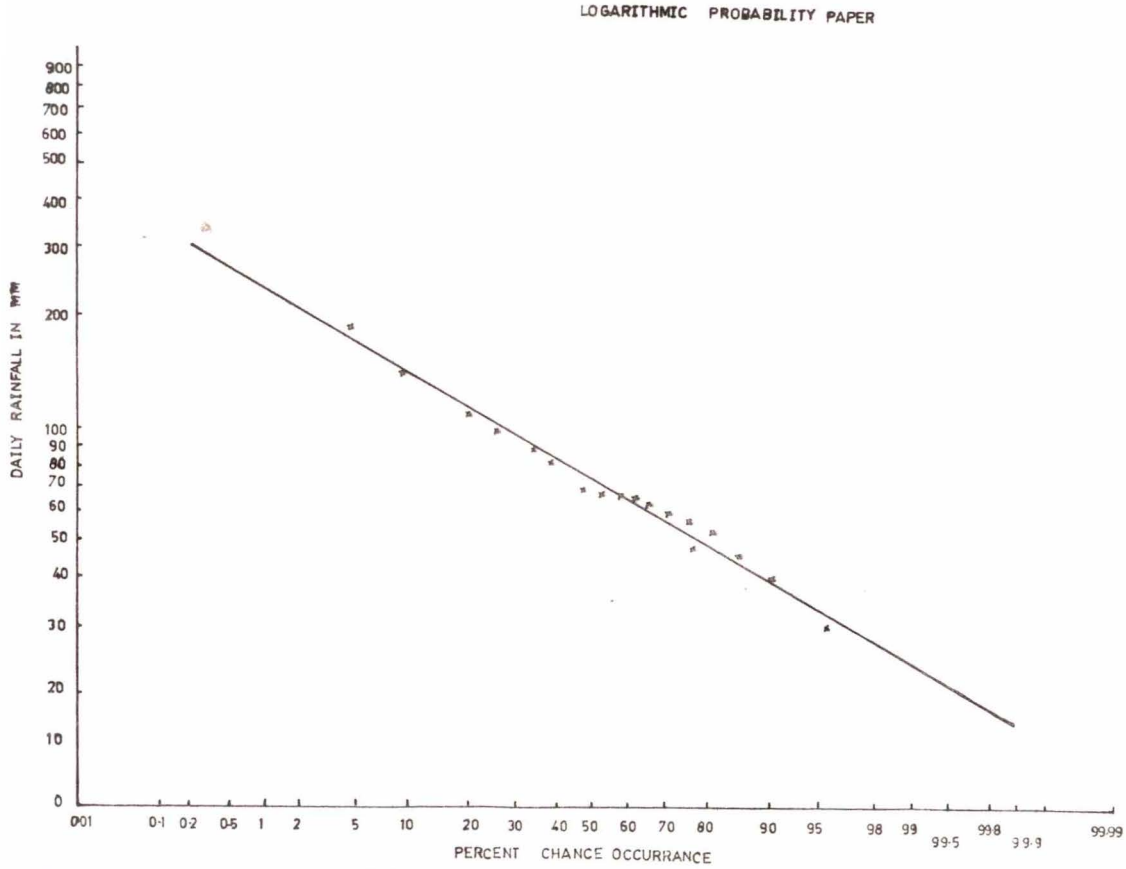


FIG 4·5 GRAPHICAL REPRESENTATION OF FREQUENCY ANALYSIS OF RAINFALL FOR 24 HOURS DURATION AT MANGRUL PIR

indicates that the maximum rainfall of 24 hrs duration for 25 year recurrence interval is 175.0 mm. Maximum daily rainfall at various frequencies is presented in Table 4.1.

Table 4.1 Maximum Daily rainfall at various frequencies at Mangarulpir

Recurrence interval year	2	10	25	50	100
Percent chance	50%	10%	4%	2%	1%
Magnitude of 24 hrs rainfall, mm	74.0	140.0	175.0	205.0	235.0

The maximum annual rainfall of one week duration at Mangarulpir station is presented in Table A-4 of Appendix-A and graphical representation of frequency analysis is presented in Fig. 4.6. It indicates that the maximum rainfall of one week duration for 25 year recurrence interval is 292.0 mm. Maximum weekly rainfall at various frequencies presented in Table 4.2.

Table 4.2 Maximum weekly rainfall at various frequencies at Mangarulpir

Recurrence interval year	2	10	25	50	100
Percent chance	50%	10%	4%	2%	1%
Maxi. weekly rainfall, mm	135	240	292	340	380

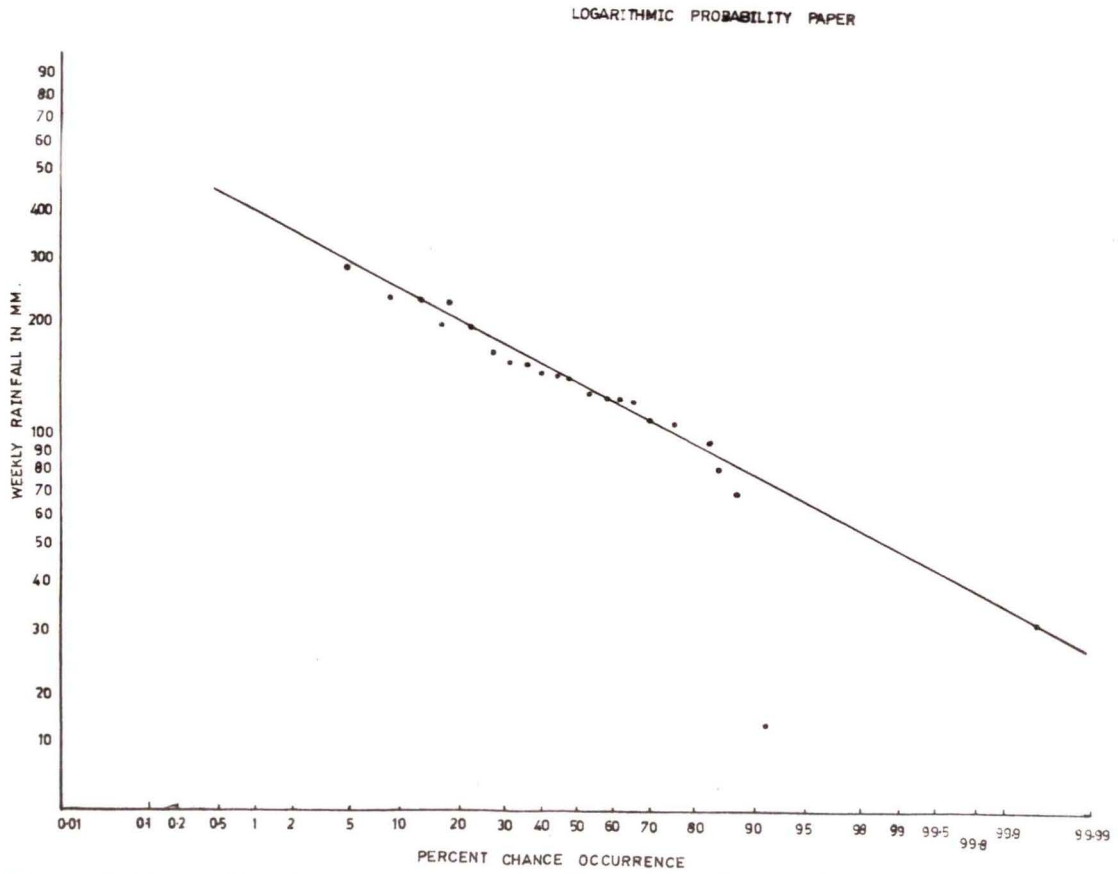


FIG 4.6 GRAPHICAL REPRESENTATION OF FREQUENCY ANALYSIS OF RAIN FALL FOR ONE WEEK DURATION AT MANGRUL PIR

4.1.4.7 Excess and deficit periods

Weekly rainfall data for the period from 1967 to 1986 was analysed to know the magnitude of rainfall at various probability levels by x using the method suggested by Doorenbos et al. (14). The results of probability analysis are presented in Table A-5 of Appendix A and graphically presented in Fig. 4.7.

Weekly pan evaporation data for the period from 1977 to 1986 were collected and analysed by arranging it in ascending order for 40, 50, 60 and 70% probabilities using Weibull method suggested by Dalrumple(12). The results of probability analysis are presented in Table A-6 of Appendix-A.

Weighted values of crop factors were calculated for different weeks considering 5% crop growth means one week growth of the crop. The crop factor values suggested by Michael, A.M. (41) were considered for Jowar and Cotton crops as these are the main crops of the area sown in the ratio of 3:2.

The values of the pan evaporation at different probability levels were multiplied by corresponding weekly crop factor to obtain evapotranspiration at 40, 50, 60 and 70% probabilities which are presented in Table A-7 of Appendix-A.

As suggested by Sharma, H.C. et al.(69) at 80% probability level of rainfall and 40% probability level of

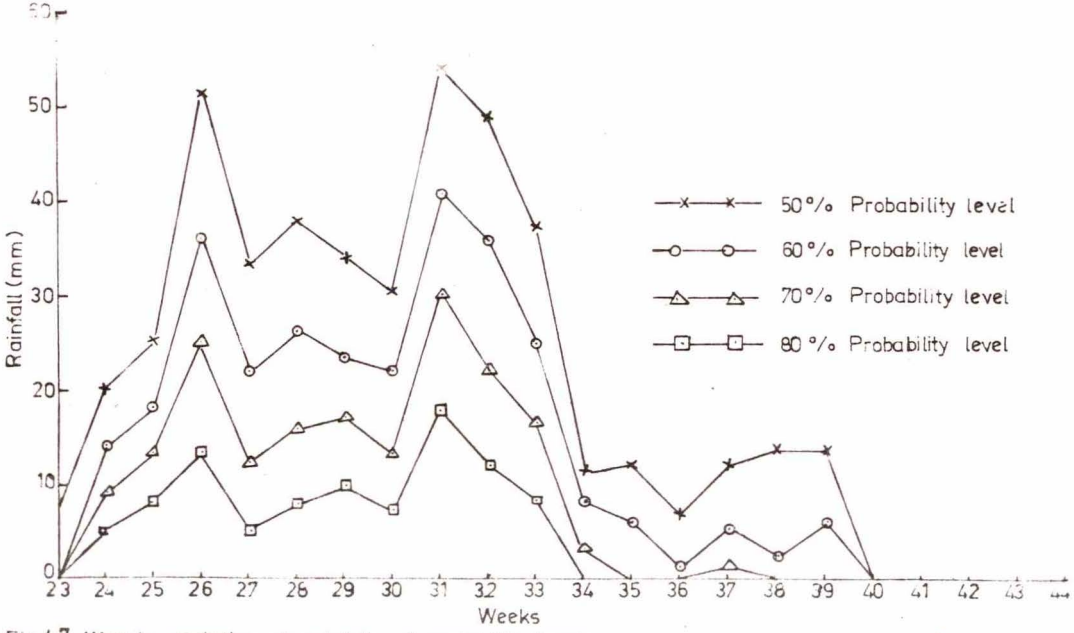


Fig 4.7 Weekly variation of rainfall at probability levels

evapotranspiration, deficit and excess periods were worked out and presented in Fig. 4.8.

It indicates that the deficit of 4.72 mm occurs in the 23rd week, whereas from 24th week to 33rd week there is excess rainfall. From 34th week onwards there is continuous dry spell having maximum deficit of 4.79 mm in the 39th week. From the Fig. 4.8 it is clear that there is a need of life saving irrigation for kharif and rabi crops in the deficit periods which can be fulfilled by harvesting the runoff water.

4.1.5 Physiography

The elevation of the highest point in the watershed is 22.38 metres. The maximum length of the watershed is 1550 metres and average width is 795 metres. It has two different slope groups. 80% of the cultivated area is under 1.0 to 1.5% slope group and 20% area is under 1.5 to 2.0% slope group. The average slope of the watershed is 1.4%.

There is a small nalla existing in the watershed which rises from the watershed itself. It has a seasonal nature of flow. It flows during rainy season only. However, it cannot retain water for the period beyond September in the year of normal rainfall. The length of the nalla is 1200 metres.

4.1.6 Soils

The soils are derived exclusively from basalt

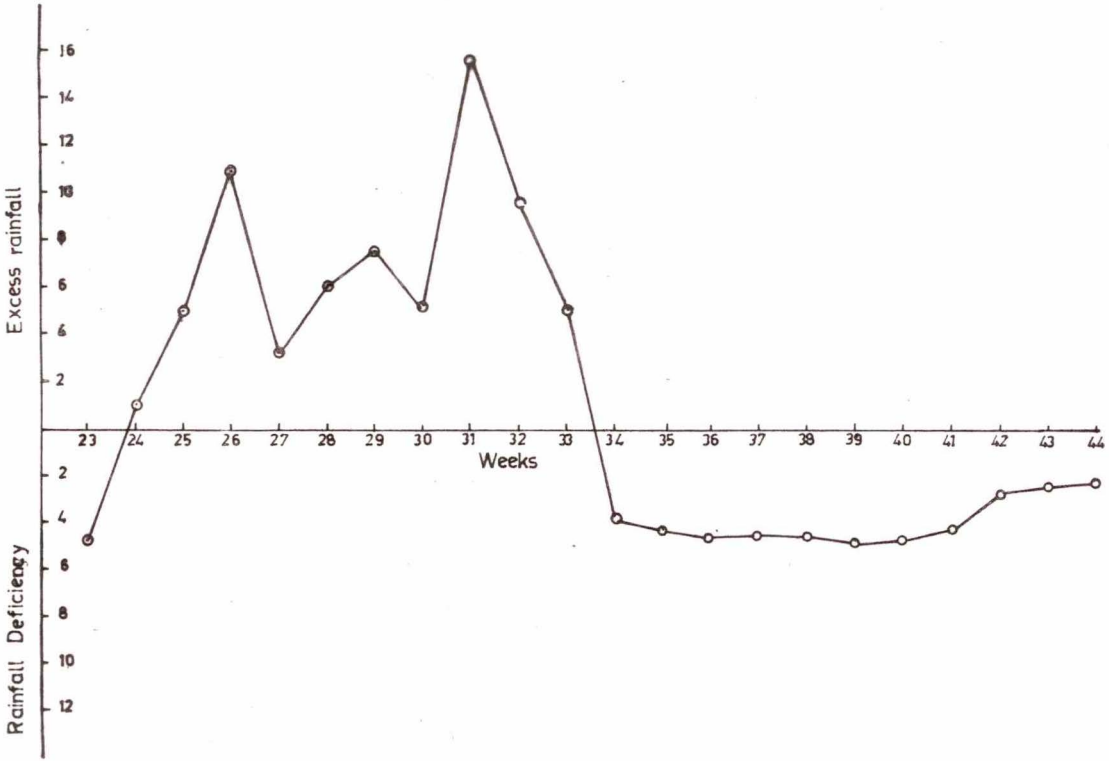


Fig.4.8 Excess and deficit periods at 80% probability of rainfall and 40% probability of evaporation.

rock of the Deccan trap. Watershed consists of shallow to medium deep soils.

4.1.6.1 Morphological description

Five typical profiles representing the total area were studied. The profiles at various sites can be seen from Fig. 4.9. The detailed description of the soil profiles are presented in Appendix-B. It shows that the soil depth varies from 10 to 60 cm.

4.1.6.2 Physico-chemical properties of soils

Physico-chemical properties were determined by standard method and the results are presented in Table 4.3 The results indicate that the soils in the watershed are silty clay, silty clay loam and silty loam.

4.1.6.3 Infiltration

The infiltration rates of different land use capability classes were determined by ring infiltrometer The cumulative infiltration against elapsed time is given in Table 4.4 . The relation between accumulated infiltration and elapsed time for different soils is presented in Fig. 4.10. The highest basic infiltration rate observed is 8.6 cm/hr. in class IV soils followed by 4.96 and 4.0 cm/hr in class III(b) and class III(a) soils respectively. Accumulated infiltration was determined by the equation 3.4. The values of constants a, α and b were calculated. The sample computation for

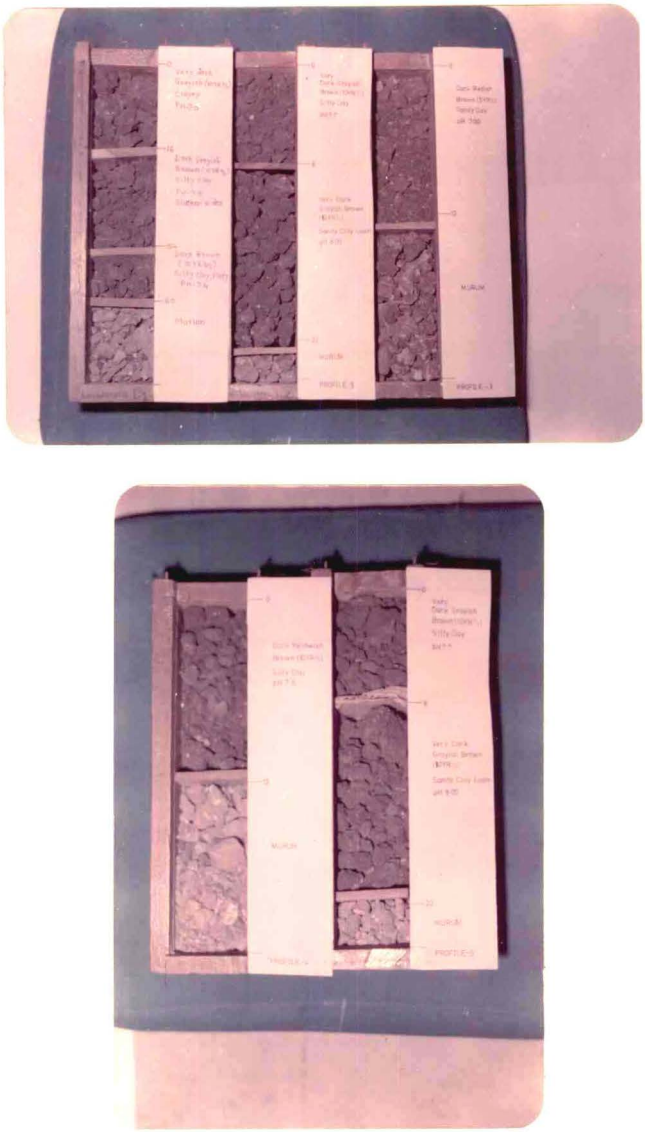


FIG 4·9 SOIL PROFILES AT VARIOUS SITES IN LAWANA-2 MICROWATERSHED

e 4.3 . Physico chemical properties of soils of Lawana-2 micro watershed

samples	Moisture Holding cap.%	$CaCO_3$ %	Silt %	Sand %	Clay %	pH	E.C.	Bulk density	Organic carbon	Available N (kg/ha)	Available P_2O_5 kg/ha	Available K_2O kg/ha
ile No.1												
cm	53.32	3.03	32.4	8.6	59.0	7.5	0.3	0.87	0.61	137.76	12.02	450
4 "	51.20	3.07	20.4	48.4	31.2	7.5	0.3	1.05	0.46	134.42	12.45	330
0 "	33.61	3.07	16.6	56.4	27.0	7.4	0.3	1.15	0.40	108.52	4.15	290
w 60 cm	40.68	3.33	40.4	32.6	27.0	8.0	0.4	-	-	120.96	4.98	210
ile No.2												
cm	57.96	3.11	20.4	56.6	23.0	7.9	0.4	1.37	0.55	164.64	13.28	330
cm	57.93	3.08	24.4	44.6	31.0	7.3	0.3	2.83	0.50	174.72	12.45	200
w 23 cm	62.97	3.06	45.4	31.6	23.0	7.3	0.4	2.03	0.31	131.04	23.24	160
ile No.3												
cm	35.83	3.28	37.6	19.4	43.0	7.0	0.3	1.43	0.25	288.96	5.81	200
w 12 cm	50.30	3.16	34.4	31.6	35.0	6.9	0.3	-	0.54	285.60	5.81	270
ile No.4												
cm	66.45	3.37	24.6	52.4	23.0	7.6	0.3	1.77	0.57	248.64	2.49	360
w 13 cm	-	-	-	-	-	-	-	-	-	-	-	-
ile No.5												
cm	69.56	9.06	17.2	56.2	26.6	7.7	0.2	1.49	0.52	222.12	13.28	410
cm	66.54	10.51	41.4	23.8	34.8	8.0	0.3	1.67	0.52	174.72	7.47	360
w 22 cm	55.17	10.51	33.6	39.6	26.8	8.0	0.4	-	0.36	184.80	2.49	310

Table 4.4 Infiltration rate of soil of different land use classes in the lawana-2 Microwatershed

Land Use class	Elapsed Time, min.	Distance of water surface from refere. point, mm		Depth of infil-tration mm	Average infilt-ration rate cm/hr	Accumu-lated infilt-ration, cm.
		After infiltr-ation	After filling			
1.	2.	3.	4.	5.	6.	7.
Class III.a soil	0	-	75.00	-	-	-
	5	84.00	75.00	9.00	10.8	0.90
	10	80.00	75.00	5.00	6.00	1.40
	15	79.16	75.00	4.16	5.00	1.82
	20	78.83	75.00	3.83	4.60	2.20
	25	78.66	75.00	3.66	4.40	2.57
	30	78.50	75.00	3.50	4.20	2.92
	35	78.41	75.00	3.41	4.00	3.25
	45	81.67	75.00	6.66	4.00	3.92
	55	81.66	75.00	6.66	4.00	4.59
	65	81.66	75.00	6.66	4.00	5.22
	80	85.00	75.00	10.00	4.00	6.25
	95	85.00	-	10.00	4.00	7.25
Class III b soil	0	-	75.00	-	-	-
	5	85.41	75.00	12.25	14.70	1.23
	10	82.50	75.00	7.50	9.00	1.98
	15	80.66	75.00	5.66	6.80	2.54
	20	79.83	75.00	4.83	5.80	3.02
	25	79.50	75.00	4.50	5.40	3.47
	30	79.33	75.00	4.33	5.20	3.90

Contd...

Table 4.4 Contd...

1.	2.	3.	4.	5.	6.	7.
	35	79.25	75.00	4.25	5.10	4.33
	45	83.33	75.00	8.33	5.00	5.16
	55	81.00	75.00	8.27	4.96	5.99
	65	81.00	75.00	8.72	4.96	6.82
	80	87.40	75.00	12.40	4.96	8.06
	95	87.40	-	12.40	4.96	9.30
Class IV soil	0	-	75.00	-	-	-
	5	92.33	75.00	17.33	20.80	1.73
	10	85.50	75.00	10.50	12.6	2.78
	15	83.83	75.00	8.83	10.6	3.66
	20	83.33	75.00	8.33	10.0	4.49
	25	83.16	75.00	8.16	9.80	5.30
	30	83.00	75.00	8.00	9.60	6.10
	35	82.83	75.00	7.83	9.40	6.88
	45	90.34	75.00	15.34	9.20	8.41
	55	89.33	75.00	14.33	8.60	9.84
	65	89.33	75.00	14.33	8.60	11.27
	80	96.50	75.00	21.50	8.60	13.42
	95	96.50	-	21.50	8.60	15.57

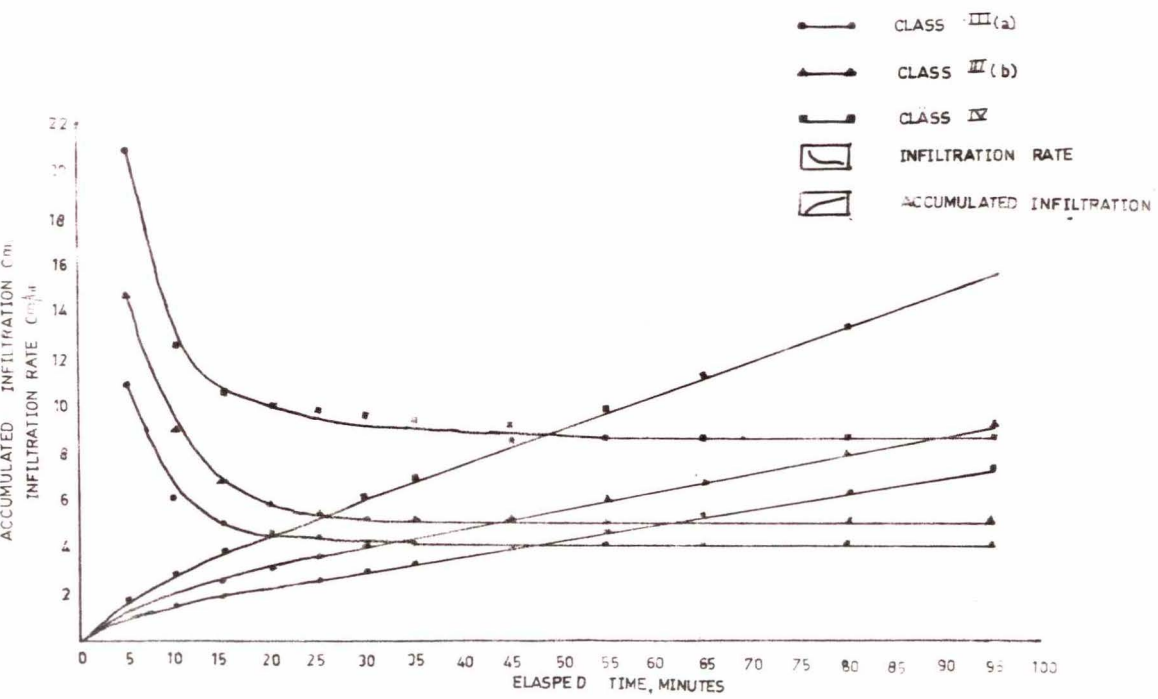


FIG 4.10 ACCUMULATED INFILTRATION AND INFILTRATION RATES OF DIFFERENT LAND USE CLASSES AGAINST ELASPED TIME

determination of values of constants is presented in Appendix-C. The results are shown in Fig. 4.11.

4.2 Socio-economic Description

The micro-watershed comprises the area of two villages, Lawana and Chandai. The total cultivators of the watershed are 23. For knowing the socio-economic condition of the farmers in the watershed, the detailed economic survey was undertaken by using standard questionnaries, From the report of the socio-economic survey it is observed that the population depending on the watershed is approximately 125 and the average family size is five per family. The male population is 52% and female population is 48%. About 50% of the population exceeds the age group of 21 years. Illiteracy percentage is high about 55% out of the total population. 20% persons maintain on wages as labourers. The economic status of the watershed is very poor and therefore it needs the integrated watershed development.

4.3 Present Land Use

4.3.1 Land use classification

The micro-watershed is utilized only for agril. crop, the land use capability classification is reported in Table 4.5 and the capability map is shown in fig. 4.12.

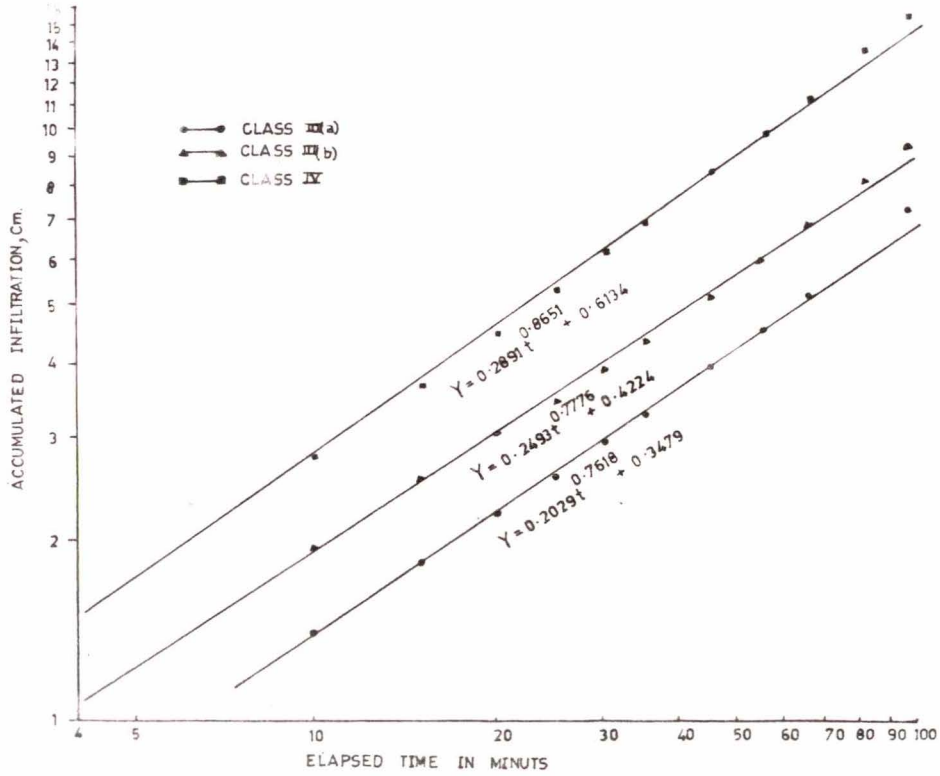


FIG. 4.11 ACCUMULATED INFILTRATION TIME RELATIONSHIP FOR DIFFERENT LAND USE CLASSES

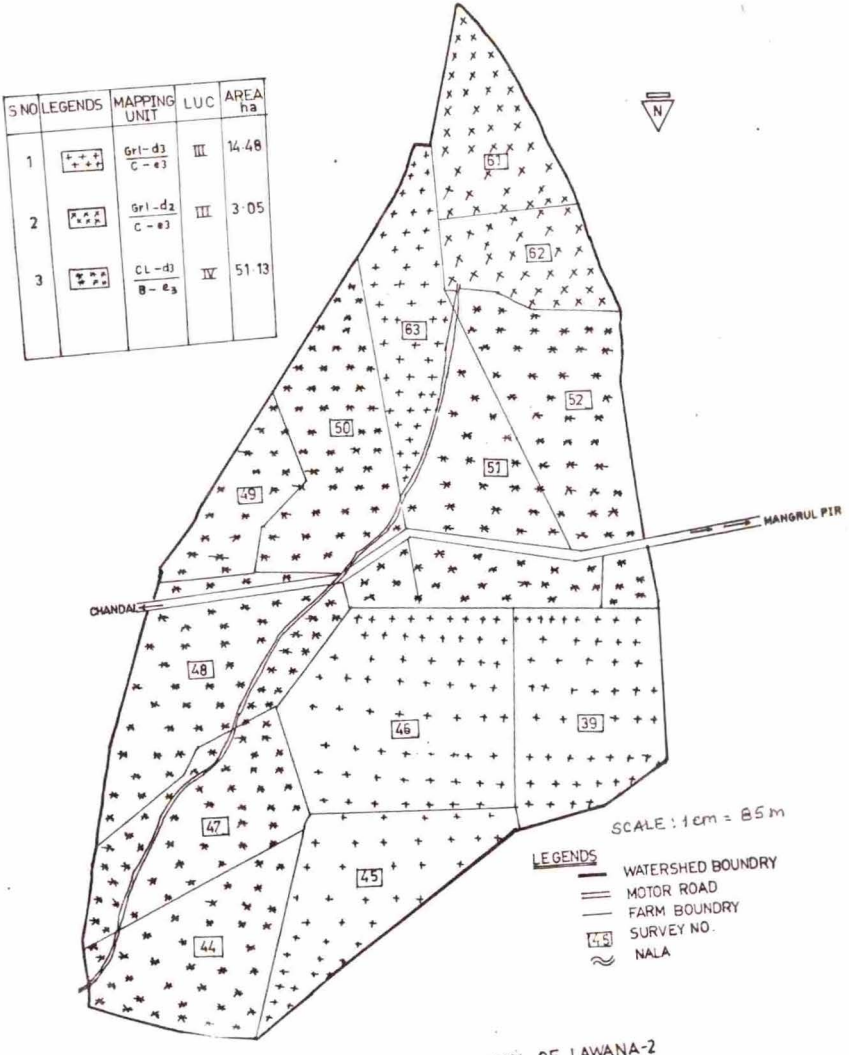


FIG 4.12 LAND USE CAPABILITY CLASSIFICATION OF LAWANA-2 MICROWATERSHED

Table 4.5 Land use capability classification of Lawana-2 micro-watershed

Sr. No.	Mapping Unit	Description	LUC	Area (ha)	Percent area
1.	$\frac{Grl\text{-}d3}{C\text{-}e3}$	Gravely loam with medium deep soil, 3 to 5% slope, severe erosion	III	14.48	21.10
2.	$\frac{Grl\text{-}d2}{C\text{-}e3}$	Gravely loam with shallow soil 3 to 5% slope, severe erosion	IV	51.13	74.47
3.	$\frac{CL\text{-}d3}{B\text{-}e3}$	Medium deep soil with clay loam, 1 to 3% slope moderate erosion	III	3.05	4.43

Source: State Deptt.of Soil Conservation, Manoli Project, Mangarulpir.

4.3.2 Land holding classification

There are 23 farmers who own total area 68.66 ha, out of which 12.89 ha is under nalla and road. The land holding classification of the area is presented in Table 4.6

Table 4.6 Land holding classification of Lawana-2 micro-watershed

Sr. No.	Size of holding ha.	No.of farmers	% of farmers	Area ha.	% Area
1.	Below 4	18	78.26	39.38	70.36
2.	4-6	3	13.04	15.12	20.02
3.	6-8	2	8.70	14.16	20.62

4.3.3 Present cropping pattern

At present the crops are grown only in kharif season. The major crops in the micro-watershed are Cotton and Sorghum; other crops like Udid, Mung and Pigeon pea are sown mainly as intercrops. Crop rotation is cotton-Sorghum followed by Sorghum-Cotton. As almost all area of the micro-watershed is under rainfed farming, the same crop rotation is adopted year after year. The present cropping pattern is shown in Table 4.7.

Table 4.7 Present cropping pattern of Lawana-2 micro-watershed.

Sr. No.	Crop	Area ha.	% Area
1.	Sorghum + G.gram/B.gram	33.40	50.89
2.	Cotton + Tur	22.37	40.11
	Total	55.77	100.00

4.3.4 Vegetative cover

There is a good vegetative cover of both plant and grasses in patches. The plant species met with are Ber (Ziziphus jojoba), Tamarind and Babul(Acacia nilotica) Very poor type of grasses such as kusal(Heteropogeon sp.) and schemea are found.

4.4 Problems and Needs of the Area

4.4.1 Soil and water conservation problems

The soils erosion is the major problem in the watershed due to slopy lands and improper methods of cultivations adopted by the farmers. There is a great need to conserve the moisture as after rainy season water is not available even for drinking purposes.

4.4.2 Needs of people

Adequate food production is not obtained from the cultivated land in the watershed, people in the watershed are not getting sufficient fuel for household purposes and fodder for their cattles.

4.4.3 Socio-economic problems

The socio-economic problems are as given below.

1. Size of the land holding is very less, minimum land holding is 0.24 ha.
2. Lack of sufficient money to invest in cultivation
3. Non-delination of crops to match the soil type
4. Non-adaptation of proper intercropping system.
5. Use of low levels of fertilizers
6. Non-introduction of oilseed crops
7. High yielding varieties of crops are not sown due to low input purchase power
8. Lack of plant protection measures.
9. Lack of complimentary enterprises to the farming system

10. Lack of sufficient know-how in agricultural system
11. Lack of spirit in raising their economic status
12. Mono-cropping system adaptation
13. Non-cooperation among the fellow farmers
14. Lack of competetion in increasing yields among the cultivators.
15. Developmental agencies were not involved in agril. production
16. Non-cooperation from some cultivators in implementatior of land development programme

4.5 Proposed Land Use

Table 4.8 shows the proposed land use cropping programme including afforestation cum forages and dryland horticultural crops. It indicates that the percent area is increased due to introduction of rabi crops. The map of proposed land use cropping is presented in Fig. 4.13.

4.6. Proposed Soil and Water Conservation Measures

For planning the development works, the micro-watershed is delineated by various measures such as graded bunding, Contour bunding, vegetative contour hedges, nalla bunding, and farm pond as against the erosion control, drainage development, rainfall utilization considering topography and land capability classes. The proposed soil and water conservation measures with delineated area is given in Table 4.9 and the map showing proposed measures is presented in Fig. 4.14.

Table 4.8 Proposed land use cropping programme

Sr. No.	Proposed land use cropping	Area	% area
1.	Agril. Crops		
A.	Kharif		
i)	Jowar Hy.	8.80	15.89
ii)	Cotton(Arborium)	6.60	11.92
iii)	Sunflower	8.80	15.89
iv)	Groundnut	4.40	7.94
v)	Bajara	6.60	11.92
vi)	Jowar Hy. + Pigeon pea(3:2)	3.52	6.36
vii)	Jowar Hy.+ Black gram(3:2)	2.64	4.76
viii)	Jowar Hy.+ Green gram(3:2)	2.64	4.76
B.	Rabi		
i)	Safflower	2.00	3.61
ii)	Wheat	2.00	3.61
iii)	Gram	2.00	3.61
2.	Farm forestry and forage Development		
A.	Forest crops	7.50	13.54
	i) Leucana leucocephala		
	ii) Eucalyptus teriticornis		
B.	Grasses		
	i) Stylo zanthus hamata		
	ii) Stylo zanthus scabra		
	iii) Cenchrus ciliaris		
3.	Dry land Horticultural Development	3.89	7.02
	Horticultural crops		
	i) Ber		
	ii) Awala		
	iii) Jambhul		
	iv) Custard apple		
		55.39	110.83

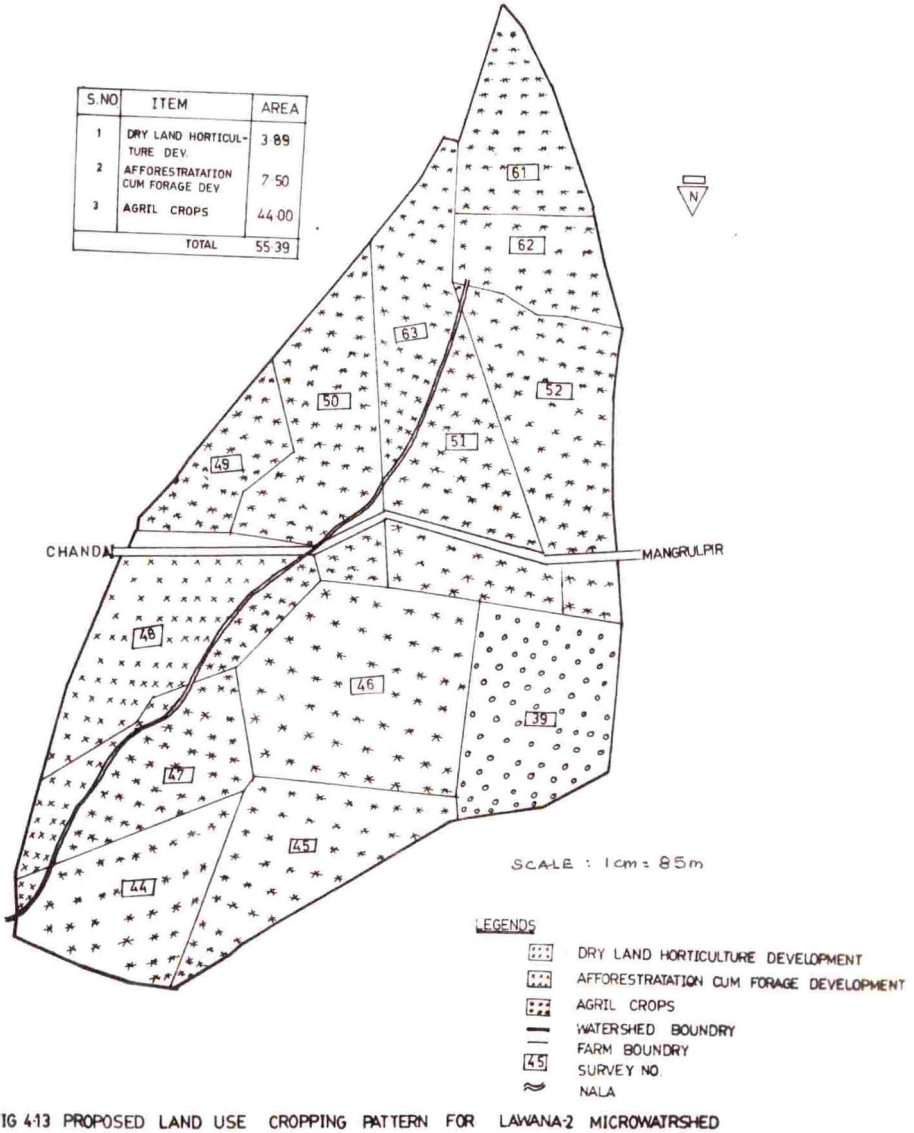


FIG 4·13 PROPOSED LAND USE CROPPING PATTERN FOR LAWANA-2 MICROWATRSHED

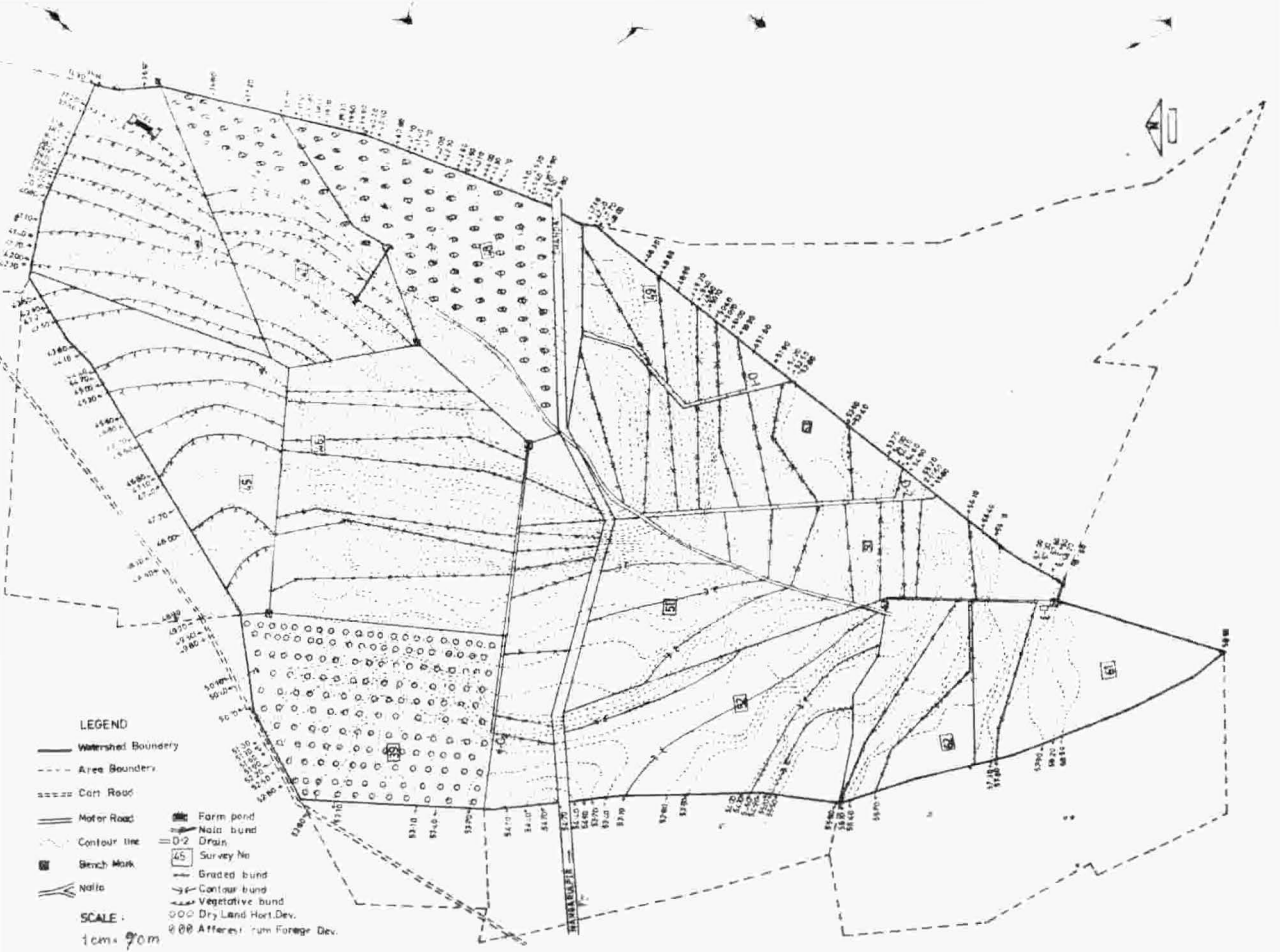


FIG.4-14 CONTOUR MAP OF LAWANA-2 MICROWATERSHED SHOWING PROPOSED SOIL AND WATER CONSERVATION MEASURES

Table 4.9 Proposed soil and water conservation measures in Lawana-2 micro-watershed

Sr.No.	Proposed conservation measures	Area, ha.
1.	Graded bunding	21.15
2.	Contour bunding	8.50
3.	Vegetative contour hedges	14.54
4.	Nalla bunding	1 No.
5.	Farm pond	1 No.

4.6.1 Graded bunding

Graded bunding is proposed in 21.15 ha for the safe disposal of excess runoff and minimise the soil loss. Graded bunds having uniform grade are proposed as the length of bunds is not more than 185 m and discharge is also less. An uniform grade of 0.2% was proposed for the bed of bund channel. The cross section area of the bund channel was calculated as 2.26 m^2 which will be suitable to carry the runoff by non erosive velocity. Side slopes of the bund was considered as 1:1 so as to save the farmer's cultivated land to a minimum possible unit and to provide stability to the bund.

The detailed design of graded bund is given in Appendix-D and the proposed cross section of graded bund is presented in Fig. 4.15 . Graded bunds may be laid out deviating from the true contour by a steady,continuous

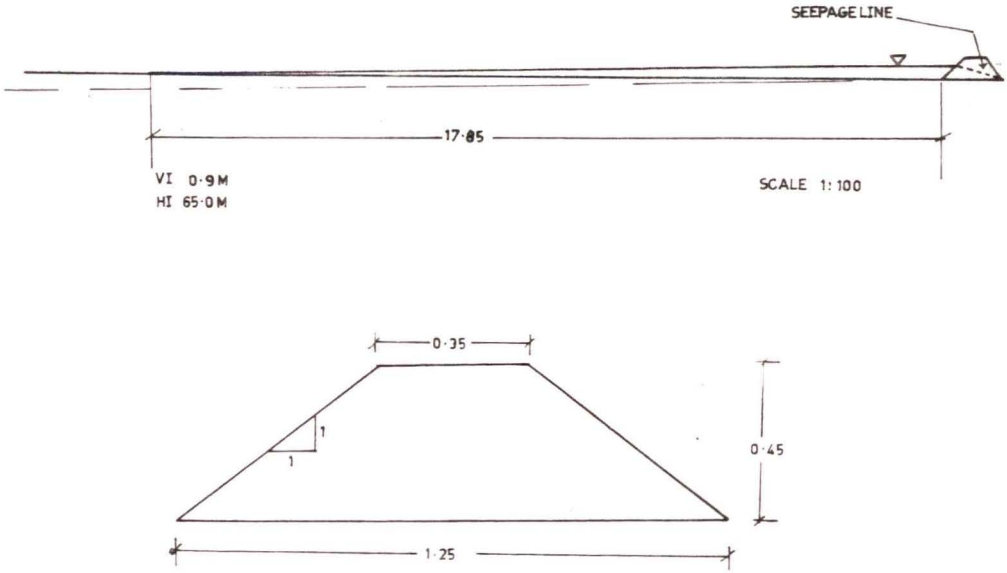


FIG 4·15 PROPOSED GRADED BUND SECTION

gradient, so as to achieve greater parallelism between terraces.

Four grassed water ways were proposed to drain the runoff water into natural drain with safe velocity. The sites of the grassed waterways are marked in the map shown in Fig. 4.14. It was assumed that 50% of the runoff water would have to be disposed through the proposed grass water way immediately after rains, remaining water will pass through this grassed waterway in 24 hrs. after rains. The grade 0.2% is considered for waterways for safe disposal of runoff with non-erosive velocity.

The sample computation of design of parabolic grassed waterway D-4 as suggested by Radhey Lal et al. (54) is presented in Appendix-E. The proposed design dimensions of various parabolic waterways are given in Table 4.10.

Table 4.10. Proposed design dimensions of various parabolic grassed waterways

Sr. No.	Drain No.	Top width m	Depth, m	Top width of flowing water, m	Depth of flowing water, m	C.S. area m^2	Length of waterway, m
1.	D_1	1.78	0.30	1.68	0.25	0.36	249
2.	D_2	4.54	0.48	4.38	0.40	1.45	384
3.	D_3	4.35	0.36	4.23	0.30	1.05	126
4.	D_4	1.86	0.42	1.72	0.35	0.52	315

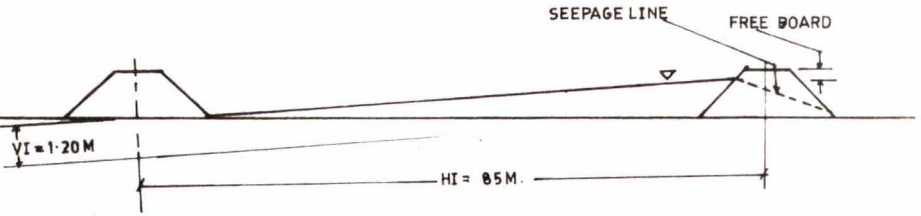
4.6.2 Contour bunding

Contour bunding is proposed in order to intercept the runoff to hold the water for moisture conservation and to check soil erosion. Contour bunds were proposed in the area where the soils are medium in depth and infiltration is moderate.

The design of contour bund is given in the Appendix F and proposed cross section for contour bund is presented in Fig. 4.16.

4.6.3 Vegetative contour headges

Vegetative contour hedges of vetiver grass (Vetiveria zizanioides)are proposed in 14.54 hectares. It will give the maximum benefits by conserving soil and water in situ. The cost of cultivation per hectare is also less in comparison to contour bunds. It will not be destroyed by the animals as it is denied by them. As stated by Greenfield (31) there is 50% increase in crop yields vetiveria hedges are one of the most beneficial assets in soil and water conservation in both high and low runoff conditions. It does have any design as the grass is planted on con tour line which can be demarketed in situ by ploughing a single furrow. The slips of grass are planted some what like rice seedling transplantation. The plantation of vetiveria grass is shown in Fig. 4.17.



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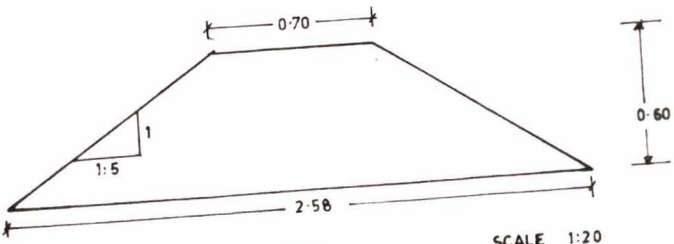

CROSS SECTION AREA 0·98 SQ M

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ALL DIAMENSION ARE IN METRE

FIG 4·16 PROPOSED CONTOUR BUND SECTION

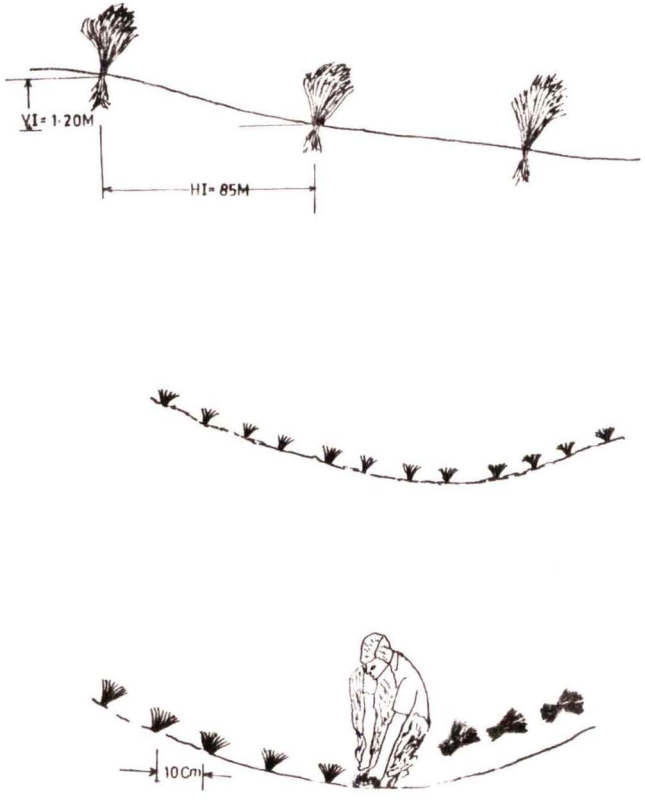


FIG 4.17 PLANTATION OF VETIVERIA GRASS ON CONTOUR

4.6.4 Nalla bunding

One nalla bund is proposed to harvest the runoff water for recharging of ground water and gully erosion below downstream. It will also help in protective irrigation by lifting the water and hence assuring the productivity. The water-storage of proposed nalla bund is 12462.78 cum out of 62820 cum, dependable yield. The map showing impounding of water and other details of nalla bund is presented in Fig. 4.18 and Fig. 4.19. The detailed design procedure is given in Appendix-G.

4.6.5 Farm pond

The basic objective in selecting the farm pond is to irrigate certain lowland fields by natural flow and the upland fields by forcing the water by pumps. Farm pond size is decided on the basis of total requirement of water for giving two life saving irrigation of 5 cm each to 6 ha. land proposed for rabi crop and livestock use.

Assuming the dimensions permissible at sites, the design dimensions are finalised. The capacity of the pond was calculated as 7299 cum. The dependable yield for farm pond was 83386.58 cum. The proposed site of the pond is parallel to the nalla, only one channel is designed which will work as inlet and outlet simultaneously. The detailed design of farm pond is given in Appendix-H and the plan and design dimensions of farm pond are

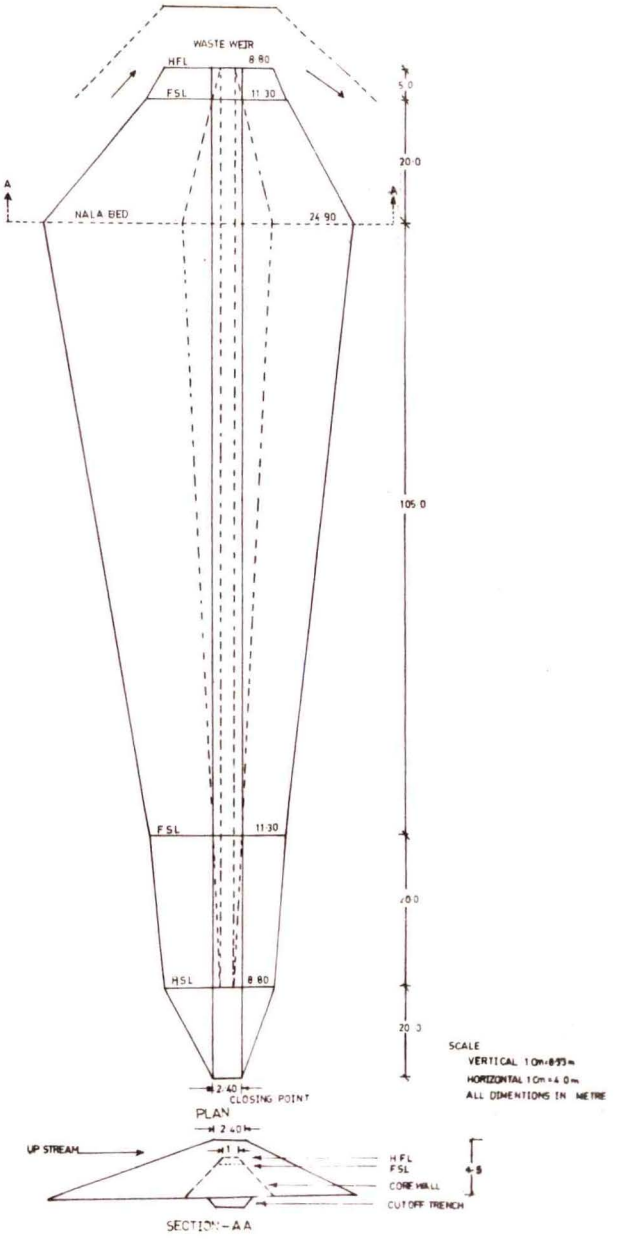
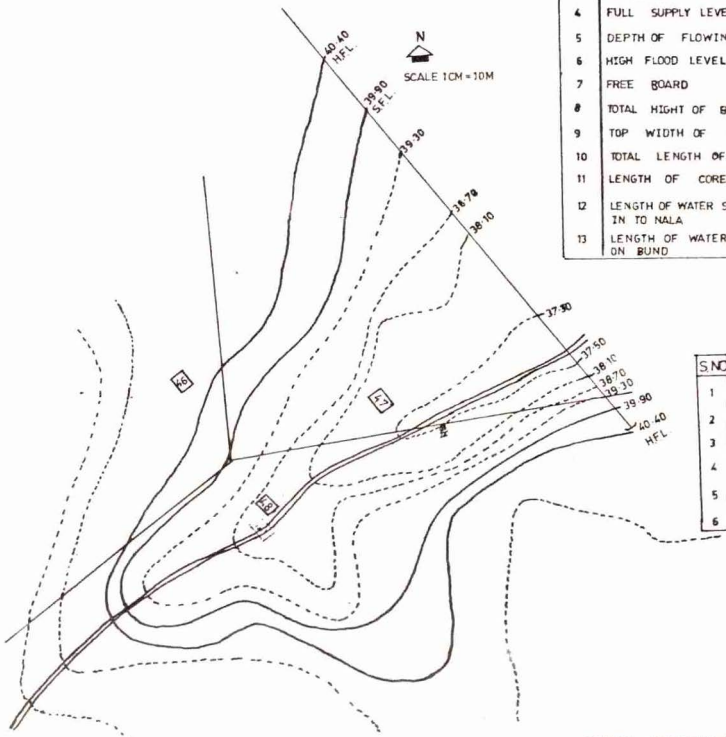


FIG418 DETAILS OF PROPOSED NALA BUND

SHORT NOTE

S.NO.	ITEMS	SIZE
1	TOTAL CATCHMENT AREA ------	45 ha
2	NALA BED LEVEL	37·80 M
3	DEPTH OF WATER IMPONDED	2·72 M
4	FULL SUPPLY LEVEL	39·90 M
5	DEPTH OF FLOWING WATER	0·50 M
6	HIGH FLOOD LEVEL	40·40 M
7	FREE BOARD	1·00 M
8	TOTAL HIGHT OF BUND	4·50 M
9	TOP WIDTH OF BUND	2·60 M
10	TOTAL LENGTH OF BUND	165·00 M
11	LENGTH OF CORE WALL	145·00 M
12	LENGTH OF WATER SPRREADING IN TO NALA	157·00 M
13	LENGTH OF WATER SPRREADING ON BUND	120·00 M



LEGENDS

S.NO	ITEMS	SIGN
1	SURVEY BOUNDRY	
2	SURVEY NO	45 39.90
3	CONTOUR LINE	
4	BENCH MARK	
5	NALA	
6	NALA BUND	

FIG 4.19 MAP SHOWING IMPOUNDING OF WATER AND OTHER DETAILS OF PROPOSED NALA BUNDING

presented in Fig. 4.20

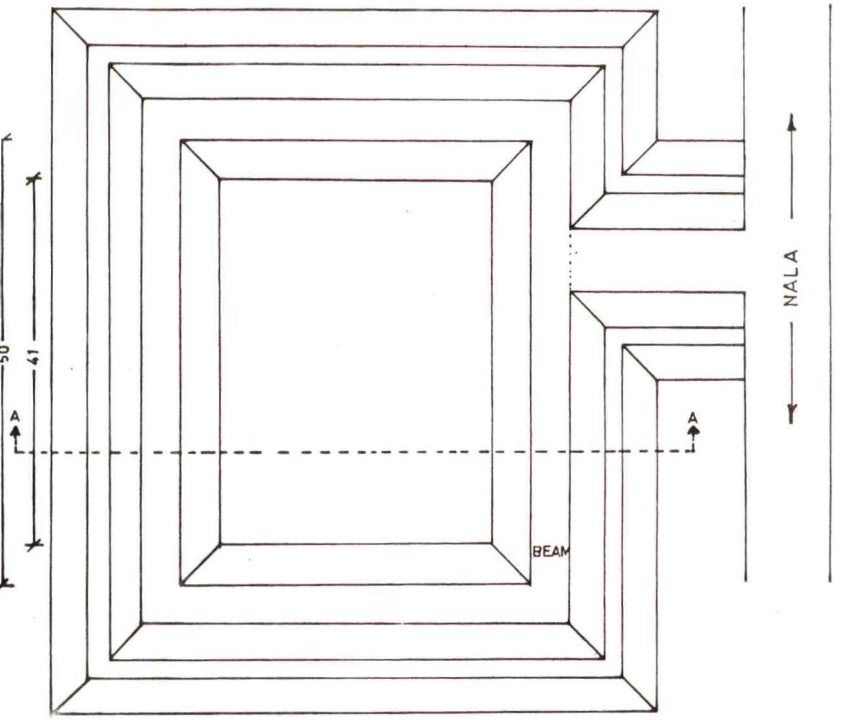
4.7 Economic Evaluation of Proposed Plan

Planning of micro-watershed was divided into three development programmes viz. soil and water resources development, afforestation cum forage development and dryland horticultural development. The cost involved in different development programmes are calculated separately.

The benefit cost analysis was carried out considering with and without the development costs and benefits and the period of analysis as 25 years.

The present value of benefits and costs were evoluated at 15% discount rate at which credit can be available for long term basis.

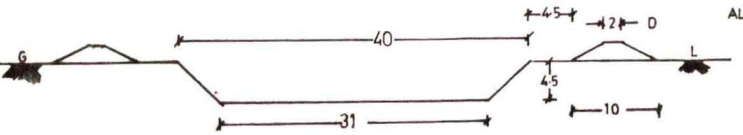
Soil and water resources development consisting graded bunding, contour bunding,contour cultivation with vegetative hedges, nalla bunding and farm pond are proposed. Estimates of cost and abstract of estimates of graded bunding, contour bunding,contour hedges,nalla bunding and farm pond are presented in Table I-1 to I-10 of Appendix-I respectively. The returns from present cropping programme and proposed cropping programme after development are given in Table J-1 and J-2 respectively of Appendix-J. Additional benefit due to proposed cropping is given in Table 4.11. The benefit cost ratio was calculated using the method suggested by Gitinger(20)and



PLAN

SCALE 1Cm=5M

ALL DIMENSION IN METRE



SECTION A A

FIG 4·20 DETAILS OF PROPOSED FARM POND

le 4.11 Additional net benefits due to proposed cropping programme

ject year considered the stable lds	Annual Net returns due to proposed cropping (Rs.)	Annual net returns due to local practices (Rs.)	Additional net returns (Rs.)	Additional net benefit per hectare (Rs.
th	191027.00	74474.00	116553.00	2649.00

Cost of cultivation per ha/year = $\frac{133893.64}{44}$

= 3043.00 Rs.

Additional net benefit per/ha/year = 2649.00 Rs.

Considering likelyhood of obtaining only 60% yield
The additional net return per year from the proposed cropping programme will be Rs. 40142.20 Say Rs. 40142.00

4.12. Cost and benefits of soil and water resource development at micro-watershed 'Lawana-2'

ct	Capital (Rs.)	Repair and maintenance at 5% of the capital (Rs.)	Total cost (Rs.)	Additional net benefit over local practices 60% considering only obtaining yield(Rs.)	Discount factor at the interest rate of 15% $\frac{1}{(1+i)^t}$	Present worth of cost(Rs.) $\frac{Ct}{(1+i)^t}$	Present worth of benefit(Rs.) $\frac{Bt}{(1+i)^t}$
	2.	3.	4.	5.	6.	7.	8.
	15260.00 (G.B., C.B., VCB)	-	15260.00	-	0.869	13260.94	-
	88442.00 (Farm pond, Nala B.)	763.00	89205.00	-	0.756	67438.98	-
		5185.00	5185.00	-	0.658	3411.73	-
		5185.00	5185.00	-	0.572	2965.82	-
		5185.00	5185.00	40142.00	0.497	2566.57	19950.57
		5185.00	5185.00	40142.00	0.432	2339.92	17341.34
		5185.00	5185.00	40142.00	0.376	1949.56	15093.39
		5185.00	5185.00	40142.00	0.327	1695.50	13126.43
		5185.00	5185.00	40142.00	0.284	1472.54	11400.33
		5185.00	5185.00	40142.00	0.247	1280.70	9915.07
		5185.00	5185.00	40142.00	0.215	1114.78	8630.53

Contd..

e 4.12 contd.

2.	3.	4.	5.	6.	7.	8.
	5185.00	5185.00	40142.00	0.187	969.60	7506.55
	5185.00	5185.00	40142.00	0.163	845.15	6543.15
	5185.00	5185.00	40142.00	0.141	731.08	5660.02
	5185.00	5185.00	40142.00	0.223	637.75	4937.47
	5185.00	5185.00	40142.00	0.107	554.80	4295.19
	5185.00	5185.00	40142.00	0.090	482.20	3733.21
	5185.00	5185.00	40142.00	0.081	419.98	3251.50
	5185.00	5185.00	40142.00	0.070	362.95	2809.94
	5185.00	5185.00	40142.00	0.061	316.28	2448.66
	5185.00	5185.00	40142.00	0.053	274.80	2127.53
	5185.00	5185.00	40142.00	0.046	238.51	1846.53
	5185.00	5185.00	40142.00	0.040	207.40	1605.68
	5185.00	5185.00	40142.00	0.035	181.48	1404.97
	5185.00	5185.00	40142.00	0.030	155.55	1204.26
					105874.57	144832.32

$$\text{B/C Ratio} = \frac{\frac{Bt}{(1+i)^t}}{\frac{Ct}{(1+i)^t}} = \frac{144832.32}{105874.57} = 1.367$$

found to be 1.367. The detailed costs and benefits of soil and water resource development is presented in Table 4.12.

Afforestation cum forage development programme consists of plantation of different fodder, fuel, timber trees and grasses in 7.50 ha in the survey no.48. The estimates of costs of proposed afforestation cum forage development is given in Table K-1 of Appendix-K. The cost worked out isRs.4677.00/ha. By taking 10% investment on maintenance the cash outflow-inflow per hectare was computed and given in Table K-2 of Appendix-K. Computation was done to calculate benefit-cost ratio and presented in Table 4.13. From this table it can be seen that at discount rate of 15%, the benefit cost ratio is 1.55.

Similarly, in dryland horticultural development programme the horticultural plants like Awala(Phyllanthus emblica), Custard apple (Annona squamosa),Ber(Zyzyphus jojoba) and Jamun (Syzigium cumins) were planted in survey No.39 over 3.89 ha. Estimates of costs for proposed dryland horticulture is Rs. 2277 per hectare. The detailed estimates of costs are given in Table L-1 and cash outflow-inflow is given in Table L-2 of Appendix-L.

The benefit cost ratio was computed and presented in Table 4.14. The benefit-cost ratio is 5.44 which indicates that this development programme is economically feasible and is the best ratio out of the three proposed development programmes.

e 4.13 Costs and benefits of afforestation cum forage development

ect	Cash outflow per hectare (Rs.) (Ct)	Cash inflow per hectare (Rs.)	Net benefit (Bt) (Rs.) (3-2)	Discount factor at 15% interest $\frac{1}{(1+i)^t}$	Present worth of cost $\frac{Ct}{(1+i)^t}$	Present worth of benefit $\frac{Bt}{(1+i)^t}$
	2.	3.	4.	5.	6.	7.
	4677.00	2500.00	-2177.00	0.756	3535.81	- 1645.81
	467.70	2500.00	2032.30	0.658	307.75	1337 .25
	467.70	750.00	282.30	0.572	267.52	161.47
	467.70	1000.00	532.30	0.497	232.45	264.55
	467.70	1000.00	532.30	0.432	202.05	229.95
	467.70	15000.00	14532.30	0.376	175.85	5464.14
	3255.00	2500.00	-755.00	0.327	1064.38	-246.88
	325.50	2500.00	2174.50	0.284	92.44	617.55
	325.50	750.00	424.50	0.247	80.98	104.85
	325.50	1000.00	674.50	0.215	69.98	145.02
	325.50	1000.00	674.50	0.187	60.87	126.13
	325.50	15000.00	14674.50	0.163	53.05	2391.94
	3255.00	2500.00	-755.00	0.141	458.95	-106.45
	325.50	2500.00	2174.50	0.123	40.04	267.46

Contd..

e 4.13 Contd..

2.	3.	4.	5.	6.	7.
325.50	750.00	424.50	0.107	34.82	45.42
325.50	1000.00	674.50	0.090	30.27	62.72
325.50	1000.00	674.50	0.081	26.36	54.63
325.50	15000.00	14674.50	0.070	22.78	1027.21
3255.00	2500.00	-755.00	0.061	198.55	-46.05
325.50	2500.00	2174.50	0.053	17.25	115.24
325.50	750.00	424.50	0.046	14.97	19.53
325.50	1000.00	674.50	0.040	13.02	26.98
325.50	1000.00	674.50	0.035	11.39	23.60
325.50	15000.00	14674.50	0.030	9.76	440.23
				7021.29	10880.68

$$\text{B/C Ratio} = \frac{\text{Present worth of benefit}}{\text{Present worth of cost}} = \frac{\frac{Bt}{(1+i)^t}}{\frac{Ct}{(1+i)^t}} = \frac{10880.68}{7021.29} = 1.549$$

e 4.14 Costs and Benefits of dryland Horticultural development

ect	Capital (Rs)	Maintenance (Rs.)	Cash outflow Rs/ha	Cash inflow Rs/ha	Margin Rs.	Discount factor at 15% interest $\frac{1}{(1+i)^t}$	Present worth of cost (Rs.) $\frac{Ct}{(1+i)^t}$	Present of benef (Rs.) $\frac{Bt}{(1+i)^t}$
	2.	3.	4.	5.	6.	7.	8.	9
	2277.00	-	2277.00	-	-2277.00	0.658	1465.36	-1465.36
		750.00	750.00	-	-750.00	0.572	429.00	- 429.00
		750.00	750.00	-	-750.00	0.497	372.75	- 372.75
		750.00	750.00	800.00	50.00	0.432	324.00	21.60
		750.00	750.00	3219.00	2469.00	0.376	282.00	928.34
		750.00	750.00	5092.00	4342.00	0.327	245.25	1419.83
		750.00	750.00	8838.00	8088.00	0.284	213.00	2296.99
		750.00	750.00	10184.00	9434.00	0.247	185.25	2330.20
		750.00	750.00	13730.00	12980.00	0.215	161.25	2790.70
	Replanting of custard apple	1239.00	1239.00	13730.00	12491.00	0.187	231.69	2335.82
		750.00	750.00	14530.00	13780.00	0.163	122.25	2246.14
		750.00	750.00	15330.00	14580.00	0.141	105.75	2055.78
		750.00	750.00	16130.00	15380.00	0.123	92.25	1891.74

Contd..

e 4.14 contd.

2.	3.	4.	5.	6.	7.	8.	9.
	750.00	750.00	15019.00	14269.00	0.107	80.25	1526.78
	750.00	750.00	15292.00	14542.00	0.092	69.75	1352.40
	750.00	750.00	15838.00	15088.00	0.081	60.75	1222.13
	750.00	750.00	16384.00	15634.00	0.070	52.50	1094.38
	750.00	750.00	16930.00	16180.00	0.061	45.75	986.98
	750.00	750.00	16930.00	16180.00	0.053	39.75	857.54
	750.00	750.00	16930.00	16180.00	0.046	34.50	744.28
	750.00	750.00	16930.00	16180.00	0.040	30.00	647.20
	750.00	750.00	16930.00	16180.00	0.035	26.25	566.30
	750.00	750.00	16930.00	16180.00	0.030	22.50	485.40
						4691.80	25533.42

$$\text{B/C ratio} = \frac{25533.42}{4691.80} = 5.442$$

The overall B/C ratio of the micro-watershed development programme is found to be 1.84 and hence the proposed development programme is economically viable.

4.8 Phasing of Development Works

The development works in the watershed are proposed to be completed in three years. The yearwise physical and financial targets are presented in Table 4.15.

Table 4.15. Phasing of the development works in Micro-watershed 'Lawana-2' showing yearwise physical and financial targets

Phasing	Development works	Targets		Total finances involved
		Physical	Financial	
1st Year	i) Graded Bunding	21.15	14164.00	
	ii) Contour bunding	8.50	6446.00	
	iii) Vegetative contour Bunding	14.54	4650.00	
2nd year	i) Nala bunding	1 No.	45085.00	
	ii) Farm pond	1 No.	43357.00	
	iii) Afforestation cum Forage development	7.50	35075.00	
3rd year	Dryland Horticultural Development	3.89	8856.00	157633/-

It shows that the work can easily be completed in three years and total cost of the development is amounting to Rs.25260.00 in first year, Rs.123517.00 in second year and Rs.8856.00 in third year.

The total cost involved for the micro-watershed development amounts to Rs.157633.00

CHAPTER V

SUMMARY AND CONCLUSIONS

In agricultural production, economic and ecological stability is an essential theme of integrated watershed development. Water is the chief agent causing erosion, catchment degradation including loss of protective cover and also the transporting the eroded materials. Again loss of proper cover and productivity of land surfaces are due to inability in optimizing use of available rain water through conservation and re-use, particularly to tide over dry spells and increasing yield potentials, thereafter, both control measures and productive land management system should involve essentially the management of rainfall and resultant runoff.

Land and water resources are not unlimited, there is therefore, increasing realization that they must be put to efficient use. Studies with a view to develop watershed for optimizing the use of land and water resources are important.

Integrated development of a microwatershed with special reference to soil and water conservation has been taken. A micro-watershed 'Lawana-2' from Manoli Watershed was selected for the purpose. Manoli watershed Lawana-2 from Manoli watershed was selected for the purpose. Manoli watershed is situated near Mangarulpir Tahsil in Akola district.

The area of micro-watershed was surveyed, hydrological data was analysed. Delineated the areas for different soil and water conservation measures. An intensive cropping programme was proposed. Soil and Water conservation measures viz. graded bunding, contour bunding, nalla bunding and farm pond were designed and the economical analysis of the proposed plan was done . The following salient conclusions are drawn.

1) Intensity of rainfall of 24 hrs duration for 25 year recurrence interval is 175.00 mm.

2) Probability analysis of rainfall and evaporation data shows that, even in monsoon, two life saving irrigations, one in first week of July and one in third week of August are needed for the most kharif crops.

3) Twenty fifth week is suitable for sowing operations

4) Rabi crops cannot be grown in the watershed without providing adequate irrigation facilities

5) Total runoff yield of the watershed is 95489.36 cum.

6) Total yield impounded in nalla bunding is 19.84%.

7) A farm pond designed to store 8.75% of the total yield, that can provide two life saving irrigations of 5 cm each for six hectares.

8) The benefit cost ratios were calculated separately and it shows that the highest benefit, cost ratio of 5.44 for dryland horticultural development followed by 1.55 for afforestation cum forage development and 1.37 for soil and water resource development programme.

9) Proposed development plan boosts net returns of the watershed from Rs. 74474.00 to Rs. 191027.00 with overall benefit cost ratio of 1.84 which indicates the economical worthiness of the plan.

CHAPTER VI

SUGGESTIONS FOR FUTURE WORK

1) Rainfall intensity duration frequency studies at Akola station should be carried out as these values are required for designing the conservation structures

2) Effect of different vegetative cover on runoff and soil loss before and after development are necessary

3) Monitoring of the development work with special reference to soil and water conservation should be carried out.

4) The proposed development programme should be evaluated at five years interval after implimentation

5) By constructing a runoff guaging station at an outlet of microwatershed, the water balance studies should be carried before and after development.

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Appendix A

Table A-1. Weekly average weather data recorded at Agromet. observatory, P.K.V.,Akola(1971-1980)

Std. Met. week	Temp. °C Maxi.	Mini.	R.H. % At morning 7.22 hrs.	At Evening 14.22 hrs.	Pan Evap. mm	Wind velocity km/hr	Sunshine Hrs/day
1.	2.	3.	4.	5.	6.	7.	8.
1	29.4	10.5	63	27	5.2	6.1	9.3
2	29.9	11.1	63	25	5.4	5.3	9.5
3	30.1	11.4	60	24	5.8	6.8	9.4
4	30.0	11.7	65	27	6.0	7.3	9.2
5	30.6	12.0	56	24	6.3	7.3	9.5
6	30.7	11.4	53	22	6.9	7.1	9.3
7	32.6	13.3	51	21	7.6	7.2	9.6
8	33.5	15.1	55	23	7.9	7.5	9.2
9	35.0	15.5	46	16	9.2	8.6	9.7
10	36.1	16.6	39	14	10.3	8.2	10.0
11	37.6	17.5	34	14	10.8	7.3	10.0
12	39.4	19.1	31	11	11.7	7.0	9.8
13	39.7	21.3	32	13	13.0	8.8	9.6
14	40.5	22.0	31	11	13.3	9.2	10.0
15	41.4	22.8	28	10	15.1	10.6	10.3
16	41.8	23.5	29	11	14.1	9.2	10.5
17	42.3	24.3	35	12	14.4	10.8	10.1
18	43.1	25.6	34	11	16.8	12.8	10.4
19	43.2	26.8	42	13	19.1	14.4	10.3
20	42.1	26.7	50	17	18.2	16.3	9.3
21	42.0	26.9	49	19	19.0	17.7	10.4
22	41.4	27.3	59	22	17.1	16.9	9.4
23	39.2	26.5	67	35	14.9	17.5	7.3
24	38.4	25.5	68	38	12.8	17.6	7.7
25	35.6	25.0	74	50	10.6	15.4	7.1
26	31.1	23.7	83	61	6.6	13.8	3.8

Contd...

Table A-1 Contd..

1.	2.	3.	4.	5.	6.	7.	8.
27	32.8	24.3	84	62	6.7	14.4	4.5
28	31.3	23.4	86	65	5.5	14.0	3.1
29	32.4	24.5	83	62	7.6	12.9	9.6
30	33.2	23.2	84	60	7.0	13.5	5.3
31	31.4	22.9	86	66	5.3	12.6	4.2
32	30.2	22.8	86	68	4.8	12.5	3.3
33	30.5	22.3	86	64	5.1	12.6	4.7
34	30.3	22.1	88	67	4.6	12.1	4.3
35	30.0	22.5	87	61	4.2	11.0	3.8
36	31.0	22.2	86	61	5.1	10.2	6.2
37	32.1	22.3	85	54	5.9	10.5	7.6
38	34.2	22.3	82	49	6.2	7.3	8.2
39	34.1	21.6	83	48	6.0	6.3	8.2
40	33.9	18.9	80	44	6.5	7.8	8.2
41	34.7	19.4	75	35	6.3	4.7	9.2
42	34.5	18.5	71	34	6.7	4.9	8.7
43	33.4	16.6	73	37	6.2	5.2	8.7
44	32.7	15.0	70	30	6.2	5.4	9.0
45	32.6	15.0	69	27	6.1	5.1	8.8
46	32.0	14.0	68	28	5.7	6.3	8.8
47	31.4	14.1	72	32	5.6	6.3	8.9
48	29.6	13.8	74	36	4.7	5.8	8.4
49	29.2	12.6	71	31	4.9	6.0	8.9
50	29.4	10.8	70	26	4.3	5.8	9.5
51	29.3	10.9	68	29	4.9	5.8	9.1
52	29.8	10.9	65	28	5.1	5.5	9.2

Table A-2. Weekly average rainfall recorded at Mangarulpir Station (1971-80)

Std. No.	Meteorological week Period	Weekly average rainfall mm	Std. No.	Meteorological week Period	Weekly average rainfall mm
1	7-7 January	0.30	27	2-8 July	61.15
2	8-14	2.00	28	9-15	53.52
3	15-21	0.00	29	16-22	26.58
4	22-28	0.20	30	23-29	38.19
5	29-4 February	0.00	31	30-5 August	55.44
6	5-11	2.70	32	6-12	59.30
7	12-18	1.86	33	13-19	40.62
8	19-25	4.10	34	20-26	60.93
9	26-4 March	0.42	35	27-2 Sept.	65.24
10	5-11	2.03	36	3-9	56.01
11	12-18	0.32	37	10-16	16.22
12	19-25	0.00	38	17-23	28.30
13	26-1 April	1.40	39	24-30	28.12
14	2-8	1.40	40	1-7 October	28.90
15	9-15	0.00	41	8-14	13.90
16	16-22	0.00	42	15.21	1. 60
17	23-29	0.00	43	22-28	7.83
18	30-6 May	0.00	44	29-4 November	1.10
19	7-13	0.00	45	5-11	3.07
20	14-20	2.07	46	12-18	0.52
21	21-27	0.30	47	19-25	7.45
22	28-3 June	11.42	48	26-2 December	5.30
23	4-10	19.71	49	3-9	1.30
24	11-17	22.93	50	10-16	0.00
25	18-24	39.37	51	17-23	0.60
26	25-1 July	53-90	52	24-31	1.24

Table A-3. Maximum annual rainfall of 24 hours duration at Mangarulpir station

Year	Maximum rainfall in 24 hrs,mm
1967	30.0
1968	59.0
1969	82.0
1970	185.0
1971	68.0
1972	46.0
1973	109.0
1974	43.0
1975	90.0
1976	112.0
1977	68.0
1978	60.2
1979	94.0
1980	54.8
1981	67.0
1982	140.0
1983	123.4
1984	64.4
1985	70.0
1986	82.0

Table A-4. Maximum annual rainfall of one week duration at Mangarulpir

Std. Meteorological week	Maximum annual rainfall of one week duration (mm)
23	107.0
24	153.0
25	105.0
26	190.0
27	124.0
28	140.0
29	223.0
30	121.3
31	146.6
32	141.0
33	152.0
34	229.0
35	228.0
36	275.8
37	125.7
38	128.4
39	99.0
40	96.0
41	164.4
42	12.0
43	70.0
44	11.0

Table A-5. Estimated weekly rainfall, mm at various probabilities at Mangarul

Standard Met.weeks	Rainfall at various probabilities			
	50%	60%	70%	80%
23	7.29	-	-	-
24	20.25	14.06	9.73	5.06
25	25.00	18.66	13.39	8.23
26	51.26	36.00	25.00	13.32
27	33.64	22.09	12.25	5.06
28	37.94	26.21	16.00	7.84
29	34.45	23.52	17.22	9.92
30	30.25	22.09	13.69	7.29
31	54.26	40.96	30.25	18.06
32	49.00	36.00	22.56	12.25
33	37.45	25.00	16.81	8.41
34	11.56	8.00	3.24	-
35	12.25	5.95	-	-
36	5.76	1.18	-	-
37	12.25	5.29	-	-
38	13.69	2.25	-	-
39	13.76	6.25	-	-
40	-	-	-	-
41	-	-	-	-
42	-	-	-	-
43	-	-	-	-
44	-	-	-	-

Table A-6. Estimated weekly pan evaporation at various probabilities based on data at Akola station

Standard Met.week No.	Pan evaporation at various probabilities			
	40%	50%	60%	70%
23	13.50	14.50	15.50	16.50
24	11.60	12.60	13.50	14.50
25	9.25	10.25	11.40	12.50
26	6.75	7.40	7.90	8.50
27	5.35	6.25	7.20	8.15
28	4.60	5.50	6.50	7.50
29	5.40	6.00	6.75	7.50
30	4.70	5.00	5.50	5.75
31	4.00	4.50	5.10	5.65
32	4.00	4.40	4.75	5.20
33	4.20	4.50	4.75	5.10
34	4.50	4.90	5.25	5.75
35	4.25	4.70	5.00	5.50
36	4.20	4.60	5.00	5.50
37	4.15	4.50	5.00	5.45
38	4.25	4.75	5.25	5.65
39	4.75	5.25	5.60	6.00
40	5.25	5.50	5.95	6.25
41	5.20	5.50	6.00	6.50
42	5.25	5.50	5.85	6.25
43	5.20	5.50	5.75	6.00
44	5.15	5.45	5.75	6.00

Table A-7. Estimated weekly evapo-transpiration at various probabilities at Mangarulpir station

Standard Met.week No.	Evapotranspiration at various probabilities				Weighted value of crop factor
	40%	50%	60%	70%	
23	9.72	10.44	11.16	11.88	0.35
24	8.35	9.21	9.72	10.44	0.35
25	6.66	7.38	8.20	9.00	0.35
26	4.86	5.32	5.68	6.12	0.35
27	3.85	4.50	5.18	5.86	0.37
28	3.31	3.96	4.68	5.40	0.40
29	3.88	4.32	4.86	5.40	0.42
30	3.88	3.60	3.96	4.14	0.46
31	2.88	3.24	3.67	4.06	0.57
32	2.88	3.16	3.42	3.74	0.67
33	3.02	3.24	3.42	3.67	0.78
34	3.24	3.52	3.78	4.14	0.86
35	3.06	3.38	3.60	3.96	1.00
36	3.02	3.31	3.60	3.96	1.07
37	2.98	3.24	3.60	3.92	1.07
38	3.06	3.42	3.78	4.06	1.06
39	3.42	3.78	4.03	4.32	1.01
40	3.78	3.96	4.28	4.50	0.91
41	3.74	3.96	4.32	4.68	0.82
42	3.78	3.96	4.21	4.50	0.50
43	3.74	3.96	4.14	4.32	0.46
44	3.70	3.92	4.14	4.32	0.42

Appendix B. Morphological description of typical soil profiles

Depth (cm)	Description
Profile 1	: Very dark, greyish brown(10 YR 3/2)
0-16	clay; boulder 1%; platy; dryhard, moistfriable; wet sticky and plastic; fine, few porous; slight effervescence; cracks developed (1.2 cm wide);pH 7.5; clear smoth boundary
16-54	: Dark greyish brown(10 YR 4/2)silty clay; moderate, medium,sub-angular, blocky structure; dryhard;moist firm; wet sticky and plastic; very fine to medium soils, sticker sides; crack developed (1 to 2 cm wide)
Below 60 cm	: Slight effervescence, pH 7.5 very fine pores, diffused boundary, Dark yellowish brown(10 YR 4/4) Silty clay loam, No structure, Murum, dryhard, wet non-sticky, slight effervecence with dilute Hcl pH 8.0
Profile 2	: (Survey No.45)
0-8 cm	Dark brown (10 YR 3/3), silty clay loam, granular structure,surface boulders 5%, dryhard, moist-friable,wet sticky and plastic,very fine few pores,very fine few rocks,very fine few cracks,No

Appendix B contd..

Depth (cm)	Description
	effervecence with dilute Hcl pH 7.9
8-23 cm	: Dark yellowish brown (10 YR 3/4);silty clay, gravelty, fine gravels, sub-angular blocky structure, dryhard, moistfriable, wet sticky and plastic, No effervescence with dilute Hcl pH 7.3
Below 23 cm	: Yellowish brown (10 YR 5/4), murum, no effervecence with dilute Hcl,clay-loam, pH 7.3.
Profile-3	: (Survey No. 44)
0-12 cm	: Dark reddish brown (5 YR 3/4); sandy clay, 75% stones, on the surface granular structure dryhand,moist friable, nonsticky,nonplastic,very fine rocks, no effervescence with Hcl, pH 7.00.
Below 12 cm	: Murum, silty clay loam,structureless, no effervecence with dilute Hcl,pH 6.9
Profile-4	: (Survey No. 50)
0-13 cm	: Dark yellowish brown(10 YR 3/4) stone 75%,silty-clay,dryhard,moist friable, wet sticky and plastic,basaltic nodules in the surface soils,very fine few pores no effervescence with dilute Hcl,pH 7.6
Below 13 cm	: Murum

Appendix B contd..

Depth (cm)	Description
Profile-5	: (Survey No. 63)
0-8 cm	: Very dark grayish brown (10 YR 3/2); silty clay, platy structure,dry hard, moist friable,wet sticky and plastic, coarse pores, very fine few rocks, strong effervecence with dil.Hcl, sticken slides cracking upto 8 cm. depth, pH 7.7. Nodules of $CaCO_3$ very fine few
8-22 cm	: Very dark grayish brown (10 YR 3/2); sandy clay-loam coarse fragments of basaltic material,sub angular block structure,dryhard, moist friable wet sticky and plastic fine few pores,fine many nodules of $CaCO_3$, strong effervecence with dil. Hcl. sticken slides, pH 8.0.
Below 22 cm	: Murum, loam, structureless.

Appendix -C

Sample computation for determination of values of constants a, α and b in modified Kostiakov's formula by Devis method

Using modified Kostiakov's formula to express infiltration of water in the soil as,

$$y = a\, t^{\alpha} + b \qquad (3.4)$$

in which,

y = infiltration rate with respect to t

t = accumulated time of application

a, α and b= constants

By refering Table 4.4

t_1 = 5 min.; y_1 = 1.23 cm

t_2 = 95 min; y_2 = 9.30 cm

$t_3 = \sqrt{t_1 x t_2}$

$= \sqrt{5 \times 95}$

= 21.79 min.; y3 corresponding to t_3=3.10 cm

(From Fig. 4.10)

$$b = \frac{(1.23 \times 9.30) - (3.10)^2}{(1.23 + 9.30) - 2(3.10)}$$

$$= \frac{1.829}{4.33}$$

$$= 0.4224$$

Taking log of equa. (1);

$\log (y-b) = \log a + \alpha \log t$

$\log (y - 0.4224) = \log a + \alpha \log t$ (1)

Appendix-C contd..

By using eq. (1) for different values of t, twelve equations were formed as,

i) $-0.0928 = \log a + \propto 0.6989$

ii) $0.1925 = \log a + \propto 1.0000$

iii) $0.3258 = \log a + \propto 1.1761$

iv) $0.4146 = \log a + \propto 1.3010$

v) $0.4840 = \log a + \propto 1.3979$

vi) $0.5413 = \log a + \propto 1.4771$

vii) $0.5919 = \log a + \propto 1.5440$

viii) $0.6755 = \log a + \propto 1.6532$

ix) $0.7457 = \log a + \propto 1.7404$

x) $0.8060 = \log a + \propto 1.8229$

xi) $0.8830 = \log a + \propto 1.9031$

xii) $0.9483 = \log a + \propto 1.9777$

Adding equations (i) to (vi) and (vii) to (xii) separately, two equations were obtained as :

$$1.8654 = 6 \log a + 7.051 \propto \quad (2)$$

$$4.6504 = 6 \log a + 10.6314 \propto \quad (3)$$

By substracting equa. (2) from equa. (3),

$$2.785 = 3.5804 \propto \quad (4)$$

$$\therefore \propto = 0.7778$$

By putting value of $\propto$ in equa. (2), the value of constant 'a' was obtained $\therefore a = 0.2493$

Hence,

$$y = 0.2493 \ t^{0.7778} + 0.4224 \quad (5)$$

Appendix-D

Design of Graded Bund

Assumptions

a) Side slope of bund for silty clay

Soil = 1:1

b) Bund channel's uniform bed slope = 0.2%

c) Runoff co-efficient (c) for cultivated land having 1.4 % average slope = 0.5

Then,

i) Length of the watershed from most remote point to the lowest point = 1570 m.

ii) Elevation difference = 22.08 m

iii) Average slope of watershed = 1.40 %

iv) Using Ramser's formula to calculate verticle interval,

$$V.I. = 0.3 \left(\frac{S}{3} + 2 \right) = 0.74 \text{ m}$$

Adding 25% extra V.I. as against moderate infiltration, good vegetation and conservation practices like contour farming.

$$V.I. = 0.74 + 0.185 = 0.925 \text{ m}$$

Say 0.9 m

v) $$HI = \frac{VI}{S} \times 100 = 64.28 \text{ m}$$

say 65.00 m

vi) Length of bund = 310 m.

vii) Length of path of water (L) = 310 + 65

= 375 m

Appendix D Contd..

viii) Finding the elevation between two consecutive bunds from highest point to the outlet point as

1.40 % slope for 65 m = 0.91 m

0.2 % slope for 310 m = 0.62 m

H= 1.53 m

ix) Using Kirpich formula in F.P.S. system for calculation of time of concentration as

$$T_c = 0.0078\ k^{0.77}$$

in which $K = \sqrt{\frac{L^3}{H}}$

$$K = \sqrt{\frac{12303}{5.0184}}$$

$$k = 19256.4$$

$$T_c = 0.0078 \times 19256.4^{0.77}$$

$$= 15.53 \text{ min.}$$

x) By refering Vanjari et al. (86)

$I = 17.99$ cm/hr

xi) $A = 310 \times 65 = 2.015$ ha

xii) Using Ramser's runoff formula

$$Q = \frac{CIA}{36}$$

$$Q = \frac{0.5 \times 17.99 \times 2.015}{36}$$

$$Q = 0.5035 \text{ m}^3/\text{sec.}$$

xiii) Check for velocity

Assuming, depth of water (d) = 25 cm

$a_1 = 2.2321$ m^2

$a_2 = 0.03125$ m^2

$a = 2.26335$ m^2

$S_1 = 17.8589$ m

$S_2 = 0.3536$ m

Appendix D contd...

Wetted perimeter (P) = $S_1 + S_2$

= 18.2125 m

Using $R = \frac{a}{P} = \frac{2.26335}{18.2125} = 0.1243$ m

Using Manning's equation,

$$V = \frac{R^{2/3} S^{1/2}}{n} = \frac{0.1243^{2/3} \times 0.002^{1/2}}{0.04}$$

= 0.2785 m/sec.

Using continuity equation,

Q = av.

= 2.26335 x 0.2785 = 0.6303 m^3/sec

Thus the bund channel have sufficient capacity to carry the runoff by non-erosive velocity.

The design dimensions for graded bunding assuming approximate value of slope of seepage line 4:1 and free board 20 cm, are

1) Height of bund = 45 cm
2) Base width of bund= 1.25 m
3) Top width of bund = 0.35 m
4) Side slope = 1:1
5) Free board = 20 cm.
6) H.I. = 65 m
7) V.I. = 0.9m

Appendix-E

Design of vegetative waterway (D4)

Using rational runoff formula for computing peak rate of runoff

$$Q = \frac{CIA}{36}$$

in which,

C = 0.50

A = 12.92 ha

$T_c = 0.0078\ K^{0.77}$

in which $K = \sqrt{\frac{L^3}{H}}$

R.L. of most remote point = 53.10 m

R.L. of lowest point = 43.80 m

H = 9.30 m

= 30.5 ft.

Length of path of water (L) = 525 m

= 1722.0 ft.

$$K = \sqrt{\frac{1722^3}{30.5}}$$

$$= 12938.97 \text{ ft}^2$$

$$T_c = 0.0078 \times 12938.97^{0.77}$$

= 11.43 minutes

By referring Vanjari et al. (86)

I = 19.5 cm/hr.

$$Q = \frac{0.5 \times 19.5 \times 12.92}{36}$$

$= 3.499\ m^3/sec$

say $3.5\ m^3/sec$.

Appendix E contd..

It is assumed that 50% of runoff will have to be disposed through the proposed grassed waterway immediately after rains. Remaining water will pass through this grassed waterway within 24 hours after the rains.

Design Q = 1.75 m^3/sec.

Length of waterway = 384 m

Drop in the waterway = 8.4 m

Slope = $\frac{8.4}{384}$ = 0.022 m/m

For parabolic cross section area

A = 2/3 td

in which

t = top width of flowing water

d = depth of water flow

Wetted perimeter, $p = t + 8/3 \frac{d^2}{t}$

Hydraulic radius, $R = \frac{2/3\ t\ d}{t + 8/3 \frac{d^2}{t}}$ (1)

Considering permissible velocity should not be less than 1 m/sec and more than 2.5 m/sec, Radhey Lal and Datta, A.C.(~~1986~~ 87),

= 1.50 m/sec

Cross-section area, $A = \frac{Q}{v} = \frac{1.75}{1.50} = 1.167\ m^2$

or $2/3\ t\ d = 1.167\ m^2$

Hence, $t.d. = \frac{1.167 \times 3}{2} = 1.75\ m^2$ (2)

Appendix E Contd...

Substituting in manning's equation,

$$= \frac{R^{2/3} S^{1/2}}{0.04}$$

$$1.5 = \left(\frac{2/3\ t\ d}{t + 8/3\ \frac{d2}{t}} \right)^{2/3} \times 0.022^{1/2} \times \frac{1}{0.04}$$

$$\left(\frac{2/3\ t.d}{t + 8/3\ \frac{d2}{t}} \right)^{2/3} = \frac{1.5}{3.708} = 0.4045$$

$$\frac{2/3\ t.d}{t + 8/3\ \frac{d^2}{t}} = 0.2572 \qquad (3)$$

Substituting value of t in terms of d. as

$$t\ d = 1.75$$

$$t = \frac{1.75}{d}$$

$$\frac{1.167}{\frac{1.75}{d} + 8/3\ \frac{d3}{1.75}} = 0.2572$$

$$\frac{0.4502}{d} + 0.3909\ d^3 = 1.167 \qquad (4)$$

Solving equation (4) by trial and error method,

$$d = 40 \text{ cm}$$

$$t = \frac{1.75}{0.40} = 4.375 \text{ m}$$

say 4.38 m

Adding 20% freeboard;

$$D = 0.48 \text{ m}$$

and $T = 4.54$ m

Appendix E contd..

Cross section area of excavation = 2/3 x 4.54 x 0.48

= 1.45 m^2

The plantation of hariyali grass was proposed. Thus, proposed design dimensions of grassed waterway are:

1) top width (T) = 4.54 M
2) total depth of excavation (D) = 0.48 M
3) Top width of flowing water(t) = 4.38 M
4) depth of flowing water (d) = 0.40 M
5) Cross section area = 1.45 m^2
6) length of waterway = 384 m

Appendix-F

Design of contour Bund

A. Design of bund section

According to Michael and Ojha (~~1978~~ 42) the vertical interval for the land having 1 to 1.5 % slope is taken as 1.20 m.

$\therefore$ V.I. = 1.20 m

$$\text{H.I.} = \frac{\text{V.I.}}{S} \times 100$$

$$= \frac{1.20 \times 100}{1.40} = 85.71 \text{ m}$$

say 85 m

One hour rainfall intensity for 25 years recurrence interval is taken 79 mm as suggested by Vanjari et al.(86) and average infiltration rate of the soil is 5.85 cm/hr.

$$\therefore \text{\% of rainfall to be infiltrated} = \frac{5.85 \times 100}{10.00} = 46.22\ \%$$

Say 45%

Expected maximum rainfall in 24 hrs. during 25 year recurrence interval is 17.5 cm taken from frequency graph. Fig. 4.5

$\therefore$ Maximum runoff to be stored in the bund = Rainfall-Infiltration

$$= (17.5) - \frac{17.5 \times 45}{100}$$

$$= 9.625 \text{ cm}$$

Storage area required, $A = \frac{9.625}{100} \times 85$

$$\therefore A = 8.18125 \text{ m}^2 \qquad \text{(i)}$$

Appendix F contd..

Assuming depth of water = d, and side slope 1.5:1 area of cross section of ponded water

$$a_1 = 35.7143\ d^2$$

$$a_2 = 0.75\ d^2$$

$$\therefore A = 36.4643\ d^2 \qquad \text{(ii)}$$

Equating (i) and (ii)

$$36.4643\ d^2 = 8.18125$$

$$\therefore d^2 = 0.22436$$

$$\therefore d = 0.47367 \text{ m}$$

say, 50 cm

Taking freeboard 20% of d i.e. 10 cm,

$\therefore$ Height of bund = 50 + 10 = 60 cm

Assuming seepage line slope 4:1

$\therefore$ Base width = 2.585 m

say 2.58 m

$\therefore$ Top width = 0.7 m

Thus, proposed design dimensions of contour bund are :

i) Base width = 2.58 m

ii) Top width = 0.7 m

iii) Height of bund = 60 cm

iv) Side slope = 1.5: 1

v) H.I. = 85 m

vi) V.I. = 1.2 m

vii) section = 0.98 sqm.

Appendix F contd..

B. Design of waste weir

Using rational peak runoff rate formula,

$$Q = \frac{CIA}{36}$$

in which, C = 0.5

A = 2.00 ha

Using Kirpitch equation for calculating the time of concentration,

$$T_c = 0.0078\ K^{0.77}$$

in which $K = \sqrt{\frac{L^3}{H}}$

Where, L = 120 m = 393.6ft.

H = 1.2 m = 3.936 ft.

$$\therefore K = \sqrt{\frac{393.6^3}{3.936}} = 3936\ ft^2$$

$$\therefore T_c = 0.0078 \times 3936^{0.77}$$

= 4.57 minutes

say 5.00 minutes

By refering, Vanjari et al. (86)

$$I = 24.25$$

$$\therefore Q = \frac{0.5 \times 24.25 \times 2}{36}$$

$$= 0.674\ m^3/sec$$

The minimum length of outlet was calculated by weir formula

$$Q = 1.711\ LH^{3/2}$$

$$\therefore L = \frac{Q}{1.711 \times H3/2}$$

Appendix F contd..

Where, $Q = 0.674\ m^3/sec$

$H = 0.5\ m$

$$L = \frac{0.674}{1.711 \times 0.5^{1.5}} = 1.114\ m$$

Say 1.12 m

Thus proposed design dimensions of waste weir are :

1) Length of crest = 1.12 m
2) Height of weir = 0.5 m

Appendix G

Design of Nala Bunding

A. Computation of Dependable yield for Nala bunding

Dependable yield is calculated by the method as reported by Dahigaonkar (11) as under.

20 yrs. rainfall data at Mangrulpir was arranged in descending order.

The dependable rainfall was determined by

$$SN = \frac{p}{100} \times N$$

in which, SN = Serial Number

p = dependability

N = No.of years whose data is taken

Assuming 60% dependability

$$SN = \frac{60}{100} \times 20$$

$$= 12$$

The dependable rainfall at 12th position is 69.08 cm

Using Inglis formula

$$R_{(cm)} = \frac{P(P-17.74)}{254}$$

in which, R = Runoff, cm

P = dependable rainfall, cm

$$R_{(cm)} = \frac{69.08\ (69.08-17.74)}{254}$$

$$= 13.96 \text{ cm}$$

yield = catchment area x runoff

= 45 x 10000 x 0.1396

= 62820 cum.

Appendix G Contd.

B. Design of Waste weir

Design Runoff Rate,

$$Q = \frac{CIA}{36}$$

Time of concentration,

$$T_c = 0.0078\ K^{0.77}$$

$$K = 3.2\sqrt{\frac{L^3}{H}}$$

$$= 3.2\sqrt{\frac{1110^3}{17.88}}$$

$$= 27986.635$$

T_c = 20.71 minutes

I = 163.228 mm/hr
from Table A.5

$$= \frac{0.3 \times 16.23 \times 45}{36}$$

= 6.09 cumecs

Design Q = $1.711\ LH^{3/2}$

Assuming H = 0.50 m

$$6.09 = 1.711\ L\ (0.50)^{3/2}$$

$$L = 10.06$$

Say length of weir = 10.00

C. Design of embankment

Full supply level is 39.90 m taken from contour map.

Height of water upto FSL = 39.90-37.18 = 2.72

Appendix G contd..

HFL will be 40.40 m by adding depth of water over crest

Height of water upto HFL,

= RL of HFL- RL of Nala Bend

= 3.22 m

Fetch, F= 0.6 km measured from contour map

Height of waves $H_w = 0.384 \ F + 0.763 - 0.271 \ F^{0.25}$

= 0.8219 m

Hence, 1m freeboard was considered as it is greater than wave height.

Height of dam = Height of water upto HFL + free board

= 4.22 m

Consolidation (5%) = $\frac{5}{100}$ x 4.22

= 0.211 m

Gross height of dam = 4,22 + 0.211

= 4.431 m

Say, 4.50 m

Top width of dam = $\frac{H}{5}$ + 1.5

= 2.40 m

Upstream and downstream slopes was taken 3:1 and 2:1 respectively as suggested by Gurmel Singh (28).

Appendix -G contd..

D. Design of core wall

Bottom of width of outoff trench was calculated as per equation 3.19

$w = h-d$

Assuming depth of trench is 0.75 m

$w = 3.22 - 0.75$

$= 2.47$

Assuming seepage line slope as 5:1 and 3:1 for previous portions and core wall respectively. The saturation line meets below downstream face which makes the section stable.

Appendix-H Design of Farm Pond

A. Computation of Dependable yield for farm pond

By using the same method given in Appendix-G the dependable yield is calculated for the catchment area of farm pond.

Yield = Catchment area x runoff

= 68.66 x 10000 x 0.1396

= 95849.36 cum.

Surface runoff of retained in nala bunding is 12462.78 cum.

Net yield for form pond,

= 95489.36 - 12462.78

= 83386.58 cum

B. Water requirement for livestock use

Assuming average livestock of each farmer of the watershed observed in socio-economic survey. The required quantity of water is calculated as follows.

1. Cow/ Buffalo = 1x 12 x 150 = 1800 litres

3 Goats = 3 x 4 x 150 = 1800 litres

Total livestock requirement of farmer = 3600 litres

Total No.of farmers = 23 No.

The water requirement for livestock = 3600 x 23

=82800 litres

= 82.80 cum.

Appendix-H contd.

For Irrigation use

To apply two protective irrigation of 5 cm to 6 ha(Proposed irrigated area) land water requirement will be :

$$= 2 \times 6.0 \times 100 \times 100 \times \frac{5}{100}$$

= 6000 cum.

Total water requirement

= 82.80 + 6000 = 6082.80

Taking 20% of the above towards evaporation, seepage and other losses.

$$= 6082.80 \times \frac{20}{100}$$

= 1216.56 cum.

Required pond capacity

= 6082.80 + 1216.56

= 7299.36 cum.

Say 7299 cum.

C. Design for the 7299 cum.capacity farm pond

Permissible depth = 4.5 m

side slope = 1:1

Assuming top dimensions as = 50 m x 40 m

Bottom dimension = 41 m x 31 m

Dimension at mid depth = 45.5 m x 35.5 m.

Appendix H contd..

Using Prismoidal formula,

Calculated volume = 7299 cum.

which is equal to design volume

Therefore pond dimensions are

Botton = 41 m x 31 m Depth = 4.5 m

top = 50 m x 40 m Side slopes 1:1

D. Design of inlet and outlet

Site for farm pond was selected in the survey no. 47 paralled to the nala bank. Therefore, only one waste weir have to design which will act as a inlet and outlet simultaniously.

Design Runoff rate, $Q = \frac{CIA}{36}$

Time of concentration,

$T_c = 0.0078\ K^{0.77}$

$K = 3.2\sqrt{\frac{L^3}{H}}$

$= 3.2\sqrt{\frac{15003}{21.48}}$

$= 40111.576$

$T_c = 27.33$ minutes

One hour rainfall intensity for 27.33 as per Vanjari et al. (86)

I = 14.20 cm/hr.

Appendix -H contd.

$$Q = \frac{0.3 \times 14.20 \times 60}{36}$$

$$= 7.1 \text{ cumecs}$$

The depth of Nala near farm pond is 0.50 m. Therefore hight of water over crest is assumed 0.50 m.

$$L = \frac{Q}{1.711 \times h^{3/2}}$$

$$= \frac{7.1}{1.711 \times 0.5^{3/2}}$$

$$L = 11.7368 \text{ m}$$

Say = 12 m

Length of crest = 12 m

and height over crest = 0.5 m

Appendix I

Table I-1. Estimates of earth work of graded bunding

Sr. No.	Item of work	No.	Length (m)	Average width (m)	Area (m^2)	Average section (m^2)	Quantity of earth work (m^3)	Rate (Rs./ unit)	Amount (Rs.)
1.	Proposed graded bunds	34	6240	-	-	0.36	2246.40	3.50/m^3	7862.40
2.	Stone outlet work	34	-	-	-	-	34 No	17.00/No.	578.00
3.	Grassed waterways	4	1074	-	-	0.845	907.53	3.50/m^3	3176.35
4.	Plantation of grass in waterways	-	1074	3.27	3511.98	-	-	3.91/14m^2	980.84
5.	Providing watchman for protection	-	10.74	3.27	3511.98	-	-	75/Ha	26.34
							Total cost		12623.93

Table I-2. Abstract of Estimates of Graded Bunding

Sr. No.	Item of works	Cost of work (Rs.)
1.	Earth work (bunds + waterways)	11038.75
2.	Construction of stone outlets	578.00
3.	Plantation of grass in waterways including watchman charges	1007.18
4.	Survey during construction @ 2.0 %	552.48
	Total Rs.	12876.41
5.	10% contingency for aminities and facilities	Rs. 1287.64
	Grand Total	14164.06
	Say Rs.	14164/-

1. Total area = 21.15
2. Survey numbers benifited = 46, 49, 50, 52, 61, 62, 63
3. Total estimated cost = Rs. 14,164/-
4. Cost per ha = Rs. 669.69

Say Rs. 670/-

Table I-3. Estimates of earth work of Contour Bunding

Sr. No.	Item of work	No.	Length (m)	Width (m)	Area (m^2)	Total area	depth (m^2)	Cross section area (m^2)	Quantity of earth work (m^3)	Rate Rs/ m^3	Amount (Rs.)
1.	Proposed contour Bunds	7	1668.00	-	-	-	-	0.98	1634.64	3.50	5721.24
2.	Waste weir stone pitching	7									
	a) weir side-1		0.18	1.14	0.2052						
	b) weir side-2		0.18	1.14	0.2052						
	c) weir side-3		1.87	0.50	0.9350						
	d) weir side-4		1.12	1.14	1.2768						
					2.62/No	18.35	0.15	-	2.75	8.63	23.76
									Total cost		5745.00

Table I-4. Abstract of estimates of Contour Bunding

Sr. No.	Item of work	Cost of work
1.	Earth work	Rs. 5721.24
2.	Construction of waste weirs	Rs. 23.76
3.	Survey during construction @ 2.0%	Rs. 114.90
	Total	Rs. 5859.90
4.	10% contingency for aminities and facilities	Rs. 585.99
	Grand total	Rs. 6445.89
	Say Rs.	6446.00

1. Total area = 85 ha
2. Survey numbers benifited = 51, 52
3. Total estimated cost = Rs.6446.00
4. Cost per hectare Rs. 758.35
   Say Rs. 758.00

Table I-5 Estimates of plantation of vetivera grass on Contour

Sr. no.	Item of work	Row spacing slip to slip(m)	Width(m)	Distance	Total length (m)	Quantity	Rate Rs/unit	Amount
1.	Preparation of furrows by ploughing along contours for transplanting	-	0.3	-	4140	0.124 ha	129/ha	16.00
2.	Cost of vetivera grass slips as per P.K.V.,rate	0.10	-	-	4140	41400 Nos.	0.10	4140.00
3.	Cost of transportation from P.K.V. to the watershed	-	-	74 km.	-	74 km.	1.00/ km.	74.00
4.	Cutting of tops off about 20 cm from base and separation of clumps into slips	-	-	-	-	41400 Nos.	Rs.0.50 per 100 slips	103.50
5.	Transplanting of slips in furrows	-	0.3	-	4140	1240 m^2	2.73/ $15m^2$	225.68
						Total cost		4559.18

Table I-6. Abstract of estimate of plantation of Vetivera grass

Sr.No.	Particular	Amount Rs.
1.	Cost vetivera grass with plantation charges	4559.18
2.	2% contingency	91.18
		4650.36
	Say Rs.	4650.00

i) Total cost - 4650.00
ii) Area of work - 14.54 hectares
iii) Survey No.of work - 44, 45 and 47
iv) Per hectare cost - Rs. 319.80

Table I-7. Estimated of earth work of Nala bunding

Nala Bund Earth work = 4237.90 cum
Earth work of outlet = 200.00 cum
} Total earth work 4437.90 cum.

Sr. No.	Item of work	Classification	Quantity cum	Rate	Amount Rs.
1.	Earth work	i) Excavation and spreading of soil with 25% soft murum, 10m lead and 1 m lift. (30% of earth work	1271.37	3.20	4060.38
		ii) Excavation and spreading of soil with 50% soft murum, 10m lead and 1 m lift(40% of earth work)	1695.16	4.00	6780.64
		iii) Excavation and spreading of hard murum with 10m lead, 1m lift	1271.37	5.87	7457.07
2.	Outlet work	i) Excavation of hard murum with 50% debris(50% of out let work)	100	6.93	693.00
		ii) Excavation of hard with more than 50% debris(50% of outlet work)	100	10.13	1013.00
3.	Lift work	Additional lift work above 1 m height	2117.95	1.00	2117.95
4.	Ramming with water charges	Ramming with watering of core wall and cutoff trench	1073.10	1.60	1620.96
5.	Lead	Additional lead above 10m to 50m	4437.90	3.20	14201.28
6.	Dressing	Dressing of bund	3806.15	0.26	989.60
				Total	38941.88
7.	Stone pitching work	Collection of stone and spreading over the upstream of bund upto HFL	233.45 sq.m.	6.00	1400.70
				Grand Total	40342.58

Table I-8. Abstract of estimates of Nala Bunding

Sr. No.	Particulars	Amount, Rs.
1.	Earth work cost	38,941.88
2.	Pitching work cost	1,400.70
3.	Survey work cost during planning	24.00
4.	Survey work cost during construction	620.00
		40,986.58
5.	10% contingency	4,098.65
		45,085.23
	Say	45,085.00

Table I-9 Estimates of earth work of farm pond

Total earth work = 7299.0 cum.

Sr. No.	Item of work	Classification	Quantity cum.	Rate Rs.	Amount Rs.
1.	Earth work	i) Excavation and spreading of soil with 25% soft murum, 10 m lead and 1 m lift	1912.00	3.20	6118.40
		ii) Excavation and spreading of soil with 50% soft murum, 10 m lead and 1 m lift	3771.00	4.00	15084.00
		iii) Excavation and spreading of hard murum with 10m lead and =1m lift	1616.00	5.87	9485.92
2.	Lift work	Additional lift work in 1-5 m	5387.00	1.00	5387.00
3.	Dressing	Dressing of dug out area and embankments	10371.00	0.26	2696.46

			Total		38771.78

Table I-10. Abstract of estimates of farm pond

Sr. No.	Particulars	Amount, Rs.
1.	Earth work cost	38,771.78
2.	Survey work cost during planning	24.00
3.	Survey work cost during construction	620.00
		39,415.78
4.	10% contingency	3,941.57
		43,357.35
	Say	43,357.00

Appendix J

Table J-1 Existing cropping pa-ttern and Annual net returns due to local practices before development

Existing land use cropping	Area (ha)	Cost of cultiv-ation (Rs/ha)	Total cost of cultiv-ation (Rs.)	Main product			Byproduct			Total returns (Rs.) (7+10)	Net returns (Rs.) (11-4)
				Yield (Q/ha)	Rate (Rs/ Q)	Returns (Rs.) (5x6x2)	Yield (Q/ha)	Rate (Rs./ Q)	Returns (2x8x9)		
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12
Kharif											
1.Sorghum + G.gram/ B.gram	33.40	1000.00	33400.00	7.00	138.00	32264.40	18.00	50.00	30060.00	62324.40	
				1.00	400.00	13360.00	1.25	70.00	2922.50	16282.50	
										78606.90	45206.90
2.Cotton + Tur	22.37	1200.00	26844.00	2.50	480.00	26844.00	7.50 stalk	10.00	1677.75	28521.75	
				1.50	530.00	17784.15	7.50 stalk	30.00	5107.50	22891.65	
						-	3.00 fodder	70-00	4697.70	4697.70	
										56111.10	29267.10
											74474.00

Table J-2. Proposed land use cropping programme and annual net returns after development

Proposed land use cropping	Area (ha)	Cost of cultivation (Rs/ha)	Total cost of cultivation (Rs.)	Main Product			Byproduct			Total Returns (Rs.) (7+10)	Net returns (11-4)
				Yield (Q/ha)	Rate (Rs/Q)	Returns (Rs.) (5x6x2)	Yield (Q/ha)	Rate (Rs/Q)	Returns (Rs.) (2x8x9)		
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12
Agril.Crops											
A. Kharif											
1. Jowar Hy.	8.8	2965.00	26092.00	30.00	138.00	36432.00	60	50.00	26400.00	62832.00	36740.00
2. Cotton (Arborium)	6.6	3019.00	19925.40	12.00	505.00	39996.00	36	10.00	2376 .00	42372.00	22446.60
3. Sunflower	8.8	2764.00	24323.2	10.00	626.00	55088.00	30	10.00	2640.00	57728.00	33404.80
4. Groundnut	4.4	3784.00	16649.6	8.50	686.00	25656.40	17	70.00	5236.00	30892.40	14242.80
5. Bajara	6.6	1772.00	11695.2	15.00	174.00	17226.00	37.5	50.00	12375.00	29601.00	17905.80
6. Jowar Hy.+ P.pea(3:2)	3.52	2993.00	10535.36	34.00+ 1.1	138.00 530.00	16515.84 2052.16	68+ 4.95	50.00 30.00	11968.00 522.72	28483.84 2574.88	20523.36
7. Jowar Hy.+ B.gram(3:2)	2.64	3021.00	7975.44	30+2.3	138.00 421.00	10929.60 2556.31	60+ 3.45	50.00 70.00	7920.00 637.56	18849.60 3193.87	14068.03
8. Jowar Hy.+ G.gram(3:2)	2.64	3021.00	7975.44	30+2.3	138.00 378.00	10929.60 2295.21	60+ 3.45	50.00 70.00	7920.00 637.56	18849.60 2932.77	13806.93
B. Rabi											
1. Safflower	2.00	1458.00	2916.00	10.00	644.00	12880.00	-	-	-	12880.00	9964.00
2. Wheat	2.00	1665.00	3330.00	10.00	248.00	4960.00	13	40.00	1040.00	6000.00	2670.00
3. Gram	2.00	1238.00	2476.00	9.00	342.00	6156.00	11.25	70.00	1575.00	7731.00	5255.00
	44.00	-	133893.64	-	-	243673.12	-	-	81247.84	324920.96	191027.32

Appendix-K

Table K-1. Estimates of costs of proposed dryland horticultural development

Sr. No.	Item of work	cost/ha (Rs.)	Area	Amount (Rs.)
1.	Cost of survey during construction	20.00	3.89	77.80
2.	Live fencing	360.00	3.89	1400.40
3.	Digging of 276 pits per hectare at the spacing 8mx8m for Ber, Awala, Jambhul and 4x4m for oustard apple @Rs.1.25 per pit	345.00	3.89	1342.05
4.	Filling the pits @ Rs.10/100 pits	27.60	3.89	107.36
5.	Cost of poly bagged plants of			
	i) Zyziphus jojoba (Ber)-40 plants @ Rs.2.50 per plant	100.00	3.89	389.00
	ii) Phyllanthus emblica(Awala)-40 plants @ Rs.1.00 per plant	40.00	3.89	156.60
	iii) Annona squamosa (Sitaphal) -156 plants @ Rs.1.00 per plant	156.00	3.89	606.84
	iv) Syzigium cumins (Jambhul)-40 plants @ Rs.1.00 per plant	40.00	3.89	155.60
6.	Cost of super phosphate,F.Y.M. and B.H.C. 10% @ Rs.1.00per pit	276.00	3.89	1073.64
7.	Planting of grafts/seedlings @ Rs.10/species	40.00	3.89	155.60
8.	Watering and mulching as and when needed in a year @ Rs.2/pit.	552.00	3.89	2147.28
9.	Spraying and dusting required 2 times @ Rs.15.00/time/species	120.00	3.89	466.80
10.	Training of the tree 2 times @ Rs.10.00/species	80.00	3.89	311.20
11.	Protection by providing watchman	75.00	3.89	291.75
				8681.92
12.	Contingency at 2%			173.64
			Total	8855.56
			Say Rs.	8856.00

1)Area of work = 3.89 ha.(2) Survey no.of work = 39 (3)Total cost=Rs.8856.00
4)Per hectare cost = 2276.60 Say Rs. 2277.00

Table K-2. Cash inflow per hectare in proposed dryland horticultural development

Project year	Zyziphus jojoba (Ber)		Phyllanthus emblica (Awala)		Custard apple (Sitaphal		Syzigium cumins (Jambul)		Total returns (Rs.) (3+5+ 7+9)
	Yield kg/plant	Amount for 40 plants @ Rs.2.00 per kg. (Rs.)	Yield (kg/plant)	Amount for 40 plants @ Rs.3/- per kg. (Rs.)	Yield (No.of fruits per plant	Amount for 156 plants @ Rs. 0.35/ fruit (Rs.)	Yield (kg/ plant)	Amount for 40 plants @ Rs. 2/- per kg.	
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
3.	-	-	-	-	-	-	-	-	-
4.	-	-	-	-	-	-	-	-	-
5.	-	-	-	-	-	-	-	-	-
6.	10	800.00	-	-	-	-	-	-	800.00
7.	30	2400.00	-	-	15	819.00	-	-	3219.00
8.	50	4000.00	-	-	20	1092.00	-	-	5092.00
9.	60	4800.00	20	2400.00	30	1638.00	-	-	8838.00
10.	70	5600.00	20	2400.00	40	2184.00	-	-	10184.00
11.	70	5600.00	25	3000.00	50	2730.00	30	2400.00	13730.00
12.	70	5600	25	3000.00	50	2730.00	30	2400.00	13730.00
13.	70	5600.00	25	3000.00	50 + replanting	2730.00	40	3200.00	14530.00

Contd....

Table K-2 Conted...

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
14.	70	5600.00	25	3000.00	50	2730.00	50	4000.00	15330.00
15.	70	5600.00	25	3000.00	50	2730.00	60	4800.00	16130.00
16.	70	5600.00	25	3000.00	15	819.00	70	5600.00	15019.00
17.	70	5600.00	25	3000.00	20	1092.00	70	5600.00	15292.00
18.	70	5600.00	25	3000.00	30	1638.00	70	5600.00	15838.00
19.	70	5600.00	25	3000.00	40	2184.00	70	5600.00	16384.00
20.	70	5600.00	25	3000.00	50	2730.00	70	5600.00	16930.00
21.	70	5600.00	25	3000.00	50	2730.00	70	5600.00	16930.00
22.	70	5600.00	25	3000.00	50	2730.00	70	5600.00	16930.00
23.	70	5600.00	25	3000.00	50	2730.00	70	5600.00	16930.00
24.	70	5600.00	25	3000.00	50	2730.00	70	5600.00	16930.00
25.	70	5600.00	25	3000.00	50	2730.00	70	5600.00	16930.00

Table L-1. Estimates of costs of proposed afforestation cum forage development

Sr. No.	Item of work	cost/ha (Rs.)	Area (ha)	Amount (Rs.)
1.	Cost of survey during construction	20.00	7.50	150.00
2.	Live fencing	360.00	7.50	2700.00
3.	Formation of 'V' shaped furrows	150.00	7.50	1125.00
4.	Cost of grass seeds as i) Stylo zanthus hamata 5 kg @ Rs. 40/kg ii) Stylo zanthus scabra 2 kg @ Rs. 30/kg iii) Cenchrus ciliaris 2 kg @ Rs. 15/kg	290.00	7.50	2175.00
5.	Digging of 1000 pits per hectare at the spacing 2 m x 5 m @ Rs. 1.25 per pit	1250.00	7.50	9450.00
6.	Filling of pits @ Rs. 10/100 Nos.	100.00	7.50	750.00
7.	Cost of poly bagged plants of i) Leucana leucocephala 600 plants + ii) Eucalyptus teriticornis 400 plants per hectare @ Rs.0.50 per sappling	500.00	7.50	3750.00
8.	Plantation of trees and sowing of grasses,3 male @ Rs.10/-	30.00	7.50	225.00
9.	Application of fertilizer(25:50:0)	800.00	7.5	6000.00
10.	Providing watering to plants @ Rs.1.00 per pit	1000.00	7.5	7500.00
11.	Protection by providing watchman	75.00	7.5	562.50
				34387.50
12.	contingency at 2%			687.75
			Total cost	35075.25
			Say Rs.	35075.00

i) Area of work - 7.50 ha. ii) Survey No.of work - 48. iii)Total cost -Rs.35075.00
iv)Cost per hectare - Rs. 4676.66 -Say Rs.4677.00

Table L-2 Cash outflow and inflow per hectare in proposed Afforestation cum forage development

Project Year	Initial capital (Rs.)	Maintenance 10% of investment (Rs.)	Cash outflow (Rs.)	Yield of poles			Yield of grass/fodder			Cash inflow (Rs.) (7+10)
				Poles (No.)	Rate (Rs/pole)	Amount (Rs.)	Grass/fodder (Q)	Rate (Rs./Q)	Amount (Rs.)	
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
2.	4677.00	Planting	4677.00	-	-	-	250 grass	10.00	2500.00	2500.00
3.		467.70	467.70	-	-	-	250 grass	10.00	2500.00	2500.00
4.		467.70	467.70	-	-	-	150 fodder	5.00	750.00	750.00
5.		467.70	467.70	-	-	-	200 fodder	5.00	1000.00	1000.00
6.		467.70	467.00	-	-	-	200 fodder	5,00	1000.00	1000.00
7.		467.70	467.70	1000	15.00	15000.00	-	-	-	15000.00
8.	3255.00	Replanting	3255.00	-	-	-	250 grass	10.00	2500.00	2500.00
9.		325.50	325.50	-	-	-	250 grass	10.00	2500.00	2500.00
10.		325.50	325.50	-	-	-	150 fodder	5.00	750.00	750.00
11.		325.50	325.50	-	-	-	200 fodder	5.00	1000.00	1000.00
12.		325.50	325.50	-	-	-	200 fodder	5.00	1000.00	1000.00
13.		325.50	325.50	1000	15.00	15000.00	-	-	-	15000.00

Contd...

Table L-2 Contd..

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
14.	3255.00	Replanting	3255,00	-	-	-	250 grass	10.00	2500.00	2500.00
15.		325.50	325.50	-	-	-	250 grass	10.00	2500.00	2500.00
16.		325.50	325.50	-	-	-	150 fodder	5.00	750.00	750.00
17.		325.50	325.50	-	-	-	200 fodder	5.00	1000.00	1000.00
18.		325.50	325.50	-	-	-	200 fodder	5.00	1000.00	1000.00
19.		325.50	325.50	1000	15.00	15000.00	-	-	-	15000.00
20.	3255-00	Replanting	3255.00	-	-	-	250 grass	10.00	2500.00	2500.00
21.		325.50	325.50	-	-	-	250 grass	10.00	2500.00	2500.00
22.		325.50	325.50	-	-	-	150 fodder	5.00	750.00	750.00
23.		325.50	325.50	-	-	-	200 fodder	5.00	1000.00	1000.00
24.		325.50	325.50	-	-	-	200 fodder	5.00	1000.00	1000.00
25.		325.50	325.50	1000	15.00	1500.00	-	-	-	15000.00

VITA

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He passed S.S.C. examination in the year, 1967 from Municipal High School, Mowar. Thereafter he joined College of Agriculture, Nagpur, Punjabrao Krishi Vidyapeeth,Akola in the year, 1967 and passed B.Sc.(Agr.) course in the year, 1971. Then he joined College of Agricultural Engineering and Technology, P.K.V.,Akola and passed B.Sc.(Agril.Engg.) course in the year, 1975.

He was selected as an Agril.Engineer in P.K.V., Akola in the year, 1976 and then promoted as a Reader in Agril.Engineering in the year, 1984.

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