

**MORPHOLOGY, CHARACTERIZATION AND  
CLASSIFICATION OF SOILS OF WATERSHED  
NO. ORR-5-4-5-2 UNDER IWDP OF JAGANNATH PRASAD  
BLOCK IN GANJAM DISTRICT**

A THESIS SUBMITTED TO  
THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, BHUBANESWAR  
IN PARTIAL FULFILMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF  
**MASTER OF SCIENCE IN AGRICULTURE**  
( AGRICULTURAL CHEMISTRY, SOIL SCIENCE AND BIOCHEMISTRY )

BY

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COLLEGE OF AGRICULTURE  
Orissa University of Agriculture and Technology  
BHUBANESWAR  
1993**

THESIS ADVISOR

Dr. S. S. K. NANDA

DEDICATED TO  
MY BELOVED PARENTS

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and Bio-chemistry)


1993


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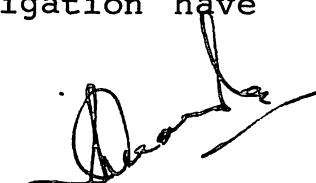
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Dated, 8th Aug '94

#### CERTIFICATE

This is to certify that the thesis entitled "MORPHOLOGY, CHARACTERIZATION AND CLASSIFICATION OF SOILS OF WATERSHED NO. ORR-5-4-5-2 UNDER IWDP OF JAGANNATH PRASAD BLOCK IN GANJAM DISTRICT" submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE IN AGRICULTURE (Agricultural Chemistry, Soil Science and Bio-chemistry) to the Orissa University of Agriculture and Technology is a faithful record of bonafide research work carried out by Sri Laxmidhar Sahoo under my guidance and supervision during the academic session 1992-93. No part of this thesis has been presented in any form for any other degree or diploma.

All possible helps and sources of information availed during the course of this investigation have been duly acknowledged.



(S.S.K.Nanda)

## ACKNOWLEDGEMENT

I feel privileged in expressing my profound sense of gratitude and heartfelt thanks to **Dr. S.S.K. Nanda**, Dean, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, the Chairman of my Advisory Committee for his suggestions for the problem, valuable guidance, constant encouragement, constructive criticism throughout the period of this investigation and helping in the preparation of this manuscript.

I am very much indebted to **Dr. N. Acharya**, Professor and Head, Department of Agricultural Chemistry, Soil Science and Bio-chemistry, College of Agriculture for providing necessary laboratory facilities to carryout this research work.

I extend my heartfelt thanks to **Dr. G.C. Sahu**, Reader, Department of Agricultural Chemistry, Soil Science and Bio-chemistry, College of Agriculture for his valuable guidance during the period of this research work.

I am very much thankful to **Sri N.Patro**, Reader, Department of Agronomy, College of Agriculture for his encouragement throughout the period of investigation.

I am also thankful to **Sri B.B. Sahoo**, SRA, Department of Agricultural Chemistry, Soil Science, College of Agriculture for his guidance during the period of this research work.

I am very much thankful to the **Director, Soil Conservation, Orissa** for selecting my name from our Department for this P.G. study.

I extend my thanks to Dr. K.L. Pujari, S.C.O. (Survey), Bhubaneswar, Sri K.N. Chari, Deputy Director, IWDP, Dr. S.C. Behera, A.S.C.O. (Survey), Bhubaneswar and Sri G.C. Pradhan, A.S.C.O., Department of Soil Conservation for their co-operation during the preparation of this thesis.

Help of Sri P.C. Dash, JSCO, Sri B.P. Dash, JSCO, Sri D. Mohapatra, Sri K.B. Sahoo and Sri L.N. Swain of Soil Conservation Department are highly acknowledged.

I am very much thankful to Pratap Babu, Hemant, Magiram, Ajay, Ujjal, Gudula, Kali, Padmanav, Manoj, Nilakanth, Pramod, Brahma, Sarada, Khitish and others for their co-operation during the research work.

I am thankful to Sri Hrudananda Sahoo for neatly and timely typing this thesis.

My special thanks are due to Jayanti for her hearty co-operation during the period of thesis work.

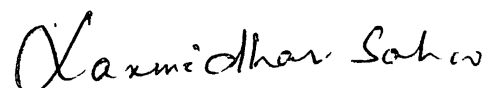
With much love and affection, I wish to express my indebtedness to Lojee, Lija, Juli, Barsa and Ani for they have missed my presence for quite a long period.

Lastly, I express my heartfelt devotion to my beloved parents for their constant blessings and sacrifice which brought me upto this level and enabled me to submit this thesis.

I pay my obeisance at the lotus feet of Lord Jagannath, the supreme master to bless me so that I lead a dedicated, devoted and balanced life surrendered at His feet.

Bhubaneswar

Dated 8<sup>th</sup> August, 1994.



(Laxmidhar Sahoo)

## ABSTRACT

**Title of Thesis:** Morphology, characterization and classification of soils of watershed No. ORR-5-4-5-2 under IWDP of Jagannath Prasad Block in Ganjam District.

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**Year of submission** 1994

Soil conservation measures help not only to increase crop yields, but also prevent further deterioration of land. The basic unit of development in relation to soil and water conservation is a watershed which is a manageable hydrological unit. Soil surveys are undertaken to determine the nature, distribution and extent of different soils in a watershed.

Morphology, physico-chemical characteristics of four typical pedons representing different land forms of watershed ORR-5-4-5-2 under IWDP in Jagannath Prasad block of Ganjam district were studied. A relationship between physiography and soil has been established. Soils at higher elevation are less developed and have low clay content, CEC, organic matter and low fertility status than the soils in lower elevation. Soils in general are coarse textured in the upper reach and of medium texture in the lower one. The water holding capacity is 32 to 40% and available soil moisture is ranging from 11 to 12.5%. All the soils are non saline and slight acidic to neutral in soil reaction. The total exchange acidity ranges from 0.215 to 0.435 me/100 g of soil. The soils have been classified taxonomically as Entisols & Inceptisols.

The soils at higher elevation suffer from moderate to severe erosion due to high slope, high intensity of rainfall and over grazing in barren land. On the basis of their ability to produce plants without deterioration for a long time the soils have been classified into the land use capability class IIc, IIIe & IVe.

Through interpretations of soil survey data and the soil characteristics, watershed has been planned for integrated development giving emphasis on soil and water conservation measures. Both mechanical and Agronomic measures have been suggested to control the soil erosion. On marginal lands alternate land use planning has been recommended through Agro-forestry, Agri-Horticultural & silvi-pastoral system.

## CONTENTS

CHAPTER	PARTICULARS	PAGE
I	INTRODUCTION	1
II	REVIEW OF LITERATURE	5
	1) Concept of Watershed	5
	2) Classification of Watershed	6
	3) Nomenclature of Watershed	7
	4) Significance of Watershed development for Agricultural Production	7
	5) NWDPRA, its scope and extent in Orissa	11
	6) Scope of IWDP and its extent in Orissa	37
	7) Research and development component under NWDPRA and IWDP	46
	8) Significance of soil survey in Watershed development	53
	9) Brief description of the Watershed (ORR 5-4-5-2)	61
	10) Impact of Watershed treatment on Agricultural development	74
III	MATERIALS AND METHODS	86
	1) General feature and location	86
	2) Materials	87
	3) Methods of Analysis	87
IV	RESULTS AND DISCUSSIONS	95
	1) Morphology of Pedons	104
	2) Physical characteristics	108
	3) Chemical characteristics	109
	4) Classification of soils (soil taxonomy)	118
	5) Interpretation of soil survey data for land use planning	122
V	SUMMARY AND CONCLUSION	131
	BIBLIOGRAPHY	

## LIST OF TABLES

Table No.	Particulars	Page
1	Watershed's name with Area and estimated cost (District and Blockwise)	17
2	Physical Target and Achievement under NWDPR	35
3	Agroclimatic zonewise watershed taken for Research work	45
4	Average temperature of Ganjam District	63
5	Monthly PET in Ganjam district	64
6	Annual rainfall data	65
7	Soil characteristics of different soil of watershed ORR 5-4-5-2	68
8	Cropping pattern of a watershed	76
9	Land capability class of a watershed	78
10	Fertility Index of a watershed	79
11	Creation of additional employment in a watershed	80
12	Details of Economic Analysis of a Watershed	81
13	Economic development of Farmers	82
14a	Site characteristics of study area	93
14b	Morphology of Pedons	102
15	Physical characteristics of soils	106
16	Chemical properties of soils	111
17	CEC and composition of the exchange complex of the soils	113
18	Soil taxonomically classification	114
19	Land capability classification	125

## LIST OF FIGURES

No. of the figures	Particulars	Page
1.	Climatic Water balance	66
2.	Index map of Ganjam district	83
3.	Site map of Study area	84
4.	Orissa map showing Agroclimatic zones	85
5.	Soil scape and profile site	93
6.	A relation between clay content and CEC with depth of profile	114
7.	A relation between pH and <del>org. carbon</del> organic carbon with depth of profile	115
8.	A relation between clay content and organic carbon with depth of Profile.	116
9	A relation between pH and base saturation with depth of profile	116(a)

## CHAPTER I

# INTRODUCTION

## INTRODUCTION

Increase in food production can be achieved when the soil on which all agriculture and human life depends, is conserved. Erosion of soil is a part of a vicious circle wherein the soils are impoverished by erosion, dislocated from one place to the other leading to the deposition of the soil on lands in the lower regions, in reservoirs, in water ways and harbours.

The deterioration of natural resources of an area in this manner can be contained and the total resources properly developed only by adopting the watershed approach in which the basic unit of development is a watershed, a manageable hydrological unit. In this approach development is done of agricultural lands, the barren hill slopes and the stream beds and all the resources of the area - water, fuel, fodder, livestock, fish and the most important one, the human resources are developed into a harmonious system. This involves the exploration and development of the complex inter-relationships between the watershed resources and its living population.

In realisation of the basic importance of soil in food production attention needs to be directed

towards the study of the physico-chemical properties of soil in relation to plant growth. Cropping systems may be devised for soils on the basis of the combination of its characteristics such as slope, erodibility, drainage, moisture retaining capacity, depth and fertility. Any watershed development plan is faulty if it takes into consideration only one soil characteristic where as in reality the performance of land when being cropped is the resultant of the interaction of all the soil properties and the environment. So soil survey are undertaken to determine the nature, distribution and extent of different soils in a watershed.

Through the soil analyses, it is possible to determine and evaluate all the conditions of soil characteristics for proper use of land. It is more logical therefore to classify or group soils on the basis of result which may be expected from a crop or cropping pattern.

An attempt has been made in the present investigation to study the characteristics and classification of soils of watershed No. ORR-5-4-5-2 under IWDP of Jagannath Prasad Block in Ganjam district.

Ganjam is one of the southern districts of Orissa and lies in between  $18^{\circ}-46'$  N to  $20^{\circ}-17'$  N latitude and  $83^{\circ}-48'$  E -  $11'$  E longitude. Two blocks namely Sorada and Jagannath Prasad in this district have been selected for inclusion in the Integrated Watershed Development Project. In Jagannath Prasad Block the mini watershed ORR-5-4-5-2 has been selected as a pilot watershed for integrated development. The project aims to apply the vegetative alternatives to enhance insitu soil and water conservation to make feasible to adopt better agricultural land use and enhance productivity. Conservation requirements should be evaluated and incorporated in agricultural development plans for the opening up new lands to production process and for changes in land use aimed at increased sustainable production. A course of action to halt degradation must be consciously followed to ensure that the land will be used effectively for the present and future generation.

**Scope and objective of the study:**

In order to develop the watershed area by improving productivity while reducing soil erosion hazards the characteristics of soils of the watershed were studied because

- (i) the soil analysis and correlation are the ultimate units which afford specific information

about the ability of soils to respond to use, management and plant growth

- (ii) soil characteristics are the major factor affecting erosion. The erodibility of a soil is influenced by the characters such as (a) Texture (b) Structure (c) Organic matter (d) Depth (e) Character of the sub soil (f) fertility status.

The physico-chemical properties of soil have been recognised as important in governing erodibility.

Classification systems are made groupings of objects so that our knowledge of them becomes organised for a specific objective. This classification of soils helps to predict the behaviour of soils about which we know little, from similar soils which we have studied, or on which we have carried out experiments - crop yields are predicted on many soils from test yields on a few related soils.

Therefore the present investigation includes study of the following characteristics of the soils.

- (a) Site characteristics of the watershed
- (b) Morphological characteristics of soil profile

4.a

- (c) Physical and chemical characteristics of soil of the watershed.
- (d) Available nutrient status of the soils.
- (e) Classification of soils as per soil taxonomy
- (f) Interpretations of the soil units for adopting proper soil and water conservation measures needed as per the land use capability class.

CHAPTER II

REVIEW OF LITERATURE

1. CONCEPT OF WATERSHED:-

Watershed is a geo-hydrological unit or a piece of land that drains at a common point. This natural unit is evolved through the interaction of rain water with land mass and typically comprises of arable lands, non-arable lands and natural drainage lines in rainfed areas. Sustainable production depends on health vitality and purity of production environment of which land and water are important constituents. Therefore for scientific utilisation of the natural resource base of land and water, the ideal geographical unit would be the product of interaction of rain with land i.e the watershed.

The deterioration of natural resources in an area can be contained and the total resources properly developed only by adopting the watershed approach. The basic unit of development is a watershed which is a manageable hydrological unit. In this approach development is not confined just to agricultural lands alone, but covers the area starting from the highest point of the area ( ridge line) to the outlet of the nala or the natural stream. This will involve implementation of ameliorative measures on barren hill slopes, marginal lands, privately owned agricultural lands and badly cutnala and river courses.

2. CLASSIFICATION OF WATERSHED:-

2.1 Catchment:- A Primary river is a long river having a drainage area of more than one lakh hectares with a number of tributaries of first, second, third fourth or even fifth order. This primary river generally discharges load to the sea. The drainage area of such a river is called Catchment.

2.2. Subcatchment:- A secondary river is a tributary of a primary river having a drainage area of more than 40 thousand hectares. The drainage area of such a river is called a sub-catchment.

2.3: Watershed:- A tertiary stream is a tributary of a secondary river having a drainage area of 4 to 40 thousand ha. The drainage area of such a stream is called a watershed.

2.4: Sub-Watershed:- A quarternary stream is a tributary of a tertiary one having a drainage area between 2 to 4 thousand ha. Such a drainage area is called a Sub-Watershed.

2.5 : Mini Watershed:- A pertad streamlet is a tributary of a quarternary one having a drainage area between 400- 2000 ha. Such a drainage area is called a Mini Watershed.

2.6 : Micro Watershed:- A hexad streamlet is a tributary to a pentad one having a drainage area of less

than 400 ha. Such a drainage area is called a micro watershed.

3. NOMENCLATURE OF WATERSHED:-

Generally, the drainage areas i.e from catchment to miniwatershed are codified as has been done for registration of Motor Vehicles in India. For example this miniwatershed's name is ORR-5-4-5-2. 'OR' stands for Orissa i.e the primary river in the state of Orissa. R signifies the name of the catchment of a primary river Rushikulya .( Generally the first letter of a primary river is used to signify its catchment). The numerals with hyphen followed by the ORR are placed to specify the sub-catchment, Watershed and miniwatershed respectively. Here ORR-5-4-5-2 is the 2nd miniwatershed of the sub-watershed ORR. 5-4-5, which is the 5th sub-watershed of the watershed ORR-5-4. The ORR. 5-4 is the 4th watershed of the subcatchment ORR- 5 which is also the 5th sub-catchment of the catchment of Rushikulya river. Micro watershed is also codified as ORR-5-4-5-2/1 or ORR- 5-4-5-2/2. The "Hyphen" and " oblique " are used according to the placement of watershed to that of basin. When the watershed is placed horizontally (-) are used and obliques are used when it is placed vertically.

4. SIGNIFICANCE OF WATERSHED DEVELOPMENT FOR AGRICULTURAL PRODUCTION:-

There are two area development approaches in the field of agriculture.

(1) Command area development:- This approach is adopted for comprehensive development of irrigated areas.

(ii) Watershed area development:- This approach is pursued in rainfed areas where availability of water is dependent on erratic amount, intensity and distribution of rainfall. An element of risk pervades the production system. Hence diversified and mixed farming systems are practised which include agriculture, forestry, animal husbandry, fishery etc.

4.1 : Importance of dry land farming under Watershed:-

Green Revolution in India is a success story which was commended all over the world. During the early periods of planned development, efforts were by and large directed towards irrigated agriculture in view of serious food shortages and urgent need of self sufficiency in food grains. Development of dry land farming was relegated to the back-ground. The objective of overall food availability in the country has been achieved, but the development process has created and aggravated serious unintended agricultural, socio-economic and ecological imbalances.

4.2 : Fluctuating food Production:-

In spite of green Revolution in irrigated areas the national food security continues to be fragile. During the years of drought, when rainfed crops suffer, there is a sharp decline in annual production of food

grains. After a record production of 152.3 mt in 1983-84, the drought of 1984-85 brought down the production to 145.54 mt. Further in 1987-88, the production declined to 140.35 mt. The estimated annual target of food production of 240 mt by 2000 AD would be achievable only if our rainfed crop-land develop to their full potential.

4.3 : Shortage of Pulses and Oilseeds:

Where as production and productivity of irrigated crops has increased manifold, the production of oil seeds and pulses which are largely rainfed, has made little progress. The serious shortages of Oil seeds and pulses and the resultant increase in their prices are assuming the production crises and need to be tackled on a sustained basis.

4.4 : Sustainability of Production in irrigated area:

Catchment area of irrigation reservoirs and tanks which contribute water are rainfed. The deterioration of production environment in catchments due to growing human and livestock population, is accelerating erosion and causing siltation of storage structure at much faster rate than what was assumed in their initial designs. The life span and capacity of big water reservoirs has been reducing at an alarming rate.

It is therefore, essential to develop rainfed catchments of irrigation systems if the production and productivity even in irrigated areas have to be kept up.

4.5: Ecological imbalance:-

Rainfed farming systems include about 148mha of land. These comprise of:

- Arable rainfed Cultivated land-	100.00 Mha
- barren and unculturable land-	20.29 Mha
- culturable waste lands-	15.55 Mha
- Permanent Pastures and other grazing lands-	12.04 Mha.

---

Total:- 147.88 Mha

or :- 148.0 Mha.

Degradation and denudation of such vast rainfed lands is one of the major cause of ecological imbalance in the country. Integrated development of such land with a holistic approach holds the key to ecological health of the country.

4.6 Socio-Economic Problems:-

The uneven production has focussed attention on the following problems:

(i) Wide spread un-employment/under employment in vast rainfed areas is accentuating all pervasive poverty with associated problems of illiteracy, poor health, frustration and unrest;

(ii) Exodus from backward rainfed hinter lands to

town and cities creating congestions and slums .

In appreciation of these agricultural, ecological and socio-economic concerns, Government have resolved that " ending neglect of vast rainfed and dry land areas " would be a major policy concern as reflected in Approach paper to VIII five year plan. In pursuance of this, the present NWDpra has been restructured ( Anonymous, 1991)

5. NATIONAL WATERSHED DEVELOPMENT PROJECT FOR RAINFED AREAS ( NWDpra ) ITS SCOPE AND EXTENT IN ORISSA:

5.1 Aim and Objective of NWDpra:

The project NWDpra would endeavour to achieve the twin objectives of sustainable production of biomass and restoration of ecological balance in the vast tract of rainfed areas in the country. It will specifically focus on.

(1) Conservation, upgradation and utilisation of endowments like land, water, plant, animal and human resources in a harmonious and integrated manner. This will aim at perpetual availability of food, fodder, fuel, fibre, timber and biomass for rural and cottage industries to meet the growing demands of human and live stock population through diversified land use.

(2) Generation of massive employment during the project period and regular employment after the project completion for enhancing the employment opportunities in the backward rainfed areas to ensure livelihood security particularly for under-privileged sections of the

rural population like small and marginal farmers, landless labourers, tribals etc.

(3) Improvement of production environment and restoration of ecological balance through scientific management of land and rain water.

(4) Reduction of inequalities between irrigated & rainfed areas. Ultimately stable production and processing of bio-mass would contribute towards better life in rural areas. This will reduce large-scale migration from rural areas to the cities. In addition to food, fuel and fodder the project would endeavour to enhance cash available with the rainfed farmers and landless agricultural labourers through increased casual employment, marketable surplus of agricultural and dairy produce, growing of cash crops like vegetables, coriander, Cumin Medicinal plants etc in suitable area.

Thus the ultimate objective of this project is to develop the natural resource-base and sustain its productivity, improve the standard of living of millions of poor farmers and landless labourers and endeavour for restoration of ecological balance ( Anonymous 1991)

## 5.2 Watershed- Selection Criteria Under NWDP. RA:

All the community development blocks in the country with less than 30 % of their cultivated areas

under assured irrigation would qualify for inclusion in the project. There would be no higher or lower limit of average annual rainfall.

In each of the selected blocks, a watershed of about 500- 5000 ha would be taken up for integrated development. The ideal size would be about 1000 ha area which could be saturated within the period of the Eighth Five year Plan. The watershed should have preferably 50 % or more of its area under cultivation so that the farmer are directly involved and benefited.

### 5.3 Operation Plan of NWDPRAs:-

It is primarily based on the twin concepts of Integrated Watershed development and Sustainable farming systems.

#### Integrated Watershed Development:-

Watershed consists of three physical sectors

- (i) Arable or cultivated lands which are privately owned
- (ii) Non-Arable land which includes village pastures and grazing grounds, Culturable waste lands and barren and unculturable lands
- (iii) Net work of natural drainage lines.

These three sub-sectors are hydrologically interspersed and would be treated as one organic geo-hydrological entity for project planning and implementation to ensure sustainable use of natural resources of land and water.

**Sustainable Farming system:-** A typical rainfed farmer derives his sustenance partly from his own cultivated land and partly from common property resources and community lands. In addition his subsistence to a great extent depends upon livestock resources and off-farm activities like wages by working as labourers on Government projects and other private fields. In some areas specialised activities like sericulture, bee-keeping Lac cultivation, cultivation and collection of medicinal and industrial plants also supplement the incomes of the farmers. The landless labourers Mostly depend upon common property resources for fuel and fodder. Thus the project will treat all components for additional income of the farmers.

**Village or Community farming System:-**

The project would analyse and treat the interdependence of individual farming systems with community production systems.

**People's Participation:-**

Stimulating and promoting people's participation in project planning, project preparation, implementation and post project management of project assets would be an integral part of the approach and strategy.

**Conservation Measures:-**

The project would heavily rely on low cost and vegetative conservation measures in place of costly

engineering structures,. In situ moisture conservation to green the entire land scope will be a major pursuit of the project.

Holistic Approach:- Thus project would address both the ecological and productivity concerns and would aim at harmonising ecology, economy and equity.

People's Participation & Training:-

The project will be planned and implemented with active participation of the concerned village community in association with voluntary agencies wherever possible.

Concept of Mitra-Kisan & Gopal :-

Mitra Kisans ( contact farmer) will serve as important links between scientists and farmers and will receive training at training centres and provide feed back to scientists. If need be new Mitra-Kisans will be identified every year to evolve a group of enlightened farmers in each village of the micro-watershed. Frequent meaningful contacts between scientists and farmers at the training centres and participation in on-farm research will help the research system to have better perception of the prevailing farming systems and farmers conditions and limitations imposed on them by their physical social and economic conditions. While the mitra Kisan will concentrate on cultivated lands, Gopal (landless agricultural labourer) would focus attention on common property resource management on behalf of the village community or farmer-group.

**Training Curriculum: -**

The three-day institutional training programmes will not only concentrate on crop production but also on management of community assets and common property resources and give an over-view of the integrated farming system which is nearer to the reality of the farming situation. In fact it is natural for the farmer to take an integrated view of his problems. It is our training and research system which splits his problems into different specialities, seldom to be integrated again. (Anonymous 1991).

T A B L E NO. 1

5:4: NAME OF THE WATERSHED WITH AREA COVERAGE AND  
ESTIMATED COST ( DISTRICT & BLOCK WISE)

SL NO.	Name of the Dist- rict.	Name of the Block	Name of the Watershed	Treatable Area in Ha.			Estim- ated Cost in Lakh
				Ara- ble	Non- Ara- ble	Total	
1	2	3	4	5	6	7	8
1.	Angul	Banrapal	Domuhari Nala	508	105	613	16.88
2.		Angul	Bhandaruni nala	474	276	750	23.95
3.		Chendi Pada	Tentuli Nala	1089	344	1433	44.67
4.		Athamallik	Sindul Nala	649	341	990	31.34
5.		Kishore Nagar	Badajora Nala	1342	774	2116	70.38
6.		Pallahara	Dhanurdhar Nala	472	219	691	22.84
7.		Kaniha	Bankuli Nala	533	281	814	25.20
8.		Talcher	Bangara Nala	251	238	489	15.49
1.	Balasore	Khaira	Bana Nalla	882	97	979	28.54
2		Sora	Kochiakoili nalla	794	93	887	25.29
3.		Bahanaga	Kantichara (Micro water- shed )	1026	151	1176	33.00
4.		Remuna	Sapuanala	527	67	594	17.11
5.		Balasore	Pagan Nala	935	134	1069	30.72
6.		Basta	Nema Nala	635	45	680	19.69

1	2	3	4	5	6	7	8
7.	Baliapal	Jalabasa Nala	590	52	643	17.73	
8.	Bhograi	Jaleswarpur Nala	732	90	822	25.04	
9.	Jaleswar	Sannai Nala	1451	350	1801	54.15	
10.	Oupada	Khemkut Nala	825	106	931	26.62	
11.	Nilagiri	Gohira Nala	599	165	764	22.53	
1.	Baragarh Bhatli	Kulianijore nala	530	123	653	17.81	
2.	Ambebhana	Dedarha nala	440	65	505	13.32	
3.	Paikamal	Khandi Jharana	630	300	930	25.13	
4.	Padmapur	Chatuahaja nala	670	190	860	23.12	
5.	Gaisilet	Banabira nala	770	350	1120	29.88	
6.	Bijepur	Sukhajora nala	770	160	930	25.04	
7.	Sohalla	Ghaganijore nala	630	340	970	27.11	
8.	Jharbandha	Gunianijhar nala	1060	380	1440	39.97	
1.	Bhadrak Chandaballi	Nunjore Nala	663	172	835	23.80	
	Basudevpur	Matainala	875	163	1038	30.92	
1.	Bolangir Deogaon	Dalkhai Nala	1050	732	1782	50.15	
2.	Gudvela	Bankinala	1676	215	1891	57.66	

1	2	3	4	5	6	7
3.	Puintala	Atgaon Mini Watershed	821.35	395.43	1180	22.55
4.	Bolangir	Sindurbahal mini Water shed	436	258	694	18.40
5.	Loisinga	Jharmunda Mini Water-shed	696	76	772	21.27
6.	Agal pur	Jharanipalli Mini Water shed	495	191	686	18.62
7.	Belpara	Ghagrajora Mini Water-shed.	841	136	617	15.92
8.	Khaprakhol	Pacher Mini Watershed.	483	73	556	14.68
9.	Patnagarh	Laxmijore Mini-water shed.	1414	299	1713	47.86
10.	Banga Munda	Mundapadar Mini water shed.	874	92	966	26.54
11.	Titilagarh	Dasarjore Mini Water-shed	617	71	668	18.10
12.	Saintala	Sunarijore mini Water-shed	413.71	326.38	740	19.67
13.	Munibahal	Tengrajore Mini Water-shed	361.06	134.96	496	13.86
14.	Tureikella	Dumerchuan	857	174	1031	19.42
1.	Boudh	Harbhanga Baringi Nala	204	300	504	14.48
2.	Kantamal	Similijore Nala	426	600	1026	31.22

<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
1.	Cuttack	Narasinghpur	Suhangi Nala	596.73	468.03	1064.76	33.77
2.		Badamba	Hadua Nala	611.47	518.53	1130	36.15
3.		Tigiria	Bandana Nala	611	126	737	22.27
4.		Athagarh	Baikani Nala	372	354	726	22.71
5.		Banki-II	Hatimara Nala	972	371	1343	41.97
6.		Banki-I (Dumpara)	Kaligiri Nala	346	127	518	16.49
7.		Tangi (Chowdar)	Thinkikata Nala	650	674	1324	43.23
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1.	Deogarh	Tileibani	Jaraikela Nala	749	510	1239	33.69
2.		Riamal	Rangiamunda Nala	700	900	1600	47.36
3.		Barkot	Matuali Nala	390	275	665	18.74
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1.	Dhenkanal	Odapada	Sankhua Nala	682	161	843	26.92
2.		Dhenkanal	Domadar Nala	555	184	740	19.30
3.		Gandia	Daunri Mini Watershed.	670	168	838	26.72
4.		Hindal	Badajori Nala	1145	990	2135	64.54

1	2	3	4	5	6	7	8
1.	Gajapati	Kashinagar	Lenguta guda Nala	343	287	630	16.18
2.		Rayagada	Bisoi Puma Nala	333	263	596	15.56
3.		Gurma	Badigum Nala	418	282	700	18.95
4.		Nuagada	Parimal Nala	299	255	554	15.98
5.		R.Udaya- gir	Baladi Mini Watershed	388	346	734	25.03
6.		Mohana	Marchima Nala	274	437	711	19.49
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1.	Ganjam	Patrapur	Bhoginala	493	250	743	19.80
2.		Digapahandi	Khajur- ianala	728	130	858	25.50
3.		Sanakhem- undi	Ghodahar- ada Nala	320	80	400	10.32
4.		Seragada	Kukudia Nala	494	152	646	19.80
5.		Dharakote	ORR-3-1- 6-1	458	153	611	12.59
6.		Sorada	ORR-6-2- 2-4	680	135	815	22.15
7.		Bhajana- gar	Lokarakh- andi Nala	548	169	717	19.10
8.		Belguntha	Boda Nala	460	120	526	13.41
9.		Buguda	Chancheri Nala	634	89	723	19.55

1	2	3	4	5	6	7	8
10,	Jagannath Prasad	ORR-5-4-5-1	650	260	910	18.61	
11.	Kabisurya nagar.	Paika Jamuna Nala	620	380	1000	27.13	
12.	Ganjam	Badasankha Nala	362	312	674	18.35	
13.	Khalikote	Kharkhari Nala	1100	70	1170	31.40	
14.	Kodala	Kharkhari Nala	360	300	660	17.19	
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1.	Jagatsinghpur.	Naugaon Bansa jore Nala	1071.60	157.88	1229.48	35.64	
2.	Ersama	Panihana Nala	592.60	349.78	942.38	26.48	
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1.	Jajpur	Bodachana Nayanihari	470	886	1356	44.05	
2.	Dharmasala	Hinjula Nala	693	525	1218	39.50	
3.	Sukinda	Naliajhar	616	420	1036	34.16	
4.	Denagadi	Kabatinala	1275	273	1548	49.69	
5.	Korei	Shalabandhi Nala	1550	730	2280	74.85	
6.	Jajpur	Dudhei Nala(Upper)	399	665	1064	32.54	
7.	Bari	Dudhei, Nala (Lower)	527	290	817	22.81	
8.	Binjharpur	Jhunabhadra Nala	570	260	830	23.64	

<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
9.	Rusulpur	Bidagada Nala	466	581	1047	30.14	
10.	Dasarath pur	Kani Nalla	1313.07	265.72	1578.79	46.88	
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1.	Jharsu- guda	Likhanpur Lilarinala	342	208	550	15.29	
2.	Jharsu- guda	Kudalkani Nala	199.14	496.08	695.22	18.61	
3.	Kolabira	Hadkhari Nala	1040	500.00	1540	42.35	
4.	Laikera	Aitapalli Nala	456	80	536	14.26	
5.	Kirmira	Brahmani- jore Nala	472	164	636	17.38	
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1.	Kalaha- ndi	Bhawani patna	Mukha Nala	753	100	853	22.88
2.	Kesinga	Kusumkhal Nala	1238	200	1438	43.88	
3.	Narla	Jampada Nala	783	196	979	29.02	
4.	M.Rampur	Talkona Nala	592	220	812	23.04	
5.	Th.Rampur	Dumerpadar Nala	550	415	965	28.11	
6.	Lanjigarh	Damanjore Nala	211	250	561	12.23	

1	2	3	4	5	6	7	8
7.	Golamunda	Udanti Nala (Left lower)	396	334	730	20.74	
8.	Junagarh	Bhatrajore	793	225	1018	29.97	
9.	Dhamagarh	Badhajore	1337	96	1433	41.46	
10.	Kalampur	Hati Nala (Right upper)	793	99	892	26.19	
11.	Jaipatna	Gaidhar Nala (Left upper)	1223	209	1436	43.40	
12.	Koksara	Upper Moter Nala	3769	577	4346	129.84	
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1.	Kendrapada.	Aul	Brahmanijore	451.76	302.66	754	21.41
2.		Garadpur	Behela-Patnali	1018	322	1340	41.99
3.		Mahakal pada	Sali janga jore	461.09	383.91	845	25.38
4.		Rajnagar	Mahulia-jore Nala	715.84	469.75	1185.59	36.06
5.		Rajkanika	Burudia-jore	358	298	656	19.43
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1.	Keonjhar	Ghusipura	Kantabania Nala	403	169	572	17.15
2.		Anandpur	Chakratirtha Nala	553	152	705	18.45
3.		Joda	Jugudidhar Micro water shed	260	290	550	16.52
4.		Jhumpura	Kasia Nala	520	210	730	21.49

1	2	3	4	5	6	7	8
5.	Champua	Changajida Nala	722	230	952	30.48	
6.	Telkoi	Baladhar Nala	384	401	785	23.87	
7.	Harichandar- pur	Masina jodi Watershed	350	400	750	22.72	
8.	Ghatgaon	Sagadia Nala	289	186	475	13.71	
9.	Keonjhar	Bhagadhar Nala	305	430	735	21.08	
10.	Bansapal	Tandijori Nala	265	490	755	22.55	
11.	Patna	Manapur Nala	536	211	750	21.62	
12.	Sahara- pada	Mahapat Nala	500	80	580	17.19	
1.	Khurda	Bhubane- swar	Malipada Nala	755	680	1435	44.38
2.	Begunia	Maintinala	1868.67	373.16	2241.83	70.53	
3.	Bolagarh	Bali Nala	1344	614	1958	65.18	
4.	Chilika	Kaithpalla Gainda, Micro watershed	964	818	1782	51.16	
5.	Jatni	Angarapada Nala	838.73	881.27	1720	23.44	
6.	Khurda	Kaipadar Nala	777	733	1510	47.36	
7.	Tangi	Trisankhu Nala	731	284	1015	28.16	

1	2	3	4	5	6	7	8
1.	Koraput	Lamtaput	Hatpata Nala	445	780	1225	37.89
2.		Nandapur	Gurandi Nalla	1264	641	1905	57.73
3.		Pottangi	Chandaka Nala	652	600	1252	38.07
4.		Similiguda	Kukragad Nala	1285	1770	3055	90.96
5.	Koraput		Mangara Nala	1483	1957	3440	97.38
6.		Dasmantpur	Tentuli-gudanala	707	566	1273	37.41
7.		Laxmipur	Kokirguma Mini Watershed	393	236	629	18.24
8.		Nayan Patna	Begam Nala	562	538	1100	32.55
9.		Bandhugaon	Nilabati Nala	655	333	988	29.43
10.		Baipariguda	Bergam Nala	709	87	796	21.87
11.		Boriguma	Boriguma Nala	1701	1210	2911	83.27
12.		Jaipur	Kabadi Mini Watershed	725	870	1595	47.88
13.		Kotpad	Amlabhata Nala	1271	215	1486	41.96
14.		Kundra	Bhalupur Nala	2056	260	2316	66.31
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1.	Malkan-agiri	Podia	Badamunda Nala	1299	1150	2449	69.45
2.		Kalimela	Bhalukanta Nala	508	790	1298	36.05

1	2	3	4	5	6	7	8
3.	Korkonda	Chitapur Nala	204	545	749	20.62	
4.	Kudumulu guma	Posapalli Nala	516	1147	1663	41.49	
5.	Malkana- giri	Ganjala Nala	671	669	1340	38.12	
6.	Mathili	Chalanguda Nala	1199	1253	2452	70.13	
7.	Khairput	Butiguda Nala	871	1253	2124	59.88	
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1.	Mayur- bhanj	Baripada	Betna Nala	831.27	241.73	1073	33.83
2.		Suliapada	Handi bhanga	685	509	1194	34.72
3.		Kuliana	Upper Jam- bhiraNala	797	115	912	27.94
4.		Saras- Kana	Bhuasuni Nala	341.10	625.9	967	28.79
5.		Bangir- Poshi	Dhedagadha	249.38	676.62	926	28.74
6.		Badasahi	Gangadhar Nalla	626	200	826	24.85
7.		Betnoti	Bhairangi Nalla	737.59	98.41	736	22.32
8.		G.B.Nagar	Deo Nalla	475	140	615	18.23
9.		Morada	Kharadiha Nala	596	118	714	22.02
10.		Rasgovinda- pur	Karanji Pada	645	160	805	23.61
11.		Sukruli	Jhao Nala	969.55	142.45	1112	34.63

1	2	3	4	5	6	7	8
12.	Kusumi	Aharbandha	2732.94	537.06	3270	96.14	
13.	Jamada	Balisudra	1446.97	315.03	1762	52.38	
14.	Bahalada	Barhai Nala	744	216	960	29.96	
15.	Tiringi	Badadalima	1557	365	1922	57.75	
16.	Karanjia	Budhi Nala	560.40	137.60	698	21.44	
17.	Thakur- Munda	Bagadafa	647.79	882.21	1530	35.60	
18.	Joshiपुर	Nanjore	1097	103	1200	34.97	
19.	Raruan	Manjori	1074	261	1335	42.13	
20.	Rairangpur	Gudia Nalla	737	317	1054	32.83	
21.	Bisoi	Luhakani	552	93	645	19.76	
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1.	Nawapara	Komna	Kodeldanda	698	874	1572	47.62
2.	Nawapara	Kharkhara Nala	760	242	1002	29.75	
3.	Boden	Alatjore Nala	834	98	932	27.60	
4.	Sinapalli	Sitilikh- alia Nala	485	161	646	19.55	
5.	Khariar	Mathiajore Nala	750	150	900	26.19	
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1	2	3	4	5	6	7	8
1.	Nayagarh	Nayagarh	Piasalia Nala	758	130	888	24.52
2.		Ranapur	Baga Nala	384	346	730	21.88
3.		Odagaon	Rohi Bank	1276	153	1429	40.68
4.		Nuagaon	Mahipur Watershed	774	206	980	29.51
5.		Khanda-para	Ratakhandi	516	197	713	21.30
6.		Bhapur	Mahula Berana Water shed	392	162	554	16.60
7.		Gania	Rasanga Nala	650	60	710	21.74
8.		Daspalla	Pakhriga Nala	455	250	705	21.37
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1.	Nawara- ngpur	Tentukh- unti	Kukudabadi Nala	696	350	1046	31.31
2.		Nandahandi	Sindijodi Nala	776	283	1059	31.06
3.		Kosagumuda	Jabaguda Nala	355	410	765	23.00
4.		Nawarang- pur	Chatahandi Nala	986	257	1243	37.64
5.		Dabugaon	Baigam Nala	1067	1043	2110	54.59
6.		Papadak- handi	Jaliguda Nala	1300	800	2100	63.83
7.		Jharigaon	Goriajore Nala	1396	1296	2692	82.04

1	2	3	4	5	6	7	8
8.		Umerkote	Bagra Nala	1557	1470	3027	90.59
9.		Raighar	Parua Nala	1069	681	1750	52.87
10.		Chandaha- ndi	Telijhar Mini Water- shed.	760	146	906	26.07
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1.	Phulbani	Phiringia	Saitigia Nala	417	663	1080	34.30
2.		Phulbani	Camera Nala	385	535	920	28.01
3.		Khajuri- Pada	Bausuni Nala	722	600	1322	40.11
4.		G.Udaya- giri	Lingagarh Nala	348.83	542.16	891	27.47
5.		Chaka- pada	Sunapada Nala	244.049	205.95	450	21.03
6.		Raikia	Borimunda Nala	139.613	365.38	505	16.55
7.		Tikabali	Bangasahi Nala	304	406	710	21.81
8.		Baliguda	Rutungia Nala	167	380	547	18.18
9.		Nuagaon	Teremaha Nala	143	350	493	14.22
10.		Daringi- bodi	Dandimaha Nala	435	365	800	24.56
11.		Tumidi- bandh	Mandal Padar Nala	323	174	497	15.90
12.		Kotagarh	Jamjhore Nala	167	359	526	16.83

1	2	3	4	5	6	7	8
1.	Puri	Krusha-Prasad	Lundisagar Nala	685	154	839	25.64
2.		Brahmagiri	Kalikabadi Nala	770	197	967	29.73
3.		Puri	Ariha Nala	614	126	740	23.44
4.		Gop	Kadua Nala	747	117	864	25.82
5.		Astarang	Kanduki Nala	290.53	169.47	460	14.74
6.		Kanas	Chhanipada Nala	967.39	182.61	1150	35.45
7.		Delang	Jamuna Nala	809	542	1351	44.31
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1.	Rayagada	Ramanguda	Kotaguda Nala	710	485	1195	36.16
2.		Gunupur	Ragada Nala	443	721	1164	36.15
3.		Padmapur	Kenduguda Nala	467	317	784	23.51
4.		Gudari	Ragam Nala	360	438	798	24.20
5.		Muniguda	Jhikimiki Nala	487	425	912	27.45
6.		Chandrapur	Dangasorada Nala	395	589	984	29.65
7.		Bissam Cuttack	Munda Nala	1004	472	1476	44.53
8.		Rayagada	Tarhakala Nala	288	1439	1727	50.97

1	2	3	4	5	6	7	8
9.		Kashipur	Galgada Nala	1298	612	1910	58.32
10.		Kalyan-singhpur	Dhumuri Padar Nala	568	640	1208	37.29
11.		Kolnara	Fakiri Nala	271	314	585	17.16
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1.	Sambal-pur	Jamankira	Katangapani	780	690	1470	42.63
2.		Kuchinda	Sarajore Nala	1090	400	1490	43.52
3.		Bamra	Bhagapada Nala	933	505	1498	43.64
4.		Rairakhal	Karandijore Nala	295	405	700	18.57
5.		Naktideul	Champalli Nala	350	400	750	19.15
6.		Jujumura	Dhengurdhar Harijhar Jone	700	800	1500	41.16
7.		Rengali	Kahajore Nala	588	386	974	26.82
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1.	Sonepur	Biramaha-pur	Left Harihar jore Jatashi-nga	906	567	1473	41.12
2.		Ulluda	Left Kulthia jore, Mini Watershed	1120	677	1797	48.68
3.		Jarbha	Right Nibruti Jore	873.72	434.43	1308	35.87
4.		Sonepur	Khari Nala	618	82	700	20.30
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<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
1.	Sundargarh	Sundargarh	Lahanda- bud Nala	1305	783	2088	60.71
2.		Tangor Palli	Nurga Nala	672	570	1242	35.93
3.		Lefnipara	Sahajbahal Nala	1209	450	1659	47.83
4.		Hemgiri	Chatudhara Nala	954	601	1555	41.66
5.		Subdega	Simdaga Nala	405	472	877	23.59
6.		Balisanka- ra	Kello Nalla	1588	495	2083	59.83
7.		Baragaon	Ostali Nalla	1175	776	1951	57.54
8.		Kutra	Matwali Nala	1008	42	1050	29.99
9.		Kuarra Munda	Kacharu Nala	408	189	594	16.79
10.		Koida	K Bolanga Mini Water- shed	325.10	194.90	520	13.91
11.		Lahuni- Para	Bada Puruna Pani	444.57	354.93	799.5	24.27
12.		Nuagaon	Hatibari- mini Water- shed.	387.99	93.01	481	13.37
13.		Gurundia	Jodaban- dha Micro Watershed	388	161	549	14.89
14.		Lathik- ata	Attaghat Nala	343.76	74.24	418	10.84
15.		Bonei	Kasada Mini Watershed	279.25	220.75	500	14.26
16.		Bisra	Udusu Nala	679.41	197.59	877	24.27
17.		Rajgangpur	Ramabhal Mini Water- shed	350.89	143.52	494.41	13.43

A B S T R A C T

District :-	30
Block :-	258
Mini Watershed:-	258
Arable Land:-	185,998.073 Ha
Non-arable Land:-	97587.576 Ha
Total Treatable Area:-	283585.649 Ha
Estimated Cost:-	8301.17 Lakh

5.5. T A B L E :- 2  
 PHYSICAL TARGET AND ACHIEVEMENT UNDER NWDPR  
 DURING 1993-94.

SL NO.	Name of the Works	Target	Progress
1.	Vegetative filter strips	356682 rmt	356682 rmt
2.	Live fencing	460933 rmt	460933 rmt
3.	Pasture land development	20,000.0 ha	7814.0 ha
4.	Bank stabilization with vegetative support	28000 rmt	27666 rmt
5.	Live check dam	9269 units	8956 Units
6.	Loose boulder structure with Veg. support	5936 nos	3890 nos
7.	Loose boulder check dam with Veg. support	4700 nos	3981 nos
8.	Run off measurement structure	1609 nos	181 nos
9.	Earthen structure	6651 nos	3999 nos
10.	Single crop demonstration	3666 nos	3058 nos
11.	Double crop demonstration	3428 nos	2429 nos
12.	Inter Cropping	7605 Ha	551 Ha
13.	Agro Forestry	478000 ha	9556 ha
14.	Dry land Horticulture	129000 ha	8484 ha
15.	Planting of trees along drainage line	340000 nos	186848 nos
16.	Gully control structure	9760 nos	1411 nos
17.	Live stock development programme production	8160 (1st Yr.) 2560(2nd Yr.)	1362
18.	Promotion of Cultivated fodder Cultivation	--	542

20.	House hold Production system	8573 nos	2290 nos
21.	Shuken Pond	171 nos	171 nos
22.	Vegetative contour hedge with furrows	25246 ha	19701 ha

**Financial Achievement:-**

(Upto 1993-94 )

**Target:- 2677.08 Lakh Rupees.**

**Expenditure Upto 1993-94:- 1780.61 Lakh rupees.**

6: SCOPE OF IWDP & ITS EXTENT IN ORISSA

6.1 INTRODUCTION:

The Orissa Component of the Integrated Watershed Development(Plains) Project with the assistance of World Bank was launched in the State in the year 1990-91, but it became effective only during 1991-92. The project envisages development of selected micro watersheds in two watersheds in the district of Phulbani (Khajuripada ORM-3-8-5-1/2) and G.Udayagiri ORM-3-16-7-2/3 and two watersheds in Ganjam ( Soroda ORR-6-7-1/2 and Jagannath-prasad ORR-5-4-5-2 ). The project is designed for 7 years: the first 3 years being the pilot phase and the next 4 years Expansion phase. Under the project in pilot phase, the approach is for comprehensive and compact treatment of degraded and endangered watershed areas in the districts of Ganjam and Phulbani. The project aims to apply the vegetative alternatives to enhance soil and water conservation to promote better agricultural land use patterns and productivity. The modus operandi of the project contains many innovative activities such as various means of encouraging farmers participation in soil and moisture conservation activities, training to the project staff, N.G.Os and the farmers, adaptive research etc. The aim and objectives of the project are broadly categorised as follows:

6.2 Aim and Objectives of IWDP.:

- A. To slow down and possibly reverse the ecological degradation of an area by promoting sustainable and replicable production system.
- B. Introduction of land management practices through development of cost effective, replicable and sustainable technology.
- C. The emphasis is on vegetative soil and moisture conservation measures (Vetiver grass)
- D. Improve ground cover and encouraging proper land use that respond to people's needs and land capability.
- E. Emphasis on rainfed/dryland area, but to treat all lands in need of treatment irrespective of ownership ( private, public, & community land ).
- F. Encouraging farmers participation in soil and moisture conservation activities as well as participation of Non-Governmental agencies.
- G. The institutional objective is to introduce effective arrangements for inter agency coordination in watershed planning and plan, implementation and to ensure the full participation of the watershed land users and their agreement at all stages of development.
- H. Institutions and policies for better management of natural resources base and for equitable access to those resources.

To achieve the above mentioned aims and objectives under the Integrated Watershed Development (plains) Project, the Watershed planning & Co-ordination Organisation(W.P.C.O) at the apex has been constituted with two implementing agencies ( Project Office) at field level: one at Ganjam and the other at Phulbani. There are 3 supporting committees one at State Level ( State level Watershed Development Policy Committee), one at District level (District Level Watershed Development Committee) and the last one at Watershed level(Watershed Development Committee). Training forms an Integral part of the project. There are 5 types of training included in the project namely:

- (a) Technical training in soil and moisture conservation technologies and project concepts.
- (b) Training in new cropping practices.
- (c) Training in consultative planning and institution building.
- (d) Training in G.I.S/Physical planning, and
- (e) Training for monitoring and evaluation.

Further this project requires specific technology recommendations for land management, crop management, fodder management and treatment of natural drainage/gully lines for which the Adaptive Research component has also been included in the project and the task has been assigned to Orissa University of Agriculture & Technology.

( O.U.A.T ).

As has been said in the preceding paragraphs that the modus operandi of the project contains many innovative activities and alternative methods for land treatments it is necessary to evaluate the application of alternative methods and innovative approach that requires for the project activities and the project as an integrated whole to be carefully and accurately monitored and evaluated. As such, the planning, monitoring and evaluation unit of the Directorate of Soil Conservation has been strengthened under the project. Further the project also envisages for conducting a project specific impact assessment study which includes;

- (a) Overall assessment of the technical results of various soil and water conservation activities under the project.
- (b) Appropriateness of the methods employed in carrying out the project activities, and
- (c) To estimate the medium and long term social and economic benefits of soil and moisture conservation activities.

This work has been entrusted to Messrs. Agricultural & Rural Development Consultancy Society (ARDCOS), a Non-Governmental Organisation. In addition, the other N.G.Os are contracted to assist the project staff in consultative planning, mobilise community groups for joint management of non arable lands through formal agreements. They will also assist the project in awareness building and motivation of the people towards I.W

D.P. technology i.e low cost, sustainable and replicable technology.

The I.W.D.P. also envisages that the physical planning of micro watersheds will be strengthened by establishment of improved cartographic production facilities, development of simple air photo and satellite imagery interpretation facilities as well as P.C. computer base G.I.S. for handling physical data and social data so called in the process of survey.

### 6.3 PRESENT STATUS OF THE PROJECT:

1.0 Salient features: Four watersheds have been selected two in Phulbani and two in Ganjam districts as pilot watersheds under the project as detailed below:

SL NO.	Code No.& Name of Pilot watersheds	Name of the District.	<u>Gross area (HA)</u> Pilot phase      Expansion phase.	
1.	ORM-3-6-7-2 ORM-3-6-7-3 (G.Udayagiri Block)	Phulbani	3539	28,506
2.	ORM-3-8-5-1 ORM-3-8-5-2 ORM-3-8-5-3 (Khajuripada Block)	Phulbani	5190	29,322
3.	ORR-5-4-5-2 (Jagannathprasad Block)	Ganjam	3120	20,542
4.	ORR-6-7-1/2 (Soroda block )	Ganjam	1234	6,314
(4 nos.Watersheds)		2 districts	13083	84,711

6.4: Menu of Treatments:

- (a) Arable land: (i) Vegetative hedge  
(ii) Crop demonstration.  
(iii) Mixed horticulture(H1)
- (b) Non arable land: (i) Multi tier canopy (F2)  
(ii) -do- (F3)  
(iii) Rehabilitation of degraded forests (F4)  
(iv) Stabilisation of shifting cultivation (F5)  
(v) Silvi pastoral development(P)  
(vi) Mixed horticulture ( H1)
- (c) Natural drainage lines: (i) Brush wood/vegetative stabilisation.  
(ii) Stone check dam.  
(iii) Earthen runoff/Management structures.  
(iv) Diversion channel.  
(v) Diversion structure(Jholla)

6.5 REVIEW OF PROGRESS:-

Physical Progress: The target and achievement under different interventions of the project watershedwise is given.

The achievement as enumerated above against the target fixed, worked out to the following percentage.

Item of works	% of achievement in Ganjam	% of achievement in Phulbani	Overall % for the entire project.
<b>I. <u>ON-FARM DEVELOPMENT:</u></b>			
(a) Vegetative hedges	87	more than 100	more than 100
(b) Crop demonstration	44	more than 100	97
(c) Mixed horticulture	More than 100	77	85
<b>II. <u>OFF-FARM DEVELOPMENT:</u></b>			
(d) Multi tier canopy F2	71	36	47
(e) -do- F3	90	62	73
(f) Rehabilitation of degraded forests F 4	58	more than 100	98
(g) Mixed horticulture H <sub>1</sub>	4	10	7
(h) Silvi pasture P1	70	100	78
<b>III. <u>NATURAL DRAINAGE LINES:</u></b>			
(i) Brushwood/vegetative stabilisation	more than 100	more than 100	more than 100
(j) Stone check dam	74	more than 100	more than 100
(k) Earthen runoff/management structure	98	50	89
(l) Diversion channel	70	more than 100	more than 100
(m) Diversion structure	61	more than 100	more than 100

Financial Progress:- There is almost no constraints on budgetary support for the project by the State Government. The yearwise budgetary allocations against the provision in S.A.R is presented below;

Year	Provision in S.A.R	Rs. in lakhs Budgetary allocations by State Govt.
1990-91	319.28	102.37
1991-92	307.97	100.00
1992-93	931.40	428.79
1993-94	903.82	325.37
1994-95 (proposed)	812.46	496.58

T A B L E- 3

7: RESEARCH AND DEVELOPMENT COMPONENT UNDER  
IWDP & NWDPR.WATERSHEDS TAKEN FOR RESEARCH WORK:  
(Agroclimatic Zone wise )

SL NO.	Name of the Agro climatic zone	Name of the Watershed	Watershed Code No.	Name of the RRS/RSRS.
(1)	(2)	(3)	(4)	(5)
1.	East & South Eastern Coastal Zone.	Malipada Paikarapur Watershed	078	Bhubaneswar (RRS)
2.	Mid Central Table land zone	Damodar Nala (Sadar)	084	Mahisapat (RRS)
3.	North Eastern Coastal plain Zone	Kochiokoilli	077	Ranital (RRS)
4.	North Western Plateau Zone.	Lahandabad	075	Kirei (R S R S)
5.	West central Table land zone	Bhutah Nala	083	Chiplima
6.	Easternghat high land Zone	Kukurgada	081	Similiguda (RRS)
7.	North Central Plateau Zone	Bhagathar Nala	076	Keonjhar (RRS)
8.	North Easternghat Zone	Lingagada Nala	079	G.Udayagiri (RRS)
9.	Western Undulating Zone	Mukha Nala	082	Bhawanipatna (RRS)
10.	South Easternghat Zone	Bhaluketa	081	Kalimela (RSRS )

7. RESEARCH AND DEVELOPMENT COMPONENT  
UNDER NWDPRA & IWDP:

Research Component of NWDPRA:-

For the success and sound implementation of the technologies, field tested recommendations are needed which can be generated from the applied research carried out in different agro-climatic zones of the country. Research Component of the World Bank Projects which were implemented in different states through State Agricultural Universities have given encouraging results on different low cost and vegetative conservation measures.

To develop suitable technology for soil and water conservation, cropping systems, agro-forestry and livestock production, on - site research will be conducted in consultation with the farmers. Research based data will be generated under each agro-climatic zone on watershed basis which can be replicated in other areas to boost production. Interaction of farmers, Scientists, development agencies/extension agencies will be given priority for conducting on-site research. Innovative ideas of the farmers, extension agencies and NGOs will be supported through research component of NWDPRA.

Research activities should be of short term nature to

- (a) Project problem solving and generation of information for development.
- (b) Investigation and documentation of current farming systems.
- (c) Operational research projects in a part of selected watersheds.

(d) Measurement and gauging of run off alongwith hydrological parameters ( Anonymous 1993).

Research component of IWDP:- The World Bank aided Integrated Watershed Development project has been sanctioned to O.U.A.T with a purpose to provide research support to the development activities of this project.

The objectives of the adaptive Research component of IWDP:-

- (i) Generation of hydrological and meteorological data base for refining the design capacity of various structures to be used in the watershed & to develop models correlating rainfall runoff and sediment loss from the watershed.
  - (ii) Identification and evaluation of suitable plant species as vegetative barrier for effective soil and moisture conservation.
  - (iii) Identification, evaluation and management of different plant species suitable for silvi-pastoral/agroforestry system
  - (iv) Identification of strip/intercropping system and combination for soil and water conservation in slopy lands.
  - (v) Evaluation of efficient feasible and low cost drainage line treatment technology for in-situ rain water conservation for increasing productivity of marginal and degraded land.
- ( Anonymous- 1994).

#### PERFORMANCE OF Vetiveria Zizanioides IN WATERSHED PROJECT:

From results of seven SAUS Vetiver remains technically the best barrier hedge for the areas receiving more than 650-700 mm annual rainfall and having 25cm soil depth for reducing the soil loss ( 14.76 %) & run off(50-69 %) on most of the soils in the third year after plantation. .

## 7.2 RESEARCH RESULTS UNDER IWDP:

The experimental details of on farm trials conducted at different centres of IWDP during 1993-94. From the research results the following inferences can be drawn:

(a) Among the different vegetative barriers Pennisetum purpureum conserved more moisture with least run-off (11.01 lit per rainfall at Jagannath Prasad resulting in highest yield of groundnut ( 12.5 q/ha). At G.Udayagiri Sabaigrass conserved more moisture which was followed by Cynodon dactylon on miniature bund. However, the yield of black gram was highest in farmer's method without any vegetative barrier. At Khajuripada maximum moisture was conserved by cynodon dactylon on miniature bund but highest yield of groundnut was obtained from the vetiveria barrier treatment.

(b) Experiment for effective establishment of vetiveria vegetative barrier indicated that 4 slips of vetiveria planted at 10 cm. distance showed maximum survival percentage of 95-100 % at Jagannath Prasad, 79.4 % at G.Udayagiri and 90 % at Khajuripada. Maximum number of tillers/clump were obtained by planting 3 slips at 5 cm spacing in higher elevation and 4 slips at 15 cm spacing in middle and lower elevation at Jagannath Prasad. At G.Udayagiri planting 2 slips at 10 cm spacing produced maximum tillers/clump which was followed by 2 slips at 5 cm spacing.

(c) Comparison of different tree planting methods showed that at Jagannath Prasad, for both mango and cashewnut maximum growth was in 'V' ditch method of planting,

which was followed by crescent method for mango and staggered trench for cashewnut. At G.Udayagiri growth rate of fruit trees were highest in case of 'V' ditch method which was followed by scattered trench and crescent method. At Khajuriapada moisture content of soil as well as growth rate of forest trees were highest in case of staggered 'V' ditch method which was followed by 'V' ditch method.

(d) Among different live fencing materials maximum survival percentage was observed in case of cereae (100%) at Jagannath Prasad. But highest growth rate was of Siju, which was adjudged to be the best live fencing material for Jagannath Prasad. At G.Udayagiri highest survival percentage was with Agave (94.3 %), but highest growth rate was with Jatropha. But Jatropha and Opuntia were considered as good live fencing materials for G.Udayagiri. At Khajuripada, Agave, Cereae and Ipomea showed higher survival percentage of 95-96 %.

(e) Trial on silvi-pastoral system showed that at Jagannath Prasad, Cassia showed good growth followed by Acacia whereas growth of Subabool was the least. Among fodder grasses hybrid Napier performed best under all the plantations, the highest ( 38.1 q/ha) being under Cassia plantation. At G.Udayagiri style (Perennial) in combination with Sisoo gave maximum fodder yield ( 52.2 q/ha) Among the tree species Gambhar showed maximum growth rate followed by Sisoo.

(f) Trial on Agri-horticultural system revealed that at Jagannath Prasad mango and cashewnut performed better with groundnut, whereas growth of Ber was better in combination with arhar. Arhar + Ber and mango + groundnut were found to be compatible combinations. At G. Udayagiri niger performed well in combination with all the fruit crops, highest being with Jackfruit. Among the tree crops growth of guava was the best followed by mango. At Khajuripada the best combination was found to be arhar with guava.

(g) Among the different low cost drainage line treatments, planting of six rows of vetiveria conserved maximum soil by depositing a soil layer of 12 cm in the bed at Jagannath Prasad. This was followed by the treatment involving 2 rows each of Vetiveria, Vitex negundo and agave resulting in soil deposit of 8.5 cm.

(h) Among the different grass species tried under medium fertility levels Stylo (Perennial) performed the best at Phulbani, where as Rhodes gave highest yield (102.4 q/ha) followed by hybrid napier ( 90.9 q/ha) and Stylo ( Perennial) ( 74.5 q/ha) at G.Udayagiri.(Anonymous 1994).

### 7.3 STATUS OF VEGETATIVE BARRIERS ESTABLISHMENT IN STATES:

#### PILOT PROJECT FOR WATERSHED DEVELOPMENT IN RAINFED AREAS:

##### Andhra Pradesh

1. The overall progress in executing the vegetative soil and moisture conservation activities in Maheshwaram

(7396 ha ) and the additional seven watersheds ( 12158 ha) is satisfactory. The survival in watersheds varies from 40 % to 70 % and can be further improved by quality control in planting ( 2-3 vetiver slips at 5 cm spacing and in furrow followed by small earthen key line of about 0.20 m cross section and planting in areas having about 700 mm rainfall) and involvement of farmers, for protection, maintenance and gap filling in second year and regular termite control.

2. In Maheshwaram watershed well established barriers are found drying and dying in a number of villages ( contrary to good survival in APAU rainfed fields) probably because of moisture stress, uncontrolled grazing combining with attack of termites and mechanical damage during agricultural operations. It is recommended two technologies- one burning and second use of new granular long acting formulations for termite control in the field in supervision of APAU.

3. It is proposed that other grasses such as Saccharum munja, Saccharum spontaneum ( locally known as Rellugadi grass, ( Cinchrus ciliaris, and Guinea mucunea and Utocho mosambisensis should also be tried at zonal stations of SAU and NWDPR watershed so as to ascertain their effectiveness to establish and form barriers in the low rainfall areas particularly Chāka soils.

Madhya Pradesh

4. The overall progress in executing the vegetative soil and moisture conservation activities in Paruanala (10602 ha) and the additional four watersheds (13741 ha) is satisfactory. The survival is above 60-75 % and can be further improved by quality control in planting and involvement of farmers for protection, maintenance and gap filling in the second year.

5. Other grasses such as Saccharum munia, Sorghum naplens (Bani), Cymbapogon martinic and Panicum maximum can be tried in NWDPARA watersheds of drier districts (receiving rainfall less than 600 mm) by SAU so as to ascertain their effectiveness to establish and for barriers. The trial should have replications so that valid conclusions can be drawn on the relative merits. (Lodha M.C ( 1994) .

7.3 Studies on Run off and Soil loss Under different Soil Conservation Practives:-

Studies on Run off and soil loss has been conducted at Bhubaneswar in 1989 Kharif. Cowpea, SEB-II was taken as crop. Here soil and moisture loss is a serious problem in undulating land with light soil. Water distribution in the inter-terrace space is uneven and moreover there is movement of soil within this space. This experiment is designed to study the effect of inter-terrace treatments on soil loss and runoff.

Treatments ( Inter-terrace Land treatments):-

T<sub>1</sub> Contour cultivation

- T<sub>2</sub> - Contour cultivation with vegetative barrier.  
 T<sub>3</sub> - Ridge & furrow cultivation  
 T<sub>4</sub> - Broad-base and furrow farming.  
 T<sub>5</sub> - Farmer's practice of cultivation (control)

Results

<u>Treatments</u>	Yield in Q/ha (green pods)
T <sub>1</sub>	38.10
T <sub>2</sub>	41.98
T <sub>3</sub>	39.00
T <sub>4</sub>	26.48
T <sub>5</sub>	38.64

The soil conservation practice of contour cultivation with vegetative barrier resulted in the highest yield of green pods of cow pea ( 41.98 q/ha) and on the other hand broad-base and furrow farming produced lowest yield of 26.48 q/ha (Anonymous-1989-90)

8. SIGNIFICANCE OF SOIL SURVEY IN WATERSHED DEVELOPMENT:-

Soil surveys are under taken to determine the nature, distribution and extent of different soils in a watershed. Through such a survey, it is possible to determine and evaluate all the combinations of soil characteristics for proper use of land to interpret them in terms of their response to management practices.

### 8.1 Type of Soil Surveys:-

The following types of soil surveys are normally conducted.

- (i) Reconnaissance survey.
- (ii) Detailed survey.
- (iii) Detailed reconnaissance survey

(i) Reconnaissance survey:- Here the mapping is less elaborate and small scale base maps are used. The field traverses are made at wider intervals and the survey covers large areas, in relatively a shorter time. Such surveys provide general understanding of the soils in the watershed area, are useful for preliminary planning. These surveys are made in the areas of lesser agricultural importance as in hilly areas.

(ii) Detailed survey:- The detailed surveys are conducted to provide maximum informations required for intensive land use according to soil characteristics. Large scale base maps are used for showing detailed information and field traverse and observations on soil characteristics are made at short interval in the field. The detailed surveys are made in areas of greater agricultural importance for intensive planning. This information is then utilized for soil classification and mapping so that it may be utilized by many users.

(iii) Detailed Reconnaissance Survey:-

These surveys are combinations of both reconnaissance and detailed surveys. The region of low potentialities for agriculture use are surveyed according to reconnaissance survey while areas of better agriculture potentialities are surveyed in detail.

8.2 Soil Survey by Traverse Method:-

Soil survey by traversing is the most traditional method. It consists of examination, classification and mapping of soils in the field. The soils are examined at intervals depending on the type of soil survey and the precision with which the information is needed. Soil boundaries are checked by examination of the soil profile in the field at prescribed intervals. Different soil characteristics and land features noted in the field include depth, texture, permeability of top soil and sub stratum, slope, erosion hazard and other additional features like colour, salinity, fertility, moisture capacity, stoniness undulations etc. The soils are differentiated on the basis of heterogeneity of the soil and the type of survey. The soil boundaries are demarkated and the area is delineated into different mapping units. In each unit a soil profile is studied to characterize the soils in detail.

Soil samples are collected for laboratory investigations for PH, EC, available nutrients and mechanical analysis etc.

### 8.3 Soil Survey by Aerial photo Interpretation:-

Aerial photos are prospective view of the portion of land surface and do not have true scale.

Soil survey data are used to categorize the soils into different soil series and soil type. These are also useful for taxonomical classification and land capability classification.

8.4 Soil Series:- A soil series represents a group of soils having soil horizons with similar characteristics and arrangements in a soil profile developed from a particular type of parent material but they may differ in texture of surface soil. The series is very informative and gives a broad picture of the soil profile as to topography, drainage, kind, thickness and arrangement of horizons colour & P.H.

Soil type:- It is the sub-division of soil series based on the variation in the texture at the top soil, other morphological features remaining the same as that of a soil series.

### 8.5 INTERPRETATIONS OF SOIL SURVEY DATA FOR WATERSHED MANAGEMENT:

#### 8.5.1 Land Capability Classification:-

The grouping of soil into different classes, sub-classes and units is done primarily on the basis of their ability to produce plants without deterioration for a long time. This classification is an interpretative classification based on the effect of the combination of climate and permanent soil characteristics on

the risk of soil damages, limitation in use, productive capacity and management requirement. All the soil within the land capability class are only similar in degree of limitation in soil use. ( Dhurbanarayana 1990).

#### 8.5.2 Slope:-

The slope of land has great influence on the soil and water loss from the area and thereby influence the land use. The slope percentage determines the erosion susceptibility of the soil depending upon its nature. The modified slope classes, their ranges and descriptions are given below:

<u>Slope Class</u>	<u>Slope range</u>	<u>Description</u>
A	0- 1 %	Nearly level
B	1- 3 %	Very gently sloping
C	3-5 %	Gently sloping
D	5-10 %	moderately sloping
E	10-15 %	strongly sloping
F	15-25	Moderately steep to steep.
G	25-33 %	Steep
H	33- 50 %	Very steep
I	Over 50 %	Very very steep.

#### 8.5.3 Drainage:-

Drainage materially influences soil forming processes. Poor drainage may have even more effect on soil

development than very rapid drainage. Drainage water tends to displace the soil solution from the surface soil and so there is loss of soil as well as plant nutrient through drainage. The following notations are used for drainage while surveying the area.

D <sub>1</sub>	= Well drained.
D <sub>2</sub>	= Moderately drained.
D <sub>3</sub>	= Ill drained.

8.5.4 Soil Depth:- Soil depth modifies to a great extent the rooting system of plants which is ultimately reflected in crop growth and yield. The depth classes and their description are given below.

<u>Depth class</u>	<u>Depth in cm</u>	<u>Description</u>
d 5	More than 100 cm	Very deep
d 4	50 to 100 cm	Deep.
d 3	25 to 50 cm	Moderately deep.
d 2	10 to 25 cm	Shallow
d 1	Less than 10 cm	very shallow.

8.5.5 Erosion:- Features of erosion is largely judged by the conditions existing in the field. Slight erosion (e<sub>1</sub>) may be associated with mild sheet erosion, and Moderate erosion (e<sub>2</sub>) with sheet and rill erosion. Severe erosion (e<sub>3</sub>) will be associated with excessive surface erosion, exposing the sub-soil. Very severe erosion (e<sub>4</sub>) includes a few shallow gully and occasional deep gully formation.

8.5.6 Hydrology:-

The water resources of a region conceived as a dynamic phase of the hydrologic cycle, are influenced by the following factors.

- (1) Rainfall.
- (2) Evapo transpiration
- (3) Channel characterstics:- carrying capacity and storage capacity.
- (4) Geometric factors such as drainage area, shape, slope and stream density.
- (5) Physical factors:- Landuse, Surface infiltration condition, Soil type
- (6) Hydrologic characterstics of the aquifers permeability, Porosity, storability etc.

Rainfall pattern and distribution in a region is a good index of its water resources. The survey data regarding the above characterstics will help for planning & development of watershed.

8.5.7 Physicochemical Properties of Soil:-

Soil characteristics must be taken into account as different erosion- Control practices are studied. All soils do not respond to the same treatments for erosion control. The erodibility of soil is influenced by the following characteristics (a) texture (b) Structure (c) Organic matter (d) depth (e) Character of Sub-soil (f) Water holding capacity. (g) fertility status .The chemical properties of clay have been recognized as important factor in erodibility.

Soil with higher Silica to sesquioxide ratio are generally plastic and erosive and those of lower ratios are friable and non erosive. The soil containing high organic matter will decrease the runoff and erosion through slowing down runoff water, increasing the rate of infiltration and causing the soil aggregates to remain stable in the presence of moving water. The erodibility of soil is also influenced by the following chemical characteristics (1) Soil reaction (2) CEC (3) Percentage of base saturation (4) Percentage of organic carbon (5) Type of clay minerals.

9. DESCRIPTION OF THE WATERSHED NO. ORR-5-4-5-2  
SELECTED AS A PILOT WATERSHED OF JAGANNATH  
PRASAD BLOCK OF GANJAM DISTRICT UNDER IWDP:

For integrated watershed development project it is proposed to include one watershed of Jagannath prasad block of Ganjam district. The Watershed has been divided into seven sub-watersheds with 14 miniwatersheds. The mini Watershed ORR-5-4-5-2 has been selected as a pilot watershed for treatment in first 3 years of the project period.

The mini Watershed comprises of an area of 3120.643 hact. Which includes the village survey area, hills, forest etc.

9.1. Climate of the Watershed:-

The watershed comes under the North easternghat agroclimatic region of the state. But the climate is is-tropical, sub-humid monsoonic type. The average annual rainfall of the watershed area is 1286 mm with 87 rainy days. The watershed is situated at an elevation of 100 to 200 m above MSL. December is the coldest month of the year with minimum temperature of 68<sup>0</sup> F & May is the hottest month with maximum temperature of 102<sup>0</sup> F The rainfall data, temperature data. has been given in Table-6 & 4.

9.2 Present land use of the Watershed:-

The followings are the present land use data which is needed to determine the use of lands for

development of watershed.

(1)	Total cultivable land:-	1377.916 ha
(2)	Area comes under hills:-	26.362 ha
(3)	Forest land :-	267.139 ha
(4)	Grass land :-	52.530 ha
(5)	Cultivable waste land:-	222.233 ha
(6)	Un-culturable waste land:-	4.610 ha
(7)	Burrial ground :-	2.897 ha
(8)	Roads & Path:-	65.365 ha
(9)	Water bodies:-	69.156 ha
(10)	Village Site:-	18.468 ha
(11)	Orchard (Cashew, Mango etc )	139.352 ha
(12)	Area under reserved forest:	871.710 ha
(13)	Others:-	2.90 ha.
	Total:-	<hr/> <u>3120.643 ha.</u> <hr/>

T A B L E :- 4

Average Temperature °C of Ganjam District.

SL NO.	Name of the Month	Max. Temp. o C	Min Temp. oC	Average Mean Temp.	R E M A R K
1.	January	26.8	16.5	21.65	
2.	February	29.3	18.8	24.05	
3.	March	30.4	21.8	26.1	These data
4.	April	31.0	24.2	27.6	collected from
5.	May	32.4	26.0	29.2	status report
6.	June	32.2	26.1	29.15	on Agril. Rese-
7.	July	30.8	25.2	28.0	arch & exten-
8.	August	31.3	25.2	28.25	sion (North
9.	September	31.8	24.0	27.9	Estern ghat
10.	October	31.5	22.5	27.0	Zone) RRS-
11.	November	29.8	19.4	24.6	G.Udayagiri
12.	December	27.5	16.1	22.05	Directorate
					of Research
					OUAT, BBSR Indi:
					1989-90.

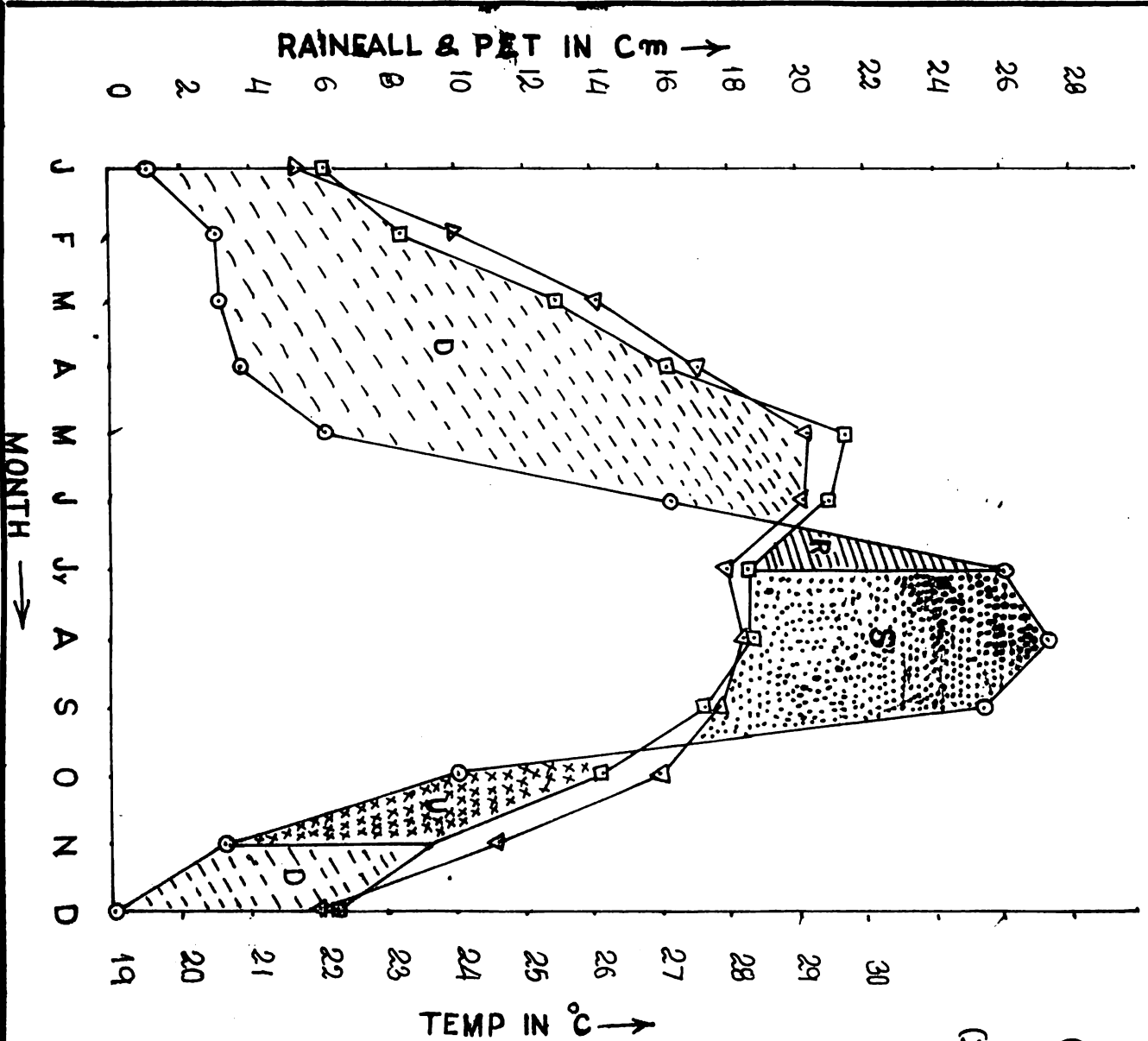
T A B L E - 5

Monthly PET (cm) in Ganjam district)

Month	PET (cm )	(Thronthwaite method)
1. January	6.17	
2. February	8.46	These data collected from the book "Irrigation and Drainage" by Dr. D.Lenka, (Page-95)
3. March	12.99	
4. April	16.28	
5. May	21.56	
6. June	20.99	
7. July	18.63	
8. August	18.70	
9. September	17.34	
10. October	14.29	
11. November	9.43	
12. December	6.49	

SL NO.	Month	1978	1979	1980	1981	Y 1982	E 1983	A 1984	R 1985	1986	1987	1988	Average Rainfall per month
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	JAN.	-	8.00	7.50	39.25	-	-	-	42.00	25.00	-	-	11.068
2.	FEB.	25.75	0.19	-	50.25	52.00	63.25	15.00	20.00	3.00	-	104.00	31.04
3.	MAR.	13.75	-	33.75	89.00	161.50	31.00	-	-	3.00	3.00	19.00	32.18
4.	APR.	51.00	6.00	26.25	15.00	22.00	137.50	78.50	20.00	-	10.00	42.50	37.16
5.	MAY	51.50	99.25	83.75	47.00	62.50	51.00	24.00	40.50	53.50	26.25	143.50	62.07
6.	JUNE	287.00	57.30	298.25	74.00	153.75	179.75	126.50	186.50	173.00	59.00	200.00	163.21
7.	JULY	323.25	267.73	237.25	127.50	329.00	302.50	274.50	277.50	268.00	226.75	231.00	260.45
8.	AUG.	313.25	156.50	262.25	517.00	461.00	384.50	181.50	278.50	220.50	84.50	172.50	275.64
9.	SEPT.	266.75	258.55	213.00	398.50	197.00	263.75	246.00	306.00	170.50	261.50	230.00	255.54
10.	OCT.	95.55	56.00	199.00	40.75	119.00	25.50	18.00	179.00	104.50	148.50	123.00	100.8
11.	NOV.	27.05	28.75	11.50	-	25.00	-	-	-	104.00	169.00	-	33.24
12.	DEC.	7.00	3.00	-	6.00	-	-	-	-	-	-	-	1.45
TOTAL:		1461.85	941.27	137.50	1412.25	1582.75	1438.75	964.00	1350.00	1125.00	988.50	1265.50	1263.85

**Fig. 1 CLIMATIC WATER BALANCE**



SCALE:  
 (1) FOR RAINFALL & PET  
 VR = 1 C<sub>m</sub> = 2 C<sub>m</sub> RF & PET  
 HR = 1 C<sub>m</sub> = 1 MONTH  
 (2) FOR TEMPERATURE  
 VR = 1 C<sub>m</sub> = 1 °C

**REFERENCE**

1. RAINFALL	○ ○ ○
2. PET	□ □ □
3. TEMPERATURE	△ △ △
4. RECHARGE	▨
5. SURPLUS	▩
6. DEFICIT	▧
7. UTILISATION	▦

9.2 Watershed Characteristics:-

1. Name of the Nala - Natuni nala
2. Drainage area - 3120.643 ha.
3. Location - 19°55' N to 19°57' N  
latitude.  
and 84°46' 30" E to 84°53' E  
Longitude
4. Shape :- Feather shape.
5. Shape Index:- 2.95
6. Drainage frequency: 3.20 nos/10,000 ha
7. Silt production rate 2.7996 hm/100<sup>2</sup>km/year.
8. Time of concentration 313 min.
9. Orientation: South east to North west.

The catchment characteristics of the watershed indicates that it is a highly eroded watershed which needs immediate conservation measures.

9.5 Soil Characteristics of the Mini Watershed:-

There are seven soil series found in this watershed. The soil characteristics of different soil series are given in table No.7.

Soil Characteristics of different Soil Series of the Miniwatershed No. ORR-5-4-5-2

SL NO.	Charac-terstics	Name of the Soil Series						
		Khalkhali.1 (Khl.1)	Takarada.1 (Tkd-1)	Khalkhali.2 (Khl-2)	Khalkhali.3 (Khl-3)	Khalkhali-4 (Khl-4)	Pingidi (Pgd)	Takarada-2 (Tkd-2)
1.	Area in ha	36.263	74.138	1342.752	363.262	890.826	244.015	12.591
2.	Land type	High land	High land	Upland	Medium & Upland	Medium land	Low land	Upland.
3.	Slope	15.25 %	3- 5 %	3- 5 %	1 - 3 %	1 - 3 %	1 - 3 %	3 - 5 %
4.	Erosion	e <sub>4</sub>	e <sub>4</sub>	e <sub>3</sub>	e <sub>1</sub>	e <sub>1</sub>	e <sub>1</sub>	e <sub>2</sub>
5.	Soil colour	Yellowish brown to Redishbrown	Strong Br- own to Red- ish brown	Very pale brown to dark brown	Yellowish brown	Light Yell- ow brown	Dark greysh brown to very dark gray	Very pale brown to browish yellow.
6.	Permeabi- lity	Rapid to moderate	Rapid	Rapid	Rapid to moderate	Moderate	Moderate	Rapid
7.	Soil depth	15 cm	180 cm	40 cm	180 cm	180 cm	180 cm	180 cm
8.	Drainabi- lity	Well drain- ed	Well dra- ined	Well dra- ined	Well dra ined	Moderate drained	ill drained	Well drained.
9.	Land capabi- lity	IV, VI	III,IV	III,IV	II	II	II	III,IV
10.	Lime status	Traces	Traces	Traces	Traces	1-7 %	1 %	Traces
11.	Ec mm/cm	0.052	0.052	0.068	0.052	0.115	0.094	0.163

Contd.P.2

1 2 3 4 5 6 7 8 8

12. Fertility status of Top soil.

(a) Available N	262 kg/ha (High)	135 kg/ha (Low)	134 kg/ha (Low)	160 kg/ha (Low)	173 kg/ha (Low)	229 kg/ha (Medium)	182 kg/ha (Low)
(b) Available P	24 kg/ha	24 kg/ha	25 kg/ha	34 kg/ha	39 kg/ha	28 kg/ha	29 kg/ha
(c) Available K	200 kg/ha	320 kg/ha	200 kg/ha	170 kg/ha	350 kg/ha	350 kg/ha	540 kg/ha

13. Infiltration

1.9 cm/hr	2.0 cm/hr	5.3 cm/hr	0.4 cm/hr.	0.3 cm/hr.	0.5 cm/hr.	9.4 cm/hr.
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14. CEC meq/100 gm Soil

3.4	1.28	0.88	3.08	4.88	7.6	0.72
-----	------	------	------	------	-----	------

15. Soil PH

6.1	5.95	5.95	5.7	5.4	6.4	6.6
-----	------	------	-----	-----	-----	-----

16. Soil Taxonomy

Lithic Ustipsamments	Udic Huplustalf	Lithic ustipsament	Udic Haplustalf	Udic Haplustalf	Vertic Tropaquept	Udic Haplustalf
----------------------	-----------------	--------------------	-----------------	-----------------	-------------------	-----------------

-----

**Agriculture:-**

Agriculture is the main stay of tribal people of the watershed area. The total agricultural land is about 1377.916 hect. out of which upland is 633.796 ha, medium land- 491.968 ha and low land is 252.154 ha.

In the uplands lesser millets and pulses are grown. In medium land, paddy is the principal crop and this is sometimes followed by pulses. Some profitable crops like Tobacco, Niger, Til, Maize are also cultivated. In low lands late variety of Paddy is the principal crop & cultivated years together . Pulses are also taken up as 2nd crop. Agricultural implements are primitive. Plant protection practices are not practised commonly, Use of FYM is a practice to Cash crop.

**Land Capability class Wise Area:**

<u>Sl No.</u>	<u>Land capability class/ sub class</u>	<u>Area in Ha</u>
1.	II	687.199 ha
2.	III e	389.854 ha.
3.	III es	1012.96 ha
4.	IV e	772.697
5.	IV es	101.137
<b>Total:-</b>		<b>2963.847 ha</b>

9.6 WATERSHED PROBLEMS:

(i) Soil erosion in upland:- The uplands are slopy and undulating having slope percentage of 3-5 %. It is subjected to severe sheet and rill enosin. At some places there is already gully formation.

(ii) Erosion in Pasture lands:-

The cattle population of the watershed is 12649 and Gochar land is only 52.530 ha which is very small compared to the cattle population of the watershed. Due to exessive grazing and poor management of pasture lands there may be severe soil erosion from pasture lands.

(iii) Erosion on Hills.

(iv) Erosion in culturable and unculturable waste lands.

(v) Erosion in forest lands.

(vi) Stream bank erosion.

Population:-

The total population is 4487 out of which 2249 are male and 2238 are female. The scheduled caste population is 644, Male- 335 & female-309. The scheduled Tribe population is 296,(Male-144, Female-152). The Scheduled Caste and Scheduled tribe population is 19 % of the total population. Total literacy population is 1109 out of which female is 253.

Total number of house holds in the miniwatershed is 890, out of which 718 have land holdings where as 172

are agricultural labourers.

- |     |                                                              |            |
|-----|--------------------------------------------------------------|------------|
| (1) | Total Marginal farmers( having land between<br>0 to 1.0 ha ) | - 399 nos. |
| (2) | Small farmers<br>( 1.0 ha to 2.5 ha )                        | - 189 nos  |
| (3) | Big farmers<br>(having morethan 2.5 ha of land)              | - 130 nos  |
| (4) | Agricultural labourers-                                      | 172 nos    |

---

Total:- 890

#### 9.7 WATERSHED DEVELOPMENT:-

The different conservation measures and other developmental activities like agriculture horticulture, Pasture development , improvement of forest etc should be taken up for development of the watershed.

The followings are the conservation measures of the miniwatershed No. ORR-5-4-5-2 to be taken up for its development.

- |     |                               |             |
|-----|-------------------------------|-------------|
| (A) | Soil conservation Programme:- |             |
| (a) | Vertiver contour plantation   | - 560 ha    |
| (b) | Miscellaneous plantation      | - 130 ha    |
| (c) | Water harvesting structures   | - 3 units.  |
| (d) | Gully control                 | - 20 units. |
| (e) | Stream bank erosion control-  | - 9 kms.    |
| (f) | Renovation of existing tank   | - 11 units. |

- (B) Horticultural Programme:-
- (a) Plantation in Govt. Lands.
- (i) Mango - 50 ha.
  - (ii) Guava - 10 ha
  - (iii) Citrus - 10 ha.
- (b) Plantation in Private lands.
- (i) Mango- 26.0 ha.
  - (ii) Guava - 25.0 ha
  - (iii) Citrus- 29.0 ha.
- (C) Pasture development Programme:-
- (a) Pasture development- 14 ha (b) Silvi Pasture- 8 ha
- (D) Forest development:-
- (a) Plantation of quick growing species - 200 ha
  - (b) Teak plantation - 100 ha
  - (c) Rehabilitation of degraded forest - 200 ha.
  - (d) Avenue Plantation - 12 kms.
- (E) Agricultural Programme:-
- (a) Vertiver contour plantation in uplands and medium lands- 100 ha.
  - (b) Vertiver nursery 6 units
  - (c) Crop demon stration 155 units.
  - (d) Training to farmers and cultivators in the watershed area ( Anonymous-Jan, 1989)

10. IMPACT OF WATERSHED TREATMENT ON AGRICULTURAL DEVELOPMENT:-

Proper management of natural resources like soil water and vegetation is a pre requisite for sustained productivity in a rainfed watershed 42 % of food grain production of India is contributed by 70 % of rainfed cropped area.

The paper deals with various aspects of watershed management introduced in the village padalsingi of Beed district, Maharashtra and benefit that accrued to the people as a result of the project between 1989-90 and 1990-91.

The project is located at padalsingi, district Beed covering an area of 324.72 ha. The average rainfall is 606 mm. Soil of the watershed are shallow to medium in depth and clay to clay loam in texture. The entire area of watershed belongs to four land capability classes i.e II, III, IV, VI having different soil series under each capability class.

To solve the problems of soil and water use in the watershed following approaches were suggested.

(i) Contour bunding (ii) Nala bunding (iii) Land shaping and grading (iv) Silvi pasture, Agroforestry and Agro-horticulture.

Following strategies were suggested to tackle the crop production problem.

- (i) Use of dry land technology.
- (ii) Spot guidance.
- (iii) Organisation of training programme for the farmers.
- (iv) Crop demonstration.
- (v) Demonstration on the use of improved implements and plant protection appliances.
- (vi) Construction of percolation tank with the following specifications.

Catchment area-	1.28 km.
Ht. of the percolation tank-	16 m
Storage capacity-	64.2 Tcm.

The project was started in 1984 and work of the components was completed by 1987.

**Crop Production and Cropping intensity:-**

Before taking up the project the main crops grown in the area in Kharif were Bajra and Mung (50.2 %) and in Rabi, Sorghum and safflower (49.8 %) Introduction of double cropping system and the water structures, the maximum area under Bajra + Redgram increased to 100 ha in kharif and 190 ha in different crops like rabi Sorghum, gram and wheat during rabi. The yield of crops increased significantly in watershed areas as compared to area outside the watershed.

T A B L E - 8

Cropping pattern of watershed during 1990-91.

C r o p	Proposed Programme (ha)	Total sown area (ha)	Total yields (q)	Average yield q/ha		Percent adoption of cropping schemes
				With- in water- shed area.	Outside water- shed area.	
KHARIF						
Bajra+Redgram	100	88.70	887.00	10	7.5	88.70
				4	3.0	
Green gram	90	74.40	297.60	3.5	2.5	82.60
Bajra	40	25.00	250.00	10	7.5	62.50
Sunflower	20	10.00	75.00	7.5	7.0	50.00
Cotton	5	5.00	60.00	12	8.0	100.0
Sorghum	10	42.00	50.40	12	10.0	42.00
Groundnut	15	12.00	96.00	8	7.0	80.00
Arhar	15	14.80	85.75	5.75	4.0	98.60
RABI						
Green gram followed by	100(1)	55.00	687.50	12.5	10.0	100.0
rabi sorghum	(R)	45.00	315.00	7.00	5.0	-
Bajra followed by wheat	40	25.00	375.00	15	12.0	65.00
Sunflower & Bajra followed by Gram	15	13.00	104.00	8	7.0	86.60
Safflower	10	9.00	45.00	5	4.5	90.00
Sunflower	20	15.00	112.50	7.5	-	75.00
Sugarcane	20	22.00	1320(T)	60 that	50 that	110.00
Vegetable	5	5.00	Rs. 30000/-	Rs. 6000	--	--

The adoption of the croppings pattern were due to the training programme, field visit, spot guidance and discussion amongs the individual farmers.

The cropping intensity continuously increased from 1984-85 upto 1989-90 (106 to 150.7 percent). However, it was decreased during 1990-91 ( 147 percent) as compared to 1989-90( 150.7 percent) due to water logging conditions below the percolation tank.

#### Dryland Horticulture:-

The mango + ber inter cropping was introduced on two ha during 1989-90 and five hundred mango plants were grafted with 90 percent success. In 1990-91 the eight hundred mango plants were planted and out of 800, three hundred mango plants were grafted with 90 percent success.

#### Fertilizer Consumption:-

The total consumption of NPK during 1984-85 was only 37.5 kg each while it increased to 6380 kg N, 5220 kg  $P_2 O_5$  and 2900 kg  $K_2 O$  ( 1990-91). The fertilizer consumption slightly increased in 1990-91 as compared to 1989-90 ( 6000 kg N, 5000 kg  $P_2 O_5$  and 2000 kg  $K_2 O$ ). The fertilizer use increased in watershed areas because of awareness of the farmers on increased crop production.

#### Land Capability Classification:

The watershed was divided into different land capability classes, depending upon the limitations imposed

by factors such as erosion, soil climate and water, In the surveyed area as given ( Table. 9) II,III, IV & VI land capability classes were delineated ( Phadnawise and Birajdar 1990)

T A B L E - 9

Land capability classes:

Land Capability Class	II	III	IV	VI
Land capability sub class	11es	111es	IVes	*VIe
Irrigability sub class	2s	3s	4st	
Productivity potential	Medium to high	Medium	Low	
	76.34	81.66	139.44	27.29

\* V1es steep land subject to severe erosion

practically very shallow to no soil rockout crops, very stoney.

#### Nutrient Index:

Soil samples collected from the individual surveys of the watershed areas and analysed for organic carbon, available phosphorus, potash and other properties of soil i.e pH, and electrical conductivity.

Fertility index was Calculated as:

Nos of samples in low x 1 + Nos of samples in medium X 1.5 + Nos of samples in high x 2.5

Nutrient Index =  $\frac{\text{Nos of samples in low} \times 1 + \text{Nos of samples in medium} \times 1.5 + \text{Nos of samples in high} \times 2.5}{\text{Nos of soil samples analysed.}}$

T A B L E- 10

## Fertility Index of Watershed:

Year	Fertility Index		
	Organic Carbon	Avail Phosphorus	Avail Potash
1985-86	1.30 ***	1.23 *	2.50 ***
1986-87	1.34 **	1.27 **	2.50 ***
1987-88	1.36 **	1.30 **	2.50 ***
1988-89	1.38 **	1.28 **	2.47 ***
1989-90	1.39 **	1.35 **	2.50 ***

\* Indicates low \*\* Indicate moderate \*\*\* Indicate high.

The soil fertility index of watershed was found slightly increased over the bench mark in organic carbon ( 1.30 to 1.35) and available phosphorus (1.23 to 1.35 ), ( Table 10) The soil contained high content of available potash. Use of farmyard manures, compost and legume crop in different cropping patterns ultimately helped in improvement of soil fertility status. Phadnawis et al ( 1990) recorded moderate to high soil fertility index.

## Well and Irrigated Area:

Due to ground water recharge the number of wells increased from 11 to 20 in the watershed. The water table observations of wells were taken monthly during years 1984-85 (B.M) 1988-89, 1989-90 and 1990-91 respectively. Observation after the completion of water structure showed

that the water table increased ( 7.97 m) during the project period over bench mark ( 12.30 m) as presented in Table.11. The source of irrigation is only wells. All structures constructed in watershed recharged the ground water table. Excess rain water was collected in water structures which ultimately affected the increase of ground water table.

T A B L E NO. 11

Creation of additional employment in the watershed:

Year	Men ( Mandays)	Women (Mandays)	Total (Mandays)	Percentage employment increase over bench mark
1984-85	6133	11705	17838	--
1990-91	9409	18194	27603	54.74

Introduction of improved technology resulted increase in the farm operation activity of participating farmers reflecting in additional labour requirement to farm operations. The additional employment generation due to introduction of improved technology was 9765 mandays which was 55 percent higher over that bench mark as given Table- 11.

Cost Benefit Ratio:

The cost analysis ratio was found to be 1:2.23 based on net profit Table-5. Similar results were reported by Phadnawis et al ( 1990). The data revealed that the income increased from Rs. 11,106 to Rs. 54,265 per family and from Rs. 1587 to Rs. 7752 per capita ( table. 6).

## CONCLUSIONS

Watershed management practices such as, construction of the water structures and improved agronomic practices resulted in improvement of farmer's income and employment to labours. The cost benefit ratio of the project was 1: 1.23 based on net profit. The watershed management proved beneficial to dryland agriculture.

T A B L E. 12

Details of Economic Analysis:

Crop	Area (ha)	Yield (q)	Yield Produce (q)	Total value of the produce (Rs)	Cost of cultivation (Rs)	Net Income (Rs)
<b>A. KHARIF</b>						
Bajra	25	250	375	62000	55938	6062
Bajra+Arhar	88.7	887	1330	525185	333689	191496
Sunflower	10	75	-	75000	26125	48875
Cotton	5	60	120	58800	23125	35675
Sorghum	4.2	50	100	19000	16645	2355
Groundnut	12	96	49	86430	42300	44130
Arhar	14.8	85	43	86720	43660	43060
<b>B. RABI</b>						
Rabi Sorghum (Irrigated)	55	688	1376	338496	114125	224371
Rabi Sorghum (Rainfed)	45	315	630	154980	88875	66105
Wheat	25	375	375	157500	89375	68125
Gram	13	104	52	84700	33969	50731
Safflower	9	45	-	45000	18675	26325

## C. SUMMER

Sunflower	15	113	-	113000	39180	73820
Sugarcane	22	1320(T)	-	396000	71720	324280
Vegetable	5	-	-	30000	5000	25000
Total:-				2232811	1002401	1230410

T A B L E. 13

## Economic Development of Farmers.

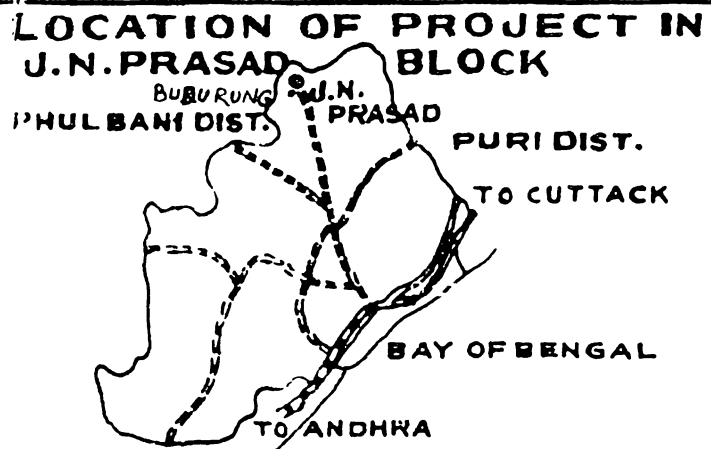
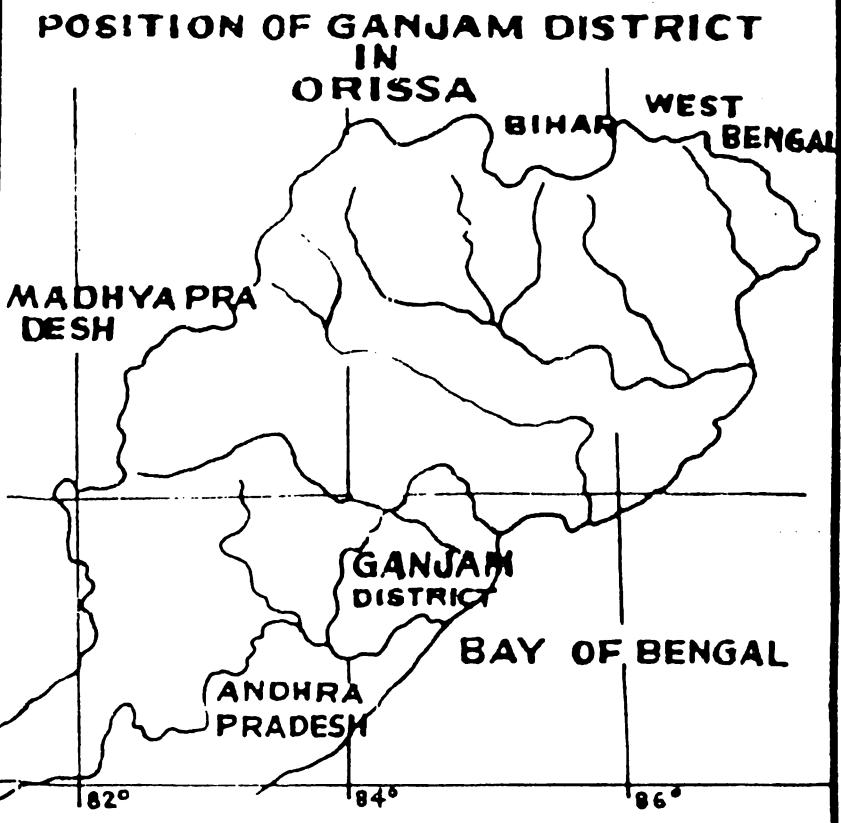
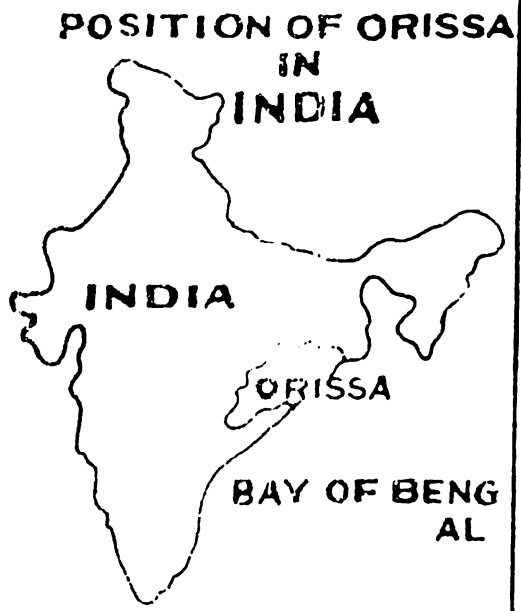
Particulars	Bench mark 1984-85	1989-90	1990-91
Income per family ( in Rupees)	11,106	45,790	54,265
Income per capita ( in Rupees)	1,587	6,541	7,752
Income per Hactare ( in Rupees)	1,780	7,895	8,355
Total Income ( in Rupees)	5,55,313	22,84,484	27,13,236

The cost benefit ratio of project was 1: 1.23 ( Phadnawis  
A.N. ( 1993) ).

CHAPTER III

**MATERIALS AND METHODS**

**FIG: 2**



**FIG - 3**  
**SITE MAP**  
**VILLAGE - BUDURUNGU**  
**P. S. - BUGUDA No. 58**  
**TAHASIL - GHUMUSAR No. 183**  
**DIST - GANJAM**  
**SCALE - 30" = 1 MILE**



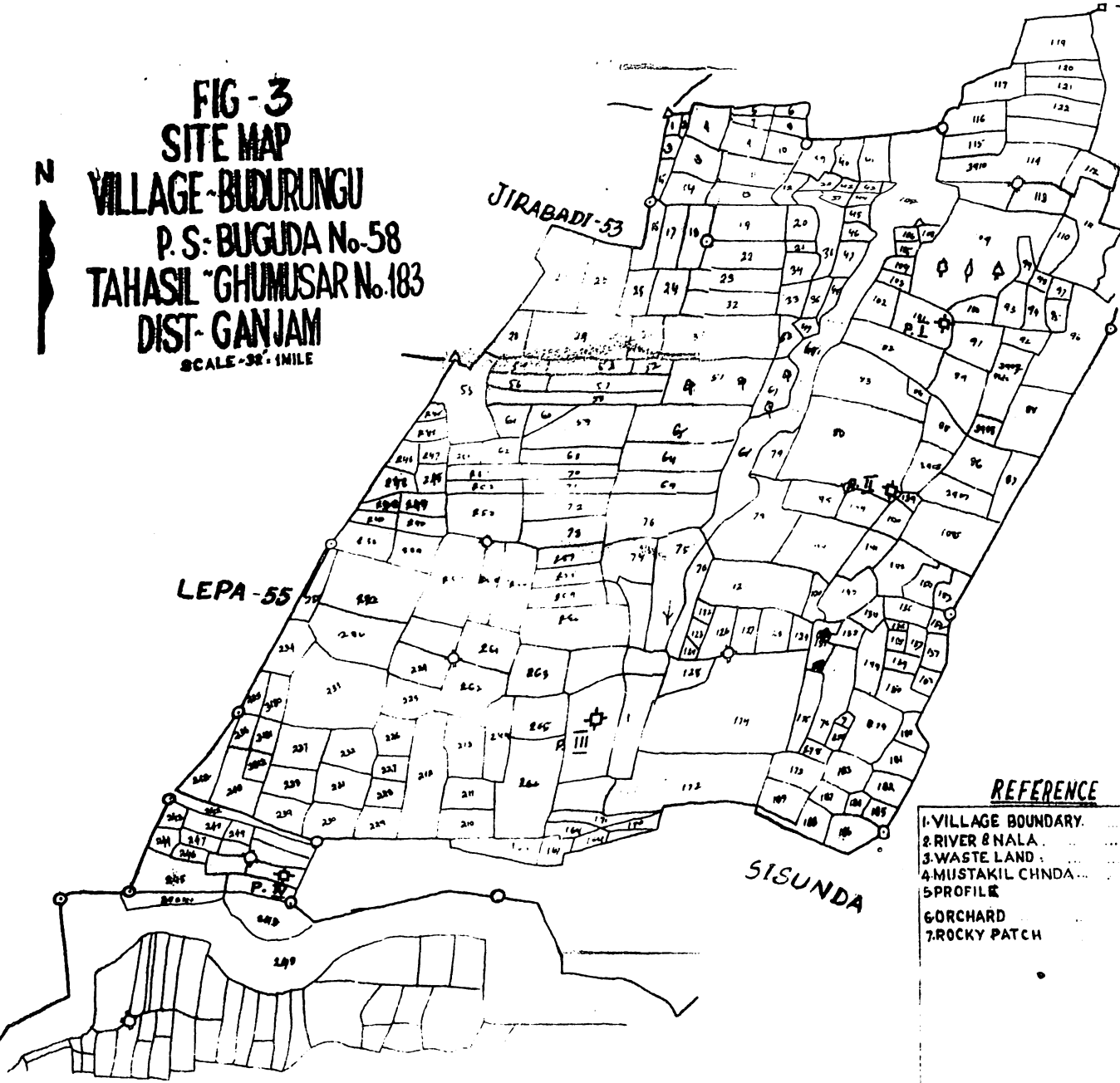
JIRABADI-53

LEPA-55

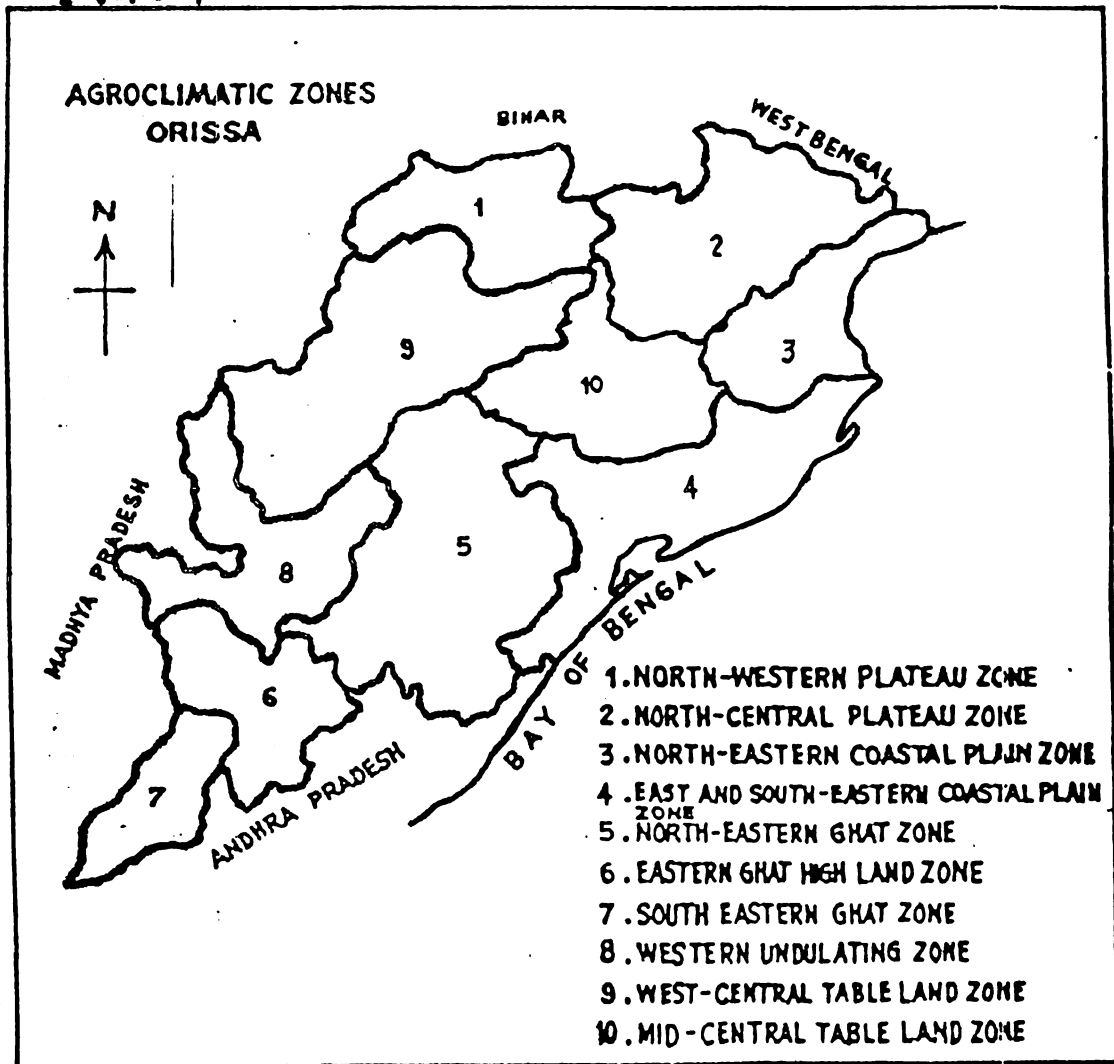
SISUNDA

**REFERENCE**

- 1. VILLAGE BOUNDARY.
- 2. RIVER & NALA.
- 3. WASTE LAND.
- 4. MUSTAKIL CHNDA.
- 5. PROFILE.
- 6. ORCHARD.
- 7. ROCKY PATCH.



**FIG: 4**



## MATERIALS AND METHODS

### General feature and location of the Area:-

The study area which is a part of the miniwatershed ORR-5-4-5-2, comes under the village, Budurungu in block of Jagannath Prasad under Ganjam district. This area lies between  $19^{\circ} 55'$  N to  $19^{\circ} 57'$  N Latitude and  $84^{\circ} 46'$  E to  $84^{\circ} 53'$  E longitude. The area is situated at a distance of 30 km from sub-division head quarter, Bhanjanagar and 120 km from the district headquarter, chatrapur. The project area is marked by isolated hillocks, pediment and wide valley land. The general altitude lies between 100m and 200 m above MSL. The valley area consists of well terraced valley slope land and extensive plain land. Depending on the conspicuous difference in topography, geomorphology, hydrology whole area can be divided into the following broad physographic units.

- (a) Sedentary land scape in in eroded phase  
( hill, hill slope ( Pediment).
- (b) Sedentary land- Scope in depositional phase  
( valley ).

**Climatic Characteristics:-** This area comes under the North easternghat agroclimatic region of the state. The year may be divided into four season, the hot season, from March to May, the monsoon season from June to september the post monsoon months from October to November and the cold season from December to February.

The average rainfall of the project area is 1286 mm with 87 nos of raindays. About 72 % of the rainfall is received during the monsoon ( June to September ) after which the rain trails off and comes to stop. The winter rains appear to be scanty and uncertain. Occasional summer showers associated with thunder storm are experienced during summer months.

The maximum temperature in this area is 102° F i.e in the month of May and minimum temperature of 68° F in the Month of December.

#### Materials:-

Four pedons were exposed on a transect starting from landform unit of upper pediment and banded, unbanded, upland and lower pediment in topo sequence at an interval of 100m to 200 m. The soil scope and pedon situations are presented in Fig. 5 . Morphology was described in the field as regards the texture, colour, structure, consistency alongwith site characteristics like slope, erosion, drainage etc. Soil samples were collected from each of genetic horizon for laboratory analysis.

#### METHODS OF ANALYSIS:-

After morphological characterization of the different horizons in each pedon the soil samples were collected and brought to laboratory for analyses. The samples were air dried, grinded with a mortar with wooden pestle and passed through a 2 mm sieve. The samples so

obtained were preserved in stoppered bottles, labelled and stored in a dry place for further study. The materials remaining on the seive were recorded as coarse fragments.

(A) Physical Methods:-

(a) Soil Colour:- The colour of the air dried and moist soil samples were determined by matching the colour with munsells' soil colour chart and was designated by the given notation i.e hue, value & chroma.

(b) Mechanical Analysis:-

Bouyoucos hydrometer method was followed and sodium hexameta phosphate was used as the dispersing agent (Piper 1950). Proportion of sand, silt and clay fractions were determined by sedimentation, decontation procedure. Textural classes were determined using international Triangular Textural diagram.

(c) Coarse Fragments:- The percentage of coarse fragments in the soil was determined by measuring the volume of the particles ( more than 2 mm ) to the total volume of the soil.

Water holding Capacity:-

The determination of water retention capacity of the soils was determined by chopra and Kanwar ( 1976) boxes described by piper ( 1950).

Bulk density:- Bulk density of the soils were determined by paraffin wax coating methods ( Block 1965) as described in " Methods of soil analysis part- 1.

Particle density- Particle density of the soil clods were determined by pycnometer ( specific gravity bottle) method ( Black- 1965).

Water Retention at 1/3 bar Pressure(Field Capacity):-

Water retention at 1/3 bar pressure (field capacity) was determined by means of pressure plate apparatus as described by Daniel Hillel ( Fundamentals of Soil Physics ( 1980, Page 161 ).

Water Retention of 15 bar Pressure ( i.e at Parmanent Wilting Point):-

Water retainision at permanent wilting point at 15 bar pressure was also determined by means of pressure membrane apparatus as described by Daniel Hillel 1980.

Infiltration Study:-

Infiltration of soil was measured by cylindrical ring infiltrometer method as applied by B.P. Ghil Dyal and R.P.Tripathi, soil Physics ( 1986).

(B) Chemical Methods:-

Soil PH :- The pH of the soil samples were determined in 1:2 soil: water suspension after equillibrating for half an hour with intermittent stirring by means of glass electrode using the Elico pH meter.

Electrical conductivity:- The electrical conductivity of soil samples were determined in 1:2 soil water suspension after equilibrating for half an hour by using ELICO conductivity Bridge ( Type= CM 82 T ).

Organic Carbon:- Percentage of Organic carbon present in the soil samples were determined by walkley and Black's wet digestion method as described by Jackson ( 1973). 2 g of soil was digested with 1N  $K_2 Cr_2 O_7$  and Conc.  $H_2 So_4$ . It was then titrated against 0.5 N ferrous ammonium sulphate solution in presence of diphenylamine ( + NaF ) indicator.

Cation Exchange Capacity: (CEC).

The CEC of soil samples were determined by the procedure of Black et al ( 1965). 10 gm of soil was shaken with 250 ml of neutral 1N  $NH_4 OAc$  and allowed to stand overnight. Then it was filtered by light suction and the residue was washed with 1N  $NH_4 cl$  for 4 times and once with 0.25 N  $NH_4 cl$  and then with ethyl alcohol until the soil was free of chloride. The absorbed  $NH_4$  was determined by the acid- Nacl method.

Exchangeable Cations:-

$Na^+$  and  $K^+$  :- Standard curves were prepared and  $Na^+, K^+$  were determined from the 1N  $NH_4 OAc$  ( pH = 7.0 ) extract directly making dilutions wherever necessary. Digital flame photometer ( ELICO ) was used for the determination.

$Ca^{++}$  and  $Mg^{++}$  :- Ammonium acetate leachate obtained during CEC determination was evaporated to dryness on waterbath treated with aquaregia and again dried on sand bath. The residue was dissolved by adding 10 ml of 0.1 N Hcl followed by slow digestion in a hot and diluted to 100 ml with

distilled water. Any insoluble materials present were filtered off. Calcium and Magnesium in suitable aliquots were determined by versenate titration method of Black et al ( 1965 ).

Exchangeable Al & H:-

Exchangeable Al & H were measured by titration method ( Black et al 1965 ). A known volume of the KCl leachate containing exchangeable Al and H was taken, 5 drops of phenolphthalein indicator was added to the leachate and the solution was titrated with 0.1N NaOH to a permanent pink end point with alternate stirring and standing. Then the solution was titrated with 0.1 N HCl after adding 10 ml of NaF solution. The milliequivalents of acid used as a measure of the exchangeable Al was computed. This value from the me of total acidity (initial base titration) was subtracted to obtain the me of exchangeable H.

Available Nitrogen:- It was determined by alkaline permanganate method by distilling 20 gm of soil with 100 ml of 0.32 % potassium permanganate and 100 ml of 2.5 % NaOH as described by Jackson ( 1973 ).

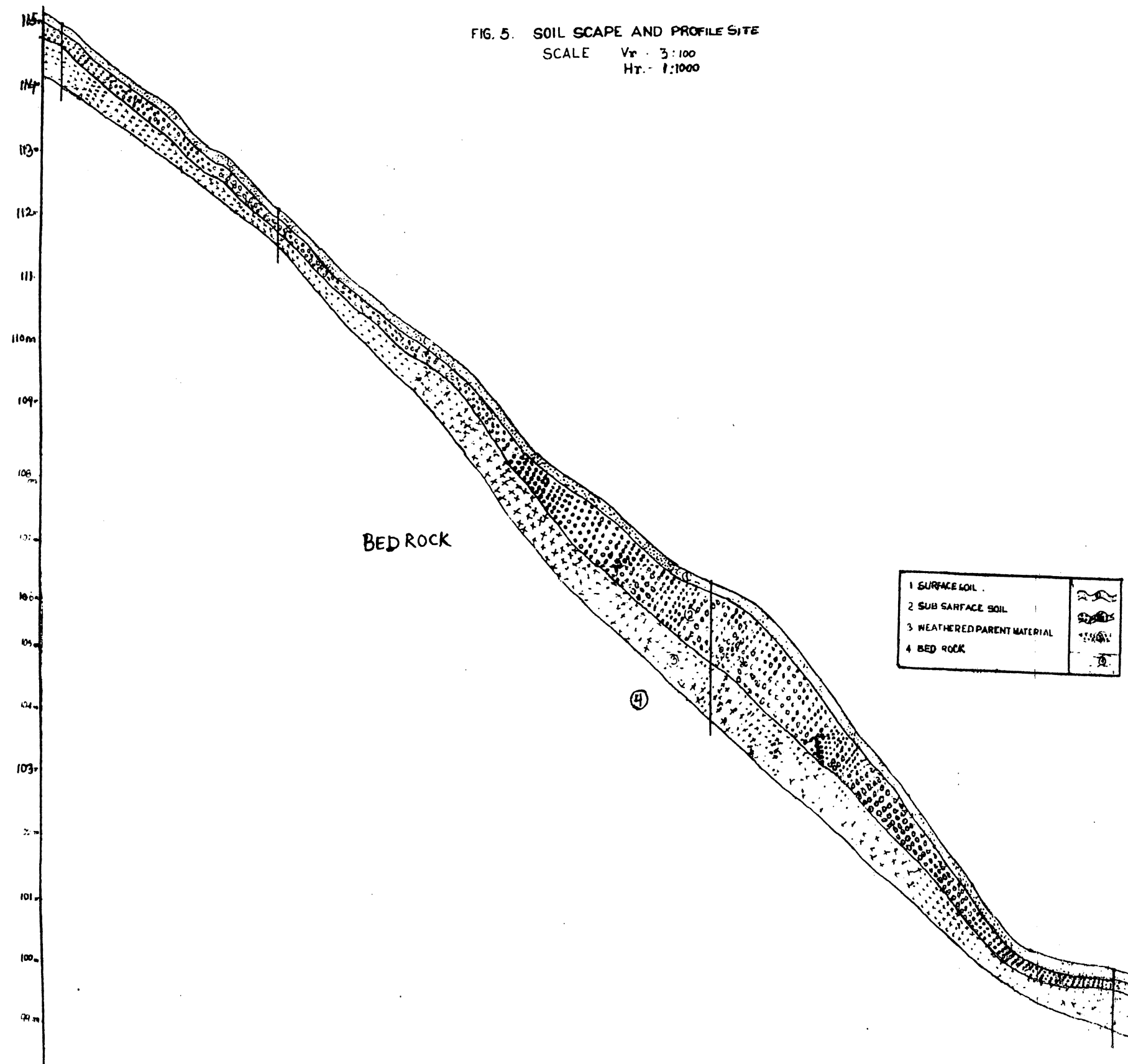
Available Phosphorus:- Available phosphorus was determined by Olsen's method by taking 2 g of soil in 40 ml Olsen reagent ( 1N NaHCO<sub>3</sub> ). A filtrate of 19 ml was mixed with 20 ml chloromolybdic acid and 1 ml of SnCl<sub>2</sub> and the

volume was made upto 50 ml and reading was taken colorimetrically ( Jackson 1973).

Available  $K_2O$ :- It was determined by equillibrating 2 g of soil in 40 ml neutral normal ammonium acetate and the reading of extract was taken in a flame photometer (Jackson 1973).

FIG. 5. SOIL SCAPE AND PROFILE SITE

SCALE Vr - 3:100  
Hr - 1:1000



## CHAPTER IV

# RESULTS AND DISCUSSION

Site Characteristics

Pedons	Location	Elevation	Slope (%)	Erosion	Land form	Surface drainage	Parent material	Natural vegetation	Land use
1	2	3	4	5	6	7	8	9	10
Profile-1	Budurung	100 M to 200 M above MSL	3-5 % (C)	Moderate (e <sub>2</sub> )	Upper Pediment	Well drained	Weathered khondalite	Mango, Jackfruit, cashew etc.	Cashew Plantation.
Profile-2	-do-	-do-	3-5 % (C)	Moderate (e <sub>2</sub> )	Pediment and banded	-do-	-do-	Mango, cashew Jackfruit	Often cultivated with pulses
Profile-3	-do-	-do-	3-5 % (C)	Severe (e <sub>3</sub> )	Slopy upland and unbanded	-do-	-do-	Acacia, Ipomea	Fallow
Profile-4	-do-	-do-	1-3 % (B)	Slight (e <sub>1</sub> )	Lower pediment	Moderate	-do-	-	Cultivated with paddy.

## 1. MORPHOLOGICAL DESCRIPTION OF SOIL PROFILE:

1. Morphological characteristics of these soil profiles as were observed during profile study, are presented below.

Profile- 1: The profile is situated on upper Pediment, un-banded. It lies at an elevation of 100M to 200 M above the MSL. Rock fragments are observed in the deeper layer. Well drained. Parent material is weathered Khondalite. Slope 3 to 5 % in North east to South West direction.

<u>Horizon</u>	<u>Depth(cm)</u>	<u>Descriptions</u>
A 21	0- 10	Colour of soil is Reddish brown (7.5 YR 6/6) When dry, dark brown(7.5 YR 4/4) when moist texture (USDA)- Loamysand, stucture - less Granular loose when dry very friable when moist, slightly sticky when wet, moderately rapid permeable, fine fibrous roots, diffuse smooth boundary, slightly acidic (pH=6.03).
A 22	10-35	Yellowish red when dry and moist, gravelly loamysand, fine weak granular to sub-angular blocky; loose when dry, very friable when moist slightly sticky when wet, moderately rapid permeable , clear wavy boundary, 15 to 40 % coarse fragments are observed, slightly acidic (pH= 6.04) common fine&coarse roots are observed.
C 1	35-74	Yellowish red in colour (5 YR 5/8) when dry; gravelly sandy loam; medium, moderate

sub angular blocky in structure, clear wavy boundary, soft when dry, friable when moist, sticky when wet; 40 to 75 % coarse fragments, moderate acidic (pH 5.94 ) moderately rapid permeable.

C<sub>2</sub>      74-100      Red ( 2.5 YR 4½) in colour when dry ,  
gravelly sandy clay loam; medium, moderate sub angular blocky in structure, slightly hard when dry, firm when moist, sticky when wet, moderately rapid permeable, 40-75 % coarse fragments, slightly acidic (pH 6.34), few common coarse roots are observed.

Profile:- 2: Situated at an elevation of 100- 200 M above MSL, upland, bunded , often cultivated with pulses, well drained, 3 to 5 % slope in North east to South West direction. Moderate erosion (e<sub>2</sub>). Rock fragments are found, Weathered khondalite as parent material.

<u>Horizon</u>	<u>Depth(cm)</u>	<u>Description</u>
A 21p	0-11	Yellowish red ( 5 YR 5/8) in colour when dry, loamy sand in texture, fine granular in structure, loose when dry very friable when moist, slightly sticky when wet, common fine fibrous roots; moderately rapid permeable, moderate acidic (pH 5.72), diffuse smooth boundary.
A 22	11-28	Yellowish red ( 5 YR 5/6) when dry, gravelly sandy loam in texture, fine weak

subangular blocky in structure, loose when dry, very friable when moist, slightly sticky when wet; common fine fibrous roots are observed, moderately rapid permeable, moderate acidic ( pH 5.87), clear wavy boundary.

C<sub>1</sub>        28-52        Red ( 2.5 YR 4/8) when dry dark red(2.5 YR 3/6) when moist, gravelly sandy loam in texture, medium, moderate sub angular blocky in structure, soft when dry, friable when moist, sticky when wet, moderately rapid permeable, 40- 75 % coarse fragments clear wavy boundary, few coarse roots, are observed. Moderate acidic (pH 5.87 ).

C<sub>2</sub>        52 +        Red (2.5 YR 4/8) dry, dark red (2.5 YR 3/6) moist in colour, gravelly sandy clay loam; Medium moderate sub angular blocky; slightly hard when dry, firm when moist, sticky when wet, 40- 75 % coarse fragments, Moderately slow permeable. Moderate acidic (pH-6.0 )

Profile. 3: Profile is situated at an elevation of 100 to 200 M above MSL, 3 to 5 % slope in North east to South West direction. Lands are fallow, unbounded Severe (e<sub>3</sub>) gullied, well drained gravelly soils. Parent material is weathered khondalite.

<u>Horizon</u>	<u>Depth(cm)</u>	<u>Description</u>
A 2	0-10	Soil colour yellowish red ( 5YR 5/8.) indry; gravelly sandy loam in texture, fine weak sub angular blocky in structure soft when dry, friable when moist slightly when wet, 15- 40 % coarse fragments are observed, moderately rapid permeable, diffuse smooth boundary, slightly acidic (pH- 6.1 )
A 3	10-28	Yellowish red ( 5 YR 5/8) in dry, gravelly sandy loam, fine weak sub angular blocky in structure, slightly hard when dry, firm when moist, sticky when wet, clear wavy boundary, moderately slow permeable, 40- 75 % of coarse fragments, slightly acidic (pH 6.14 )
B 1	28-59	Yellowish red ( 5YR 5/6) in dry, gravelly sandy clay loam in texture, medium, moderate sub angular blocky in structure, hard when dry, firm when moist, very sticky when wet, moderate permeable, 40- 75 % of coarse fragments, clear wavy boundary, moderate acidic (pH-5.95)
B <sub>2</sub>	59-108	Yellowish red ( 5YR 5/8) in colour when dry, medium strong subangular blocky, gravelly sandy clay in texture, few fine mottles are observed .

<u>Horizon</u>	<u>Depth(cm)</u>	<u>Description</u>
		its colour(2.5YR 5/6) hard when dry, firm when moist very sticky when wet, Moderately slow permeable. Clear wavy boundary, 40-75% coarse fragments, slightly acidic (pH-6.31)
B <sub>3</sub>	108-124	Strong brown ( 7.5 YR 5/8) in colour when dry gravelly sandy clay loam medium moderate subangular blocky; hard when dry, firm when moist, very sticky when wet, moderately slow permeable, clear wavy boundary, Moderate acidic (pH 5.98), 40-75 % coarse fragments.
C	124 +	Strong brown ( 7.5 YR 5/8) in colour when dry, gravelly sandy clay loam, medium moderate sub angular blocky, hard when dry, firm when moist very sticky when wet moderately slow permeable, 40-75 % coarse fragments, few fine distinct mottles are found whose colour ( 2.5 YR 5/6).

Profile-4 :- The profile is situated at lower pediment slope 1 to 3 % in North east to south west direction; slight erosion ( $e_1$ ). Lands are cultivated, banded Parent material is weathered khondolite.

Ap	0- 14	Strong brown ( 7.5 YR 5/8) in colour when dry and dark brown ( 7.5 YR 4/4) when moist, sandy clay loam in texture, fine weak sub angular blocky in structure, slightly hard when dry, friable when moist slightly sticky when wet, diffuse smooth
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<u>Horizon</u>	<u>Depth(cm)</u>	<u>Description</u>
		boundary rapid permeable, common fine fibrous roots are observed, slightly acidic (pH-6.37)
A 12	14-32	Reddishyellow ( 7.5 YR 6/8) when dry, brown ( 7.5 YR 5/4) when moist,sandy clay loam in texture, friable weak subangular blocky in structure, slightly hard when dry, friable when moist, sticky when wet Moderately rapidpermeable,clear wavy boundary fine common roots observed. slightly acidic (pH- 6.1 ).
C 1	32-53	Yellowish red ( 5YR 5/8) when dry sandy clay loam in texture, Medium moderate sub angular blocky, hard when dry, firm when moist, sticky when wet, Moderately slow permeable, clear wavy boundary,slightly acidic (pH-6.06), fine few Mn concretions are observed.
II C <sub>2</sub>	53-72	Yellowish red ( 5YR 5/8) when dry,sandy loam in texture, Medium,moderate sub angular blocky in structure, hard when dry, firm when moist, very sticky in wet clear wavy boundary, Moderately slow permeable, Neutral soil (pH=6.6) .

<u>Horizon</u>	<u>Depth(cm)</u>	<u>Description</u>
III C <sub>3</sub>	72-118 +	Dark reddish brown ( 5YR 3/3) in dry, clay loam in texture, Medium, strong sub angular blocky in structure very hard when dry very firm when moist, very sticky when wet, Neutral soil( pH-6.75), slow permeable common medium Mn concretions are observed Common medium distinct mottles are observed ( colour 7.5 YR 5/6)

MORPHOLOGY OF PEDONS

Horizon	Depth (Cm)	Lower Boundary.	SOIL COLOUR		Texture	Structure	Consistency.	Other features.		
(1)	(2)	(3)	MATRIX Dry	Moist	Mottles (dry)	(6)	(7)	(8)	(9)	(10)
PROFILE: 1										
A 21	0-10	ds	7.5 YR 6/6 Reddish Yellow	7.5 YR 4/4 (dark Brown)	-	ls	fogr	dl, mvfr, WSS	-	
A 22	10-35	Cw	5 YR 5/8 Yellowish red	5 YR 4/8 (Yellowish red)	-	gls	figr. Sbk	dl, Mvfr, WSS	-	
C 1	35-74	CW	5 YR 5/8 Yellowish red.	5 YR 4/8 Yellowish red.	-	gsl.	M2 Sbk	ds, mfr, WS	Coarse fragments are found.	
C 2	74-100	-	2.5 YR 4/8 (Red)	2.5 YR 4/6 (Red)	-	g scl.	M 2 Sbk	dsh, mfi, WS	-do-	
PROFILE-2										
A 21	0-11	ds	5YR 5/8 (yellowish-red)	5 YR 4/6 (YR)	-	ls	fogr	dl, Mvfr, WSS	-	
A 22	11-28	Cw	5 YR 5/6(YR)	5 YR 4/6 (YR)	-	gsl.	f1 sbk	dl, mvfr, WSS	-	
C 1	28-52	CW	2.5 YR 4/8 (Red)	2.5 YR 3/6 dark red	-	gsl.	M 2 sbk	ds, mfr, WS	coarse fragments are found.	
C 2	52 +	-	2.5 YR 4/8 (red)	2.5 YR 3/6	-	gscl	M2 sbk	dsh, mfi, WS	-do-	

-(1) -(2) -(3) -(4) -(5) -(6) -(7) -(8) -(9) -(10) -

PROFILE-3

A 2	0-10	ds	5 YR 5/8 Yellowish red.	5 YR 4 8 (Yellowish red)	-	gsl	f1 sbk	ds,mfr,WSS	Gullied
A 3	10-28	Cw	5 YR 5/8 (YR)	5 YR 4/8(YR)	-	gsl	f 1 sbk	dsh,mfi,WS	
B 1	28-59	Cw	5 YR 5/6(YR)	5 YR 4/6	-	gscl.	M 2 sbk	dh,mfi,Wvs.	
B 2	59-108	Cw	5 YR 5/8	5 YR 4/8	2.5 YR 5/6 (Red)	gsc	M 3sbk	dh,mfi,Wvs.	
B 3	108-124	CW	7.5 YR 5/8 Strong brown	7.5 YR 5/6 Strong brown	-	gscl	M2 sbk	dh,mfi,Wvs	
C	124 +	-	7.5 YR 5/8 Strong brown	7.5 YR 5/6 (Strong Brown.	2.5 YR 5/6 (Red)	gscl.	M2 sbk	dh,mfi,Wvs.	

PROFILE-4

A p	0-14	dw	7.5YR 5/8 (Strong brown)	7.5 YR 4/4 dark brown	-	scl	f 1 sbk	dsh,mfr,WSS	
A 12	14-32	cw	7.5 YR 6/8 (Reddish yellow)	7.5 YR 5/4 (Brown)	-	scl	f 1 sbk	dsh,mfr,ws	
C 1	32-53	cw	5 YR 5/8(YR)	5 YR 4/6 (Yellowish red)	-	scl	M2 sbk	dh,mfi,ws	
II C 2	53-72	cw	5 YR 5/8 Yellowish red	5 YR 4/8(YR)	-	sl	M2 sbk	dh,mfi,wvs	Mn concretions are observed.
IIIC 3	72-118+-	-	5 YR 3/3 dark reddish brown	5 YR 2/2 dark reddish brown.	7.5 YR 5/6	cl	M 3 sbk	dvh,mvfi, wvs.	-do-

2. MORPHOLOGY OF PEDONS:-

Some important morphological characteristics of the Pedons have been represented in Table No.14.

Profile-1:- It is characterised by A.C. sequence with the A, truncated, subject to moderate erosion. The soil texture varies from loamy sand to clayloam texture in the substrata. It is a deep soil. Soil colour varies from Reddish yellow on the surface through yellowish red and red with depth in profile. The soil structure is very weak fine granular in the surface and moderately sub angular blocky in the sub soil. Surface drainage is excessively drained. Slope varies from 3 to 5 %. Soil consistency is loose under dry, friable under moist and sticky under wet condition.

Profile-2:- Situated at a location relatively lower in physiographic position to the former is having the morphological characteristics almost similar to above excepting that the sub soil is sandy loam as contrast to the former of loamy sand structure. The profile in dry condition impart redder hues in comparison to the profile-1, It is a moderately deep soil.

Profile- 3:- It is a very deep, situated on unbunded up land, excessively drained. It is excessively eroded and gullied. It is sandy loam on the surface grading through gravelly sandy loam, gravelly sandy clayloam, gravelly sandy clay to gravelly sandy clayloam in the substrata. The colour is yellowish red in the surface and red beneath. The land is lying barren. Soil structure is weak fine subangular

blocky on the surface and moderately strong to strong subangular blocky in the substrata,. Soil consistency is slightly hard in dry, friable in moist and slightly sticky in wet, hard in dry, firm in moist and very sticky in wet in the substrata.

Profile- 4:-

Situated in lower pediment soil is very deep, Sandy clayloam texture to a depth of 53 cm and clay loam in the deeper parent material . Soil colour is strong brown in the surface through reddish yellow, yellowish red and dark reddish Brown with depth of profile. Paddy is grown under levelled and bunded condition. Erosion is slight on a gentle sloping terrain. Drainage is moderate. Soil consistency is slightly hard in dry, friable in moist & slightly sticky on the surface. It is hard, firm and sticky to very sticky in deeper loyer.

PHYSICAL CHARACTERISTICS OF SOILS

Depth (in cm)	Sand (%)	Silt %	Clay %	Texture	B.D gm/cc	P.D. gm/cc	Porosity %	WHC %	Coarse fragm- ent %	Infil- tration cm/hr.	Soil moisture refaintion At 1/3 bar At 15 bar (Field capacity) (PWP)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
0-10	84.6	4.0	11.4	ls	1.5	2.35	36.17	34.12%	1	5.3cm	16.5 %	4 %
10-35	76.6	8.0	15.4	gls	1.47	2.35	37.44	34.8%	23	per hr		
35-74	70.6	6.0	23.4	gsl	1.41	2.31	38.96	38.82	73			
74-100	64.6	4.0	31.4	scl	1.32	2.32	43.10	39.80	68.			
0-11	87.0	2.0	11.0	ls	1.49	2.41	38.17	32.2	5	5.3cm	16.0 %	4 %
11-28	77.0	4.0	19.0	gsl	1.5	2.4	37.1	33.1	11			
28-52	73.0	8.0	19.0	gsl	1.38	2.39	42.3	36.83	72			
52 +	75.0	4.0	21.0	gscl	1.4	2.3	39.13	40.55	70			
0-10	77.0	6.0	17.0	gsl	1.45	2.56	43.4	33.8	31	2.0 cm	16.5 %	5 %
10-28	75.0	6.0	19.0	gsl	1.46	2.48	41.1	34.9	62	per hr.		
28-59	63.0	7.0	30.0	gscl	1.33	2.29	41.9	34.9	51			
59-108	60.0	8.0	32.0	gscl	1.34	2.27	41.0	36.0	60			
108-124	59.0	9.0	32.0	gscl	1.3	2.25	42.2	36.0	48			
124 +	61.0	6.0	33.0	gscl	1.3	2.26	42.5	40.1	64			

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
0-14	73.0	4.0	23.0	scl	1.47	2.4	38.8	34.23	2	0.5cm	18.0 %	6 %
14-32	59.0	12.0	29.0	scl	1.35	2.23	39.5	37.84	10	per hr		
32-53	64.0	8.0	27.4	scl.	1.36	2.22	38.7	40.29	17			
53-72	77.0	4.0	19.0	sl	1.32	2.29	42.36	36.12	14			
72-118+	44.6	18.0	37.4	cl.	1.29	2.28	43.4	46.88	20			

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3. PHYSICAL CHARACTERISTICS:-

The physical characteristics of pedons have been presented in Table-15.

Profile-1.

The clay content increases with depth of profile ranging from 11.4 on the surface to 31.4 in deeper layers. B. D. ranges from 1.5 g/cc. on the surface to 1.32 g/cc in deeper layer. Particle density- around 2.35 indicates the presence of light minerals on the soil matrix. Coarse fragment shows fairly high amount upto 73 % in the deeper layer indicating the gravelly character in the soil. The infiltration rate 5.3 cm/hr. is good. The available soil moisture retention as a difference between the 1/3 bar and 15 bar is 12.5 % ( data collected from soil survey report published by the Department of Soil conservation, Orissa).

Profile-2:-

The clay content is 11 % on the surface to 21 % in the deeper layer. Soil is gravelly under-neath with gravel content arround 70 %. Bulk density is higher on the surface 1.49 g/cc and 0.1 unit lower in the deeper horizon. The infiltration rate is 5.3 cm/hr , which indicates good infiltration. Available moisture is 12 % ( collected from soil survey report).

Profile-3:-

The clay content is 17 % on the surface to 33 % in the deeper layers increasing with depth of profile.

The bulk density is similar to profile-2. The soil profile is gravelly throughout ranging from 31 % to 61 % in the substratum. The infiltration rate 2.0 cm/hr indicates moderate infiltration and the available soil moisture is 11 %.

Profile-4 :-

Clay content varies from 23 % on the surface to 37.4 % in deeper layer. It is sandy clay loam texture with lesser coarse fragments ranging from 10 to 20 % in the subsoil and substratum. Infiltration is slow ( 0.5 cm/hr) and available soil moisture of 12 % is high.

4. CHEMICAL CHARACTERISTICS:-

Profile-1 :-

The soil is slightly acidic having pH 5.94 to 6.34, non saline , very low in organic carbon ( 0.2 %) CEC is low ranging from 5.32 to 7.4 me/100 g. Percentage of base saturation is 70 %. Total exchange acidity ranges from 0.21 to 0.38 meq per 100 g. It is low in available N ( 132 kg/ha) medium in P ( 20 kg/ha) and low in available K ( 110 kg/ha).

Profile - 2:-

Soil is moderately acidic ranging in pH 5.7 to 6.01 Non saline, very low in organic carbon ( 0.17 to 0.23 %) CEC is low ( 5.3 to 6.46 meq/100 g). Percentage of base saturation is around 70 % . Exchange acidity is attributed

mostly to exchangeable Al on the surface layer. Total exchange acidity is higher ( 0.43 meq/100 g) in the surface layer in comparison to the former ( Profile-1). Available N is low ( 134 kg/ha). Available P is medium which sharply decline to low status in the sub soil alike to profile-1. Available K is low.

Profile- 3 :-

It is slightly acidic, pH ranging from 5.95 to 6.3. It is non saline. Very low in organic carbon, CEC is low to medium . Percentage of base saturation is 70 to 75. The total exchange acidity ranges from 0.3 to 0.5 me/ 100 g, exchangeable H is relatively contributing in higher proportion. The fertility status is low in available N. Available P status is medium. Available K is medium.

Profile- 4:-

Soil is slightly acidic, non saline, low in organic carbon, CEC is medium. Percentage of base saturation ranges from 71 to 78 % . They have higher base saturation in lower layers coinciding with neutral pH. The total exchange acidity ranges from 0.22 to 0.317 me/100 gm. As regards to fertility status it is medium in N status, Medium in available P and medium in available K.

## Chemical Properties of Soil.

Profile NO.	Depth (cm)	pH (1.2)	Ec (e) dsm <sup>-1</sup>	Org. Carbon	Exch Al+++ me/100g.	Exch. H + Meg/100g.	Total Exch. acidity	Available N kg/ha	Avail. P kg/ha	Avail K kg/ha.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1.	0-10	6.03	0.068	0.21	0.22	0.16	0.38	132.6	20.0	110.0
	10-35	6.04	0.116	0.207	0.11	0.215	0.325	128.7	11.2	120.0
	35-74	5.94	0.068	0.203	0.22	0.105	0.325			
	74-100	6.34	0.05	0.164	0.11	0.107	0.217			
2.	0-11	5.72	0.098	0.171	0.33	0.105	0.435	134.9	32.9	130.0
	11-28	5.86	0.098	0.23	0.28	0.092	0.372	134.4	9.6	140.0
	28-52	5.87	0.083	0.228	0.11	0.215	0.325			
	52 +	6.01	0.078	0.186	0.11	0.215	0.325			

-- (1) -- (2) -- (3) -- (4) -- (5) -- (6) -- (7) -- (8) -- (9) -- (10) -- (11) --

3.	0-10	6.1	0.083	0.21	0.11	0.324	0.434	140.5	35.2	170.0
	10-28	6.14	0.088	0.21	0.11	0.215	0.325	129.5	11.2	150.0
	28-59	5.95	0.088	0.20	0.11	0.215	0.325			
	59-108	6.31	0.068	0.193	0.11	0.107	0.217			
	108-124	5.98	0.078	0.186	0.11	0.215	0.325			
	124 +	6.23	0.042	0.164	0.11	0.107	0.217			

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4.	0-14	6.37	0.10	0.18	0.11	0.161	0.271	254.4	30.4	220.0
	14-32	6.10	0.088	0.39	0.22	0.107	0.317	258.9	16.8	224.0
	32-53	6.06	0.078	0.31	0.22	0.107	0.317			
	53-72	6.6	0.078	0.17	0.11	0.107	0.217			
	72-118 +	6.75	0.078	0.421	0.11	0.105	0.215			

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T A B L E- 17

CATION EXCHANGE CAPACITY AND COMPOSITION OF THE EXCHANGE COMPLEX OF THE SOILS OF WATERSHED.

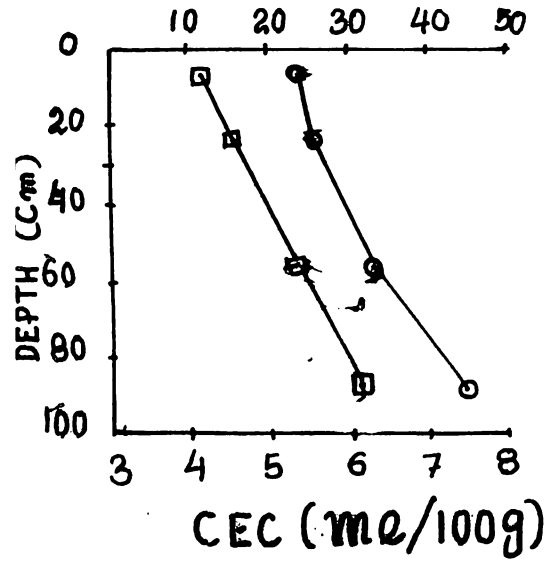
Depth in Cm.	CEc me/100g of soil	Exch. Ca ++ Me/100g.	Exch. mg ++ me/100g	Exch. K + Me/100g.	Exch. Na + Me/100g.	Total Exch. bases.	Percentage of Base satur ation.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Profile-1							
0-10	5.32	2.35	1.1	0.109	0.18	3.739	70.28
10-35	5.56	2.57	0.98	0.23	0.15	3.93	70.68
35-74	6.28	2.82	1.1	0.314	0.17	4.404	70.12
74-100	7.4	3.43	1.61	0.141	0.14	5.321	71.9
Profile-2							
0-11	5.35	2.4	0.9	0.166	0.2	3.666	68.52
11-28	5.8	2.6	1.07	0.130	0.23	4.03	69.48
28-52	6.2	2.8	1.23	0.147	0.12	4.297	69.31
52 +	6.46	3.07	1.23	0.141	0.16	4.601	71.22
Profile-3							
0-10	5.78	2.7	0.97	0.199	0.22	4.089	70.74
10-28	5.8	2.9	1.1	0.064	0.05	4.114	70.93
28-59	6.8	3.14	1.48	0.083	0.10	4.803	70.6
59-108	7.6	3.52	1.47	0.166	0.33	5.486	72.18
108-124	7.6	3.8	1.21	0.141	0.28	5.431	71.46
124 +	8.36	4.8	1.4	0.012	-	6.212	74.3
Profile-4							
0-14	6.0	2.8	1.16	0.166	0.33	4.456	74.26
14-32	6.2	2.78	1.3	0.224	0.12	4.424	71.35
32-53	6.2	3.27	0.73	0.256	0.2	4.456	71.87
53-74	5.48	3.15	0.85	0.12	0.11	4.23	77.16
72-118+	7.63	4.56	1.36	0.058	0.02	5.998	78.56

# Fig. 6: CEC AND CLAY% IN RELETION TO DEPTH

SCALE: HR-1Cm=1(CEC me/100g)  
AND 1Cm=10%(CLAY)  
YR-1Cm= 20 Cm

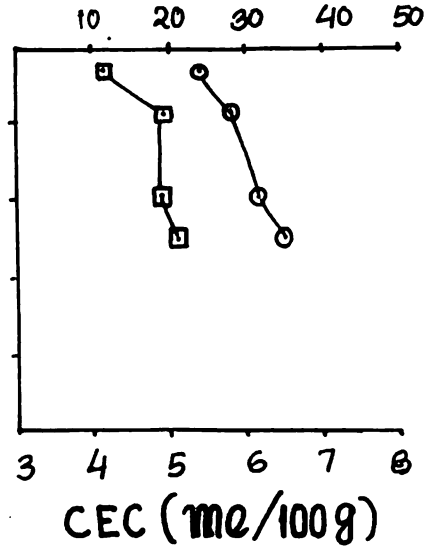
### PROFILE-1

#### CLAY %



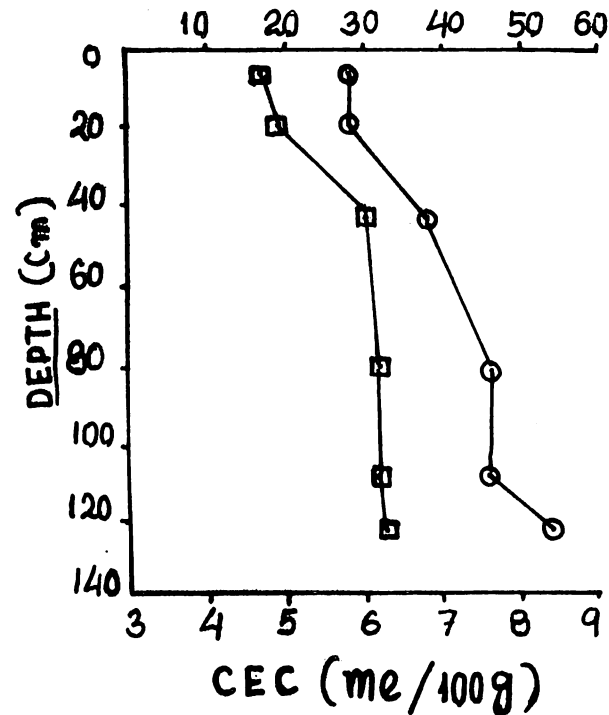
### PROFILE-2

#### CLAY %



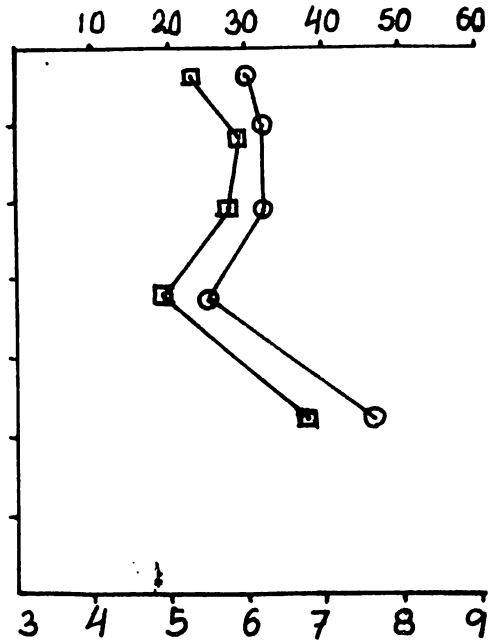
### PROFILE-3

#### CLAY %

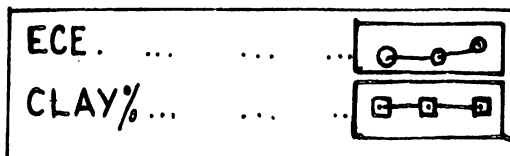


### PROFILE-4

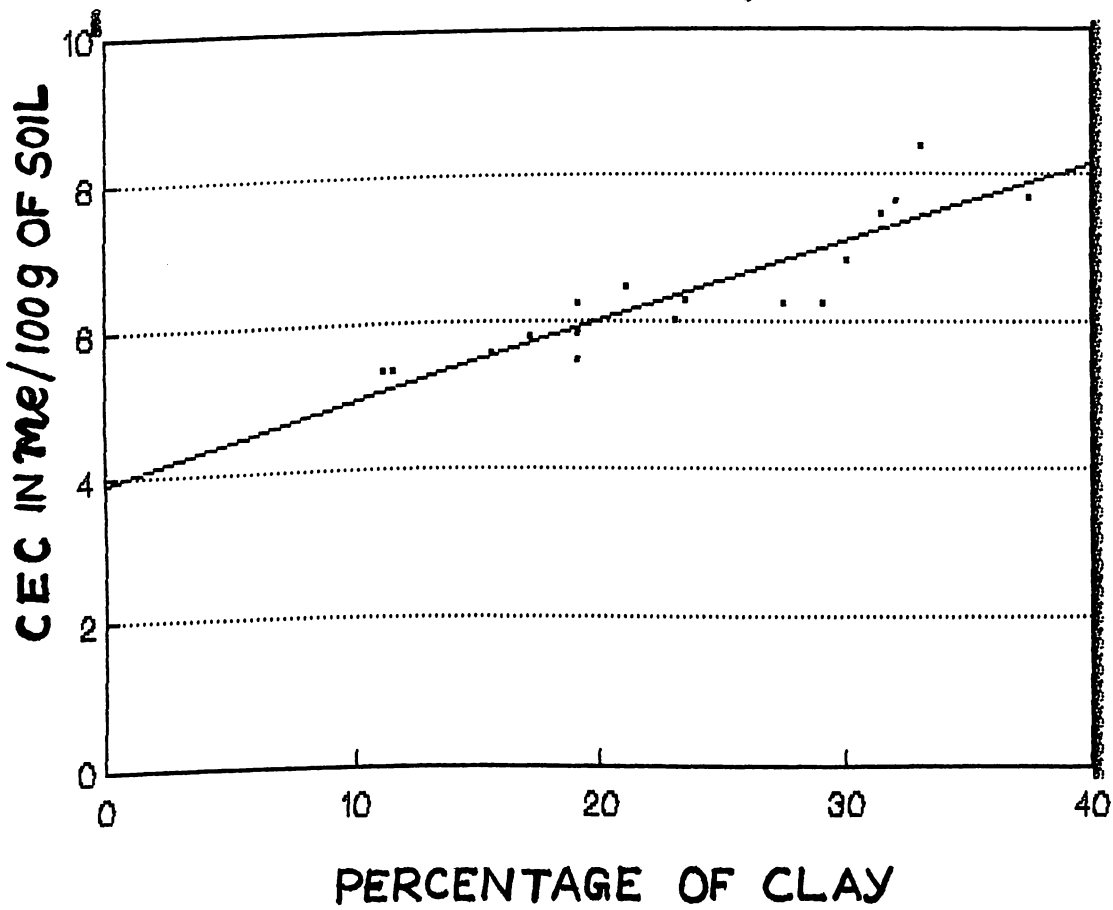
#### CLAY %



### REFERENCE



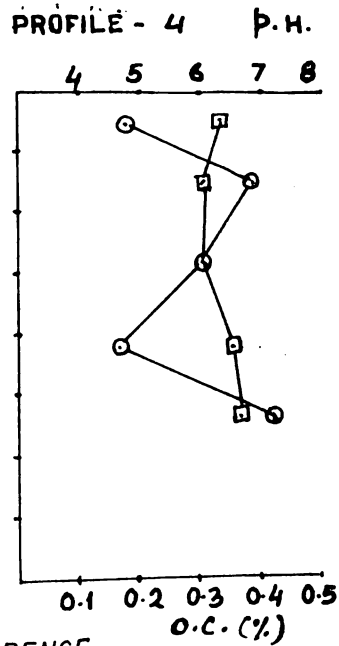
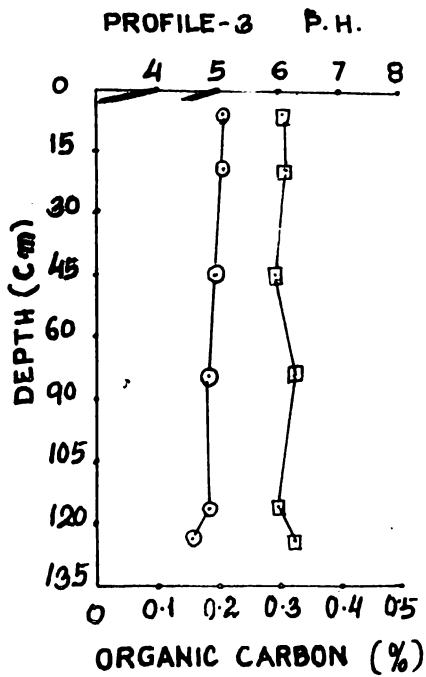
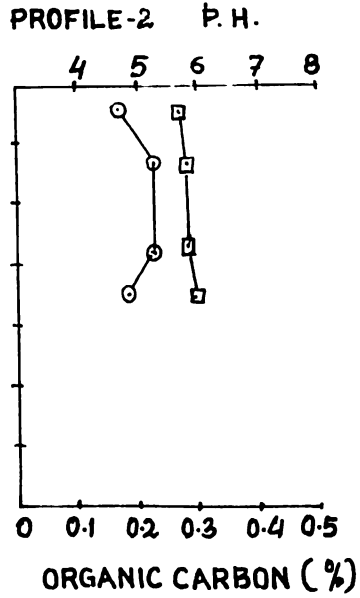
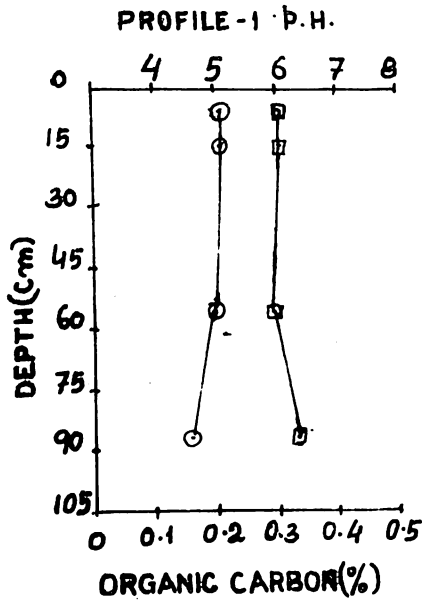
$$Y = 3.93 + 0.104 X$$
$$r = 0.895$$
$$n = 19$$



**FIG: 6(a) — RELATIONSHIP BETWEEN  
PERCENTAGE OF CLAY & CEC (NH<sub>4</sub>OAc)**

**Fig. 7: PH AND ORGANIC CARBON IN RELATION TO DEPTH OF SOIL PROFILE**

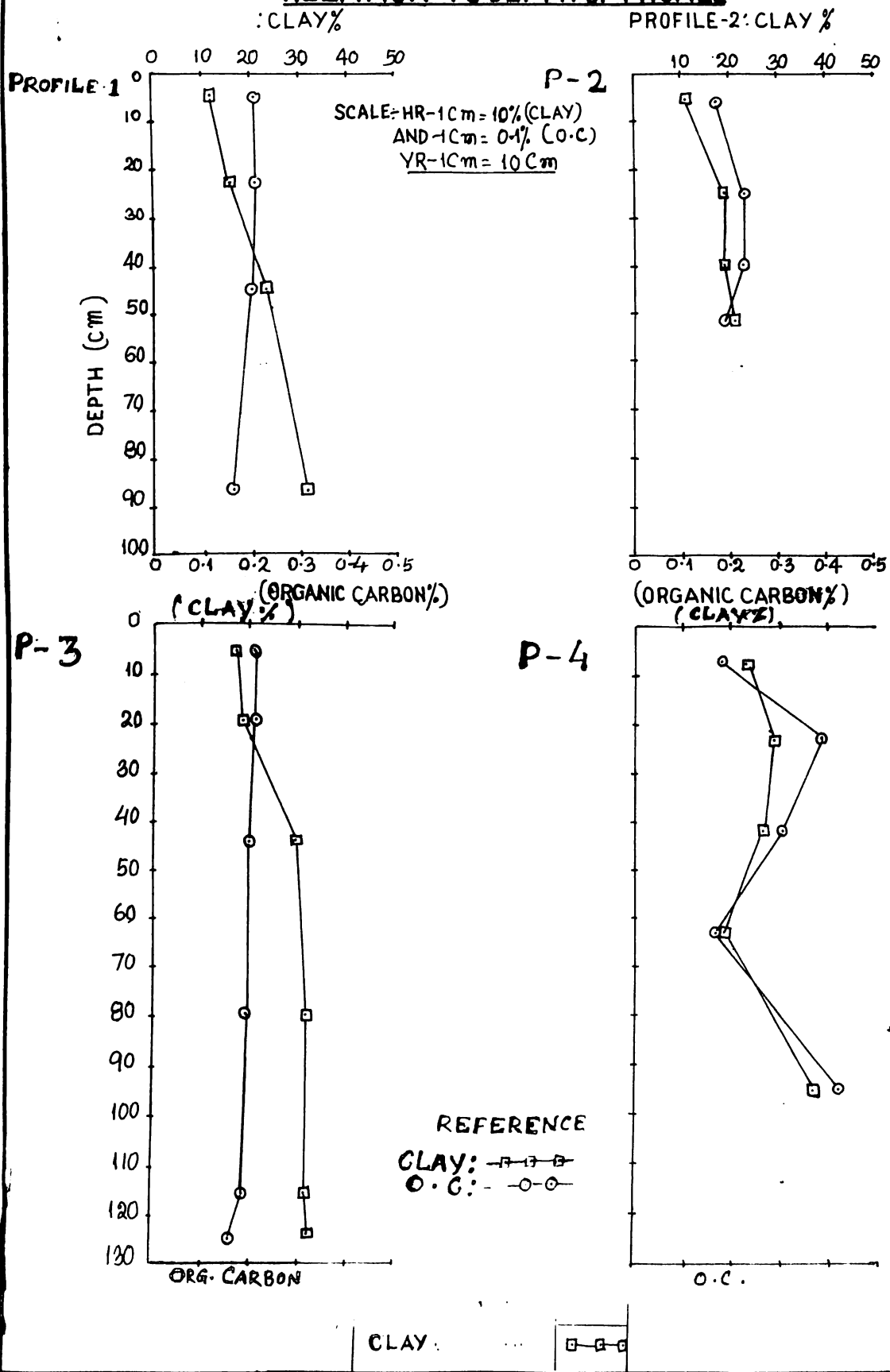
SCALE: VR = 1 cm = 15 cm  
 HR = 1 cm = 1 (PH) & 1 cm = 0.1% (ORG. C)



**REFERENCE**

ORGANIC CARBON	○—○—○
P.H.	□—□—□

Fig. 8: CLAY CONTENT AND ORGANIC CARBON  
RELATION TO DEPTH OF PROFILE

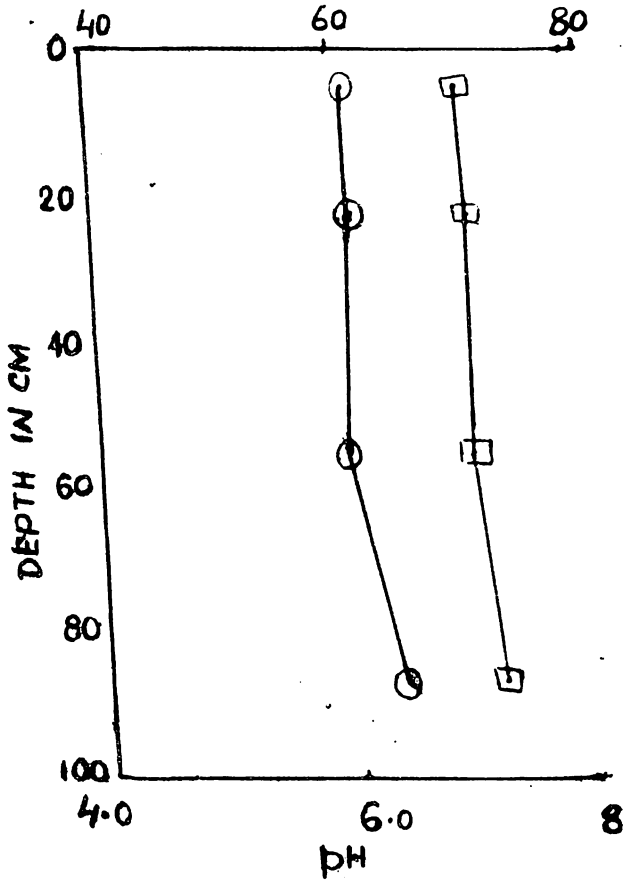


# FIG-9: PH AND BASE SATURATION

(116a)

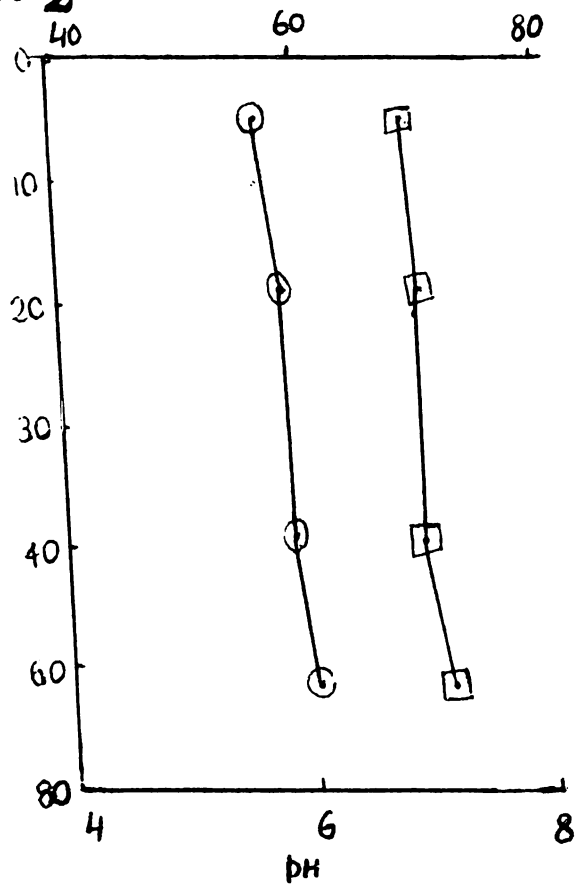
PROFILE - 1

BASE SATURATION %

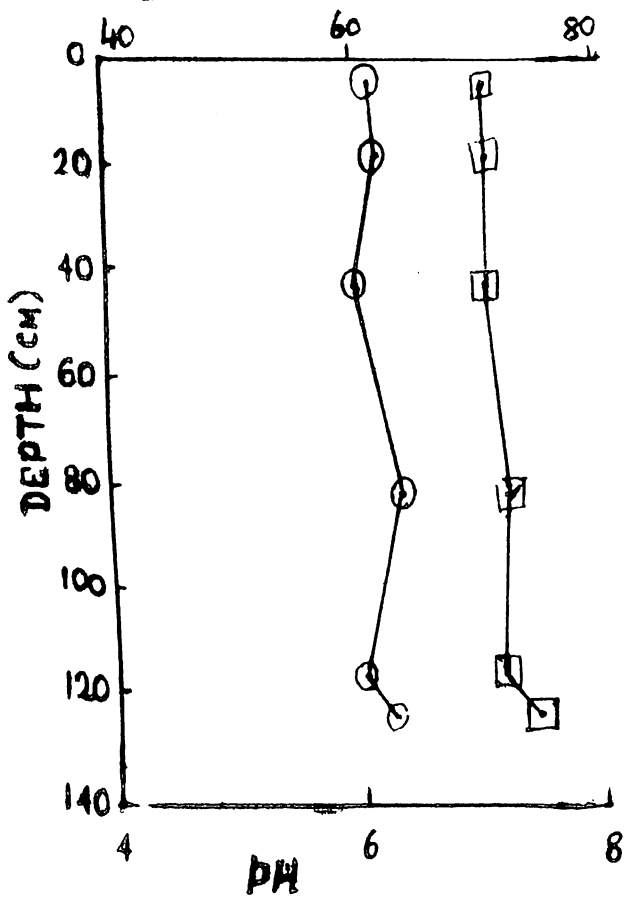


P-2

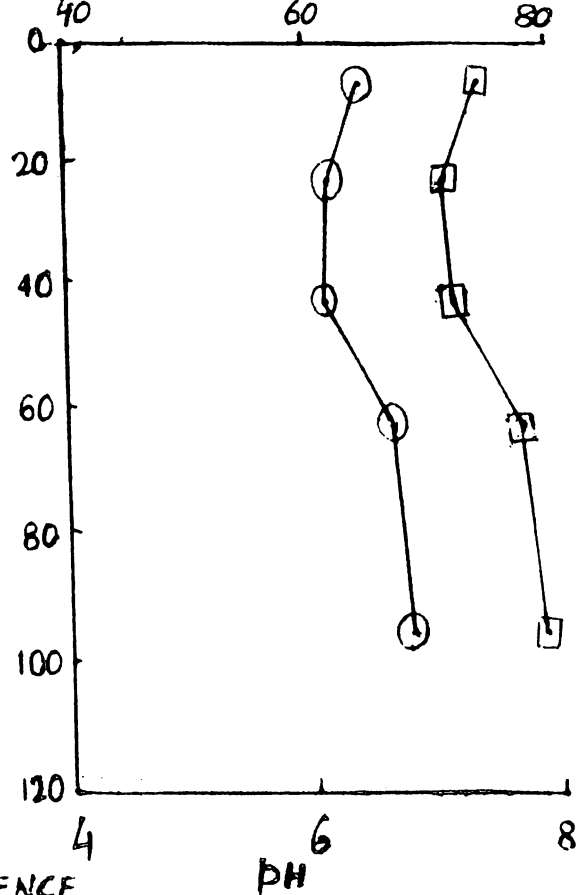
B.S. %



P-3



P-4



REFERENCE

pH - ○-○-○  
B.S. - □-□-□

$$Y = 14.07 + 9.42X$$
$$r = 0.94$$
$$n = 19$$

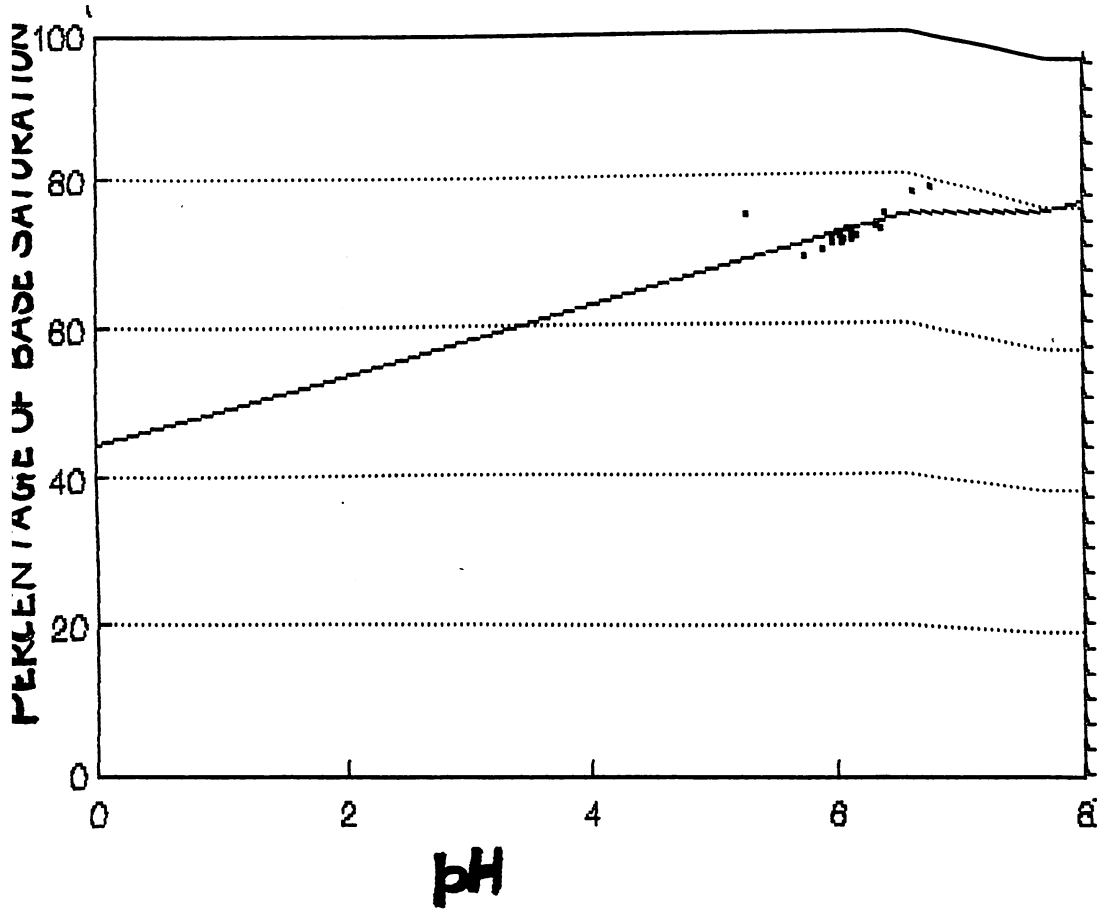


FIG: 9(a) - RELATIONSHIP BETWEEN PERCENTAGE OF BASE SATURATION AND  $pH_{(w)}$

T A B L E - 18

## CLASSIFICATION OF THE SOILS ACCORDING TO SOIL TAXONOMY(USDA)

SL NO.	Soil Series	Profile No.	Order	Sub-Order	Great Group	Sub-Group	Family
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Budurung-2	Profile-1	Entisols	Orthents	Ustorthents	Typic ustorthents	Loamy skeletal mixed, hyperthermic.
2.	Budurung-2	Profile-2	Entisols	Orthents	Ustorthents	Typic ustorthents	Loamy skeletal mixed hyperthermic.
3.	Budurung-3	Profile-3	Inceptisols	Ochrepts	Ustochrepts	Typic Ustochrept	Loamy skeletal mixed hyperthermic.
4.	Budurung-1	Profile-4	Entisols	Fluents	Ustifluents	Typic Ustifluents.	Fine loamy mixed hyperthermic.

5. CLASSIFICATION OF SOIL(Soil Taxonomy)

An attempt has been made in the present investigation to classify the soils as per soil taxonomy ( 1978).

Profile- 1:- Order - Entisols.  
Sub order- - Orthents.  
Great group - UStorthents.  
Sub-group- -Typic Ustorthents  
Family - Loamy-Skeletal, mixed hyperthermic.

These soils are mineral soils without a lithic or paralithic contact within a 50 cm depth, situated an upper pediment with 3-5 % slope . Rock fragments are observed in the deeper layer. Ochric epipedon is noticeable. There is lack of marked profile development for which the soils are placed under the order Entisols.

These soils are placed under sub order Ustorthents and subgroup Typic Ustorthents because:

- (1) These soil have an ustic soil moisture regime.
- (2) Their soil temperature regimes are hyperthermic because the mean Annual soil temperature is more than  $22^{\circ}$  C.
- (3) The E.c is  $\leq 2 \text{ d } 5 \text{ m}^{-1}$  at  $25^{\circ}$  C in all sub horizons.
- (4) These are not saturated with water within 1.5 m of the surface for as long as 1 month in most years.
- (5) They have not a lithic contact within 50 cm at surface.

(6) Do not have cracks at some period in most year that are 1 cm or more wide at a depth of 50 cm.

(7) Do not have clay more than 35 % in horizons.

Textural family is loamy skeletal mixed hyperthermic because rock fragments make up 35 % or more by volume and the fraction finer than 2 mm is loamy, and no single mineral appears to be dominant in the sand fraction and hence the mineralogical family is mixed.

Profile-2 :

These are almost similar to that of profile-1  
So it belongs to

Order	Entisols.
Sub-order -	Orthents.
Great group-	Ustorthents
Sub-group-	Typic ustorthents.
Family-	Loamy skeletal mixed hyperthermic.

Profile-3:

Order-	Inceptisols.
Sub-order-	Ochrepts.
Great group-	Ustochrepts.
Sub group-	Typic Ustochrepts.
Family-	Loamy skeletal mixed hyperthermic.

These soils are placed under the order Inceptisols and suborder Ochrepts because they.

- (1) do not have spodic, orgillic, natric, oxic or gypsic horizon.
- (2) do not have plinthite that forms a continuous phase within 30 cm of the soil surface.
- (3) do not have cracks on the surface.
- (4) have a cambic horizon with alteration in colour, structure and texture and mottles.
- (5) have a conductivity of the saturation extract at 25°C that is less than 2  $\text{dsm}^{-1}$  in all horizon and have an ochric epipedon.
- (6) have a difference of more than 5°C between the mean summer and mean winter temperature and mean annual soil temperature is more than 22°C.
- (7) have a bulk density of more than 1.5  $\text{M}_g \text{ m}^{-3}$
- (8) do not have a plaggen epipedon.

The great group is ustochrepts because they have an ustic moisture regime.

These soils are placed under sub group Typic ustochrept because they satisfy all the requirements of Typic UStochrepts.

These soils are classified in the family level as Loamy-skeletal mixed hyperthermic.

Profile-4

Order -	Entisols
Sub order-	Fluvents
Great group-	UStifluvents
Sub group-	Typic ustifluvents
Family-	Fine loamy mixed hyperthermic.

These soils are classified as order-Entisols and sub order fluvents because they

- (1) have little development of pedogenic horizon and is characterised by A- C sequence.
- (2) have an ochric epipedon.
- (3) have been formed in recent water-deposited sediments on alluvial fan of small stream.
- (4) have the strata of clayey or loamy materials that have more organic carbon than overlying more sandy strata. Thus the percentage of organic carbon decreases irregularly with depth as the materials are stratified and remains at level of 0.2 % to a depth of 1.25 m.
- (5) do not have a lithic or paralithic contact within 25 cm of soil surface and that have slopes of 25 %.
- (6) Mean annual soil temperature is higher than 22° C.
- (7) Soil moisture regime is ustic.

These soils are placed under sub group Typic ustifluvents because they qualify all the requirements of typic ustifluvents and these are classified in the family level as fine loamy mixed hyperthermic.

## INTERPRETATION OF SOIL SURVEY DATA:

## 6. Interpretation of Soil Survey data for Land use Planning:-

A standard detailed soil survey provides information on (i) the inherent soil characteristics (ii) the external land features. The taxonomic soil units established after fieldwork, laboratory analysis and correlation are the ultimate units which afford specific information about the ability of soils to respond to use, management and plant growth.

The inherent soil characteristics are (a) Depth (b) Colour (c) Texture (d) Structure (e) Consistence (f) Permeability (g) Reaction (h) Parent Material (i) Rootdistribution. Each of the above factors has a definite role to play in the behaviour of the soil and its management. The parent material gives an indication of the potential nutrient status of the soil. The soil colour gives an idea of organic matter content and the state of leaching and hydration. Texture and structure influence retention and movement of air, water and plant root down the profile. The type of clay mineral modifies the exchange capacity of the soil, supply of plant nutrients, available water and related factors. Slow permeability which is an indication of the presence in the subsurface layer of clay pan, fragipan, indurated layer etc., can influence root development and cause continuous or periodic water logging, a high water table or flooding.

Root distribution determines the depth of soil materials to layers inhibiting root development and affect moisture retention and infiltration resulting in enhanced run off. Soil reaction determine the base saturation status & also the balance of available plant nutrients or their toxicity or deficiency.

Besides the above inherent soil characteristics, external land features like slope, erosion and climatic conditions may limit the safe and productive use of soil. The slope gradient and the length of slope very much effect the rate of run off and soil removal and indirectly affect the amount of moisture absorbed by the soil. The degree of erosion indicate the decrease of productivity and suggest the future use and treatment to overcome the limitation. Climate controls the plant growth, precipitation and temperature.

From the detailed study of soil and from the soil survey data it has been observed that there is a diversity of soils due to climate, vegetation and topography. However the soils of the area are placed under red soils. The ancient crystalline and metamorphic rocks has given rise to red soils on weathering. The depth of the soil is deep to very deep. Soils on the pediments are deep but very deep on lower pediments. The soils are found to be low in available N & K and medium in available P on the upper pediment and medium in N, P & K on lower pediment. The clay fraction of the soil is of admixture

of koolinite and illite type of clay mineral. The water holding capacity of the soil is 32 % to 46 % which is good for taking agricultural crops in up and medium lands. Available soil moisture is from 11 to 12.5 %, which is very high. In general the infiltration rate is good. The soil is slightly acidic and highly leaching under slopy terrain. Rejuvenation through biomass build up is recommended.

The CEC of these soils is from 5.3 to 8.3. The CEC varies with (a) Kind of clay (b) the percent of clay & (c) the percent of organic matter. It correlates with the soil fertility status. In general soils with a relatively high ion-exchange capacity are fertile and have good lasting quality for crop production, that is they are depleted more slowly than are soils with low ion-exchange capacity. The soils of the study area having low to medium in CEC are susceptible for exhaustion of plant nutrient reserve, under a freely leaching environment unless. Otherwise adequately conserved.

The organic carbon of these soils are low. Organic matter exerts a controlling influence on soil properties and its productivity. The organic matter content of soil is one of our most important resources for plant growth. Base saturation is another important chemical property of the soil that refers to the portion of the CEC occupied by the basic ions (Ca, Mg, K & Na). Thus the base saturation is 68 % to 78 %.

From the above discussion it is clear that the soils of the watershed are low to medium in fertility due to excessive soil erosion, which require some management practices for future crop planning.

These soils are classified in the following land use capability classes and sub-classes on the basis of their ability to produce plants without deterioration for a long time. This classification is an interpretative classification based on the effect of the combination of climate and permanent soil characteristics on the risk of soil damages, limitation in use, productive capacity and the management requirement. All the soils within one land capability unit are only similar in degree of limitation in soil use.

T A B L E - 19

Name of the Village.	Soil Series	Profile No.	Mapping Unit.	Land use capability Classes.	Land forms	Present land use.	Area in ha.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Burudung	Burudung-1 (Bdg-1)	4	<u>Scl</u> d B-e <sub>1</sub>	5 II c	Lower	Paddy followed by pulses.	1.5
..	Bdg-2	1 & 2	<u>ls</u> -d5 c-e <sub>2</sub>	III e	Upper	Pulses Pedi-ment.	25.376
..	Bdg-3	3	<u>qs</u> l-d5 c-e <sub>3</sub>	IV e	Pedi-ment	Barren unbanded	11.65

6.1. Conservation Technology:-

Soil conservation is the only way to protect the productive lands. The area to be treated in the watershed are categorised as follows.

(1) On farm Lands:-

The on farmland includes all available lands cultivated such as upland, medium land and low land. These land belongs to cultivators. The following conservation measure are taken in land use capability class II and III lands.

- (i) Planting of vertiver an coutour
- (ii) Contour cultivation and vegetative bunding
- (iii) To introduce suitable cropping pattern with modern technology.
- (iv) Conservation farming and organic mulching

(2) Off-farm Land:-

The off farm lands includes all non available land such as the barren pediments, village forest, culturable waste lands, unculturable waste lands etc.

The following programme will be taken up in Class III and IV lands.

- (i) Plantation of timber species by forest department
- (ii) Plantation of fuel, fooder, small timber species.
- (iii) Plantation of quick growing species.
- (iv) Rehabilitation of degraded forest.
- (v) Horticultural plantation(Mango, guava, ber, Lemon etc) with alternate land use system like Agri-Horti, Agro-forestry & Silvi-Pastoral.

(3) Natural drainage lines:-

- (i) Diversion channel.
- (ii) Gully control measures.
- (iii) Run-off storage structure.
- (iv) Stream Bank Erosion control.

Run-off Storage Structure:-

Harvesting of runoff for storage and recycling is necessary for better utilisation of rainfall, control of erosion and providing life-saving irrigations to crops during dry spells. Small ponds and tanks are essentially micro reservoir for storing the excess runoff water during the intense storm period.

Gully control:- Deep and shallow gullies are observed in these area. Shallow gullies can be reclaimed by clearing, minor levelling and construction of a series of contour bunds at a vertical interval of about 0.7 m. Pipe outlets or grassed ramps are to be provided for draining the excess runoff water. At the end of the small gully system, a composite check dam is provided as a protective measure against any loss of soil. The deep gullies which occur in the lower reaches of a gully system are unsuitable for agriculture. These are therefore utilized as wood lands by adopting appropriate afforestation techniques with suitable tree species and constructing gully heads, and sides are stabilized by planting grass species

like Dichanthium annulatum. Gully plugging ( with live hedges, brush wood earthen, and composite ones) is done in the gully beds.

Contour bunding:- Contour bunding can be adopted in these area which has high erodibility . Contour bundings are useful to reduce surface runoff and soil erosion considerably.

Establishment of vegetative cover:- It is one of the effective ways of soil and water conservation. Vegetative cover with grasses or shrubs or both give the least and negligible runoff and soil loss when compared with the practice of cultivated fallow.

Agronomic Measures in Soil & Water Conservation:-

Soil conservation agronomy or the agronomic practices which govern soil erosion have to be considered in co-ordination with other measures and not in isolation. Soil conservation agronomic practices help in reducing the impact of raindrops through interception and thus reduce splash erosion. These practices also help in increasing infiltration rate and there by reduce runoff and overland flow. Reduction in runoff and soil losses is achieved through land management practices, choice of crop and crop management practices and associated agronomic practices such as mulching and crop-residue management. Crop cover or canopy is one of the most important factors which affects soil loss. Plant roots are

the best binding factors for soil. Grasses and legumes have been found to control soil erosion, improve soil structure largely due to their good canopy and excellent binding force of the roots.

Agronomic measures should include the following cultural practices.

- (a) Land preparation:- A concept of minimum tillage can be advantageously applied for soil and water conservation.
- (b) Planting Time:- Planting crops needs to be so adjusted that maximum canopy synchronizes with, high intensity rains, thus reducing the impact of rainfall on land directly.
- (c) Contour farming:- Contour cultivation and contour planting which are non-monetary inputs are basic agronomical practices, which should be adopted on slopy lands.
- (d) Crop Geometry:- Optimum plant population and crop geometry are important for having an optimum crop cover. From the point of view of soil and water loss, denser plant population may be better but excess population may lead to severe moisture and nutrient stresses from soil and consequently, the crop failures under rainfed conditions.
- (e) Mixed Cropping:- Advantages of this type of cropping are good crop cover, feeding of crops from different soil layers. Incorporation of legumes with cereals for mixed cropping, intercropping or, strip cropping has been found to reduce runoff and soil losses.

- (f) Mulching:- The objectives of mulching are to minimize splash and influence of rain on bare surface, to reduce evaporation, to control weeds, to reduce excessive heating and to allow micro-biological changes to occur at optimum temperature.
- (g) Adoption of organic manures, green manure and fertilizer:- Organic manures and green manures improve the rate of <sup>of</sup> infiltration, soil structure and there by effect soil erosion process. The effect of fertilizer by improving vegetative growth of crop/crop canopy and thereby reducing soil erosion.
- (h) Strip Cropping:- This system of cropping involves growing of few rows of erosion resisting and erosion permitting crops in alternate strips on contour or across the slope with the objective of breaking up long slopes on farm and preventing erosion and soil loss.
- (i) Crop rotation:- Crop rotation involves incorporation of legumes with cereals in a sequence in order to take advantages of different feeding zones, both for nutrients and water and to off set disadvantages of Mono-cropping in controlling insects, pests and diseases.

## CHAPTER V

# SUMMARY AND CONCLUSION

## SUMMARY AND CONCLUSION

The Miniwatershed ORR-5-4-5-2 has been selected as a pilot watershed under Integrated Watershed Development Project ( Plains) of Jagannath Prasad block in Ganjam district. The watershed comes under the north easternghat agroclimatic region of the State. Average annual rainfall is 1286 mm. The maximum mean temperature is 102° F and mean minimum temperature is 68°F. Soil climate is hyper-thermic.

Four pedons representing distinct physiographic units of the watershed were studied. The physiographic units are (1) Upper pediment (2) Pediment with bunding (3) Unbunded upland (4) Lower pediment.

In the present study, soils were characterised for their morphology, physical and chemical properties and classified under land use capability units and soil taxonomy. All the combinations of soil characteristics were evaluated for proper land use and to interpret them in terms of their response to the management practices. The salient findings are presented in the following para.

The morphology of pedons were studied in the fields. The soil samples were collected from each horizon for laboratory estimation which includes mechanical composition and physical characteristics including density, water holding capacity and porosity of the soils, chemical characteristics consisting of pH, organic carbon, E.C, exchange acidity, exchangeable bases and available N, P & K.

(1) Soils of upper pediment are reddish yellow, yellowish red, Red and that of lower pediments are strong brown, reddish yellow, yellowish red and dark reddish brown. The colour is mainly attributed to the content of organic matter, ferruginous compounds and the different degree of hydration.

(2) Soils are of varying texture of loamy sand, sandy loam- the light texture being usually seen on the surface and the clay content increases with depth. The texture of the surface soils bears a relationship with the toposequence- becomes finer with the lower micro relief and slope. This is attributed to differential degree of soluf-action and colluviation. The percentage of coarse fragments are ranging between 40 and 75 % in the sub soil layers of all the profiles except the profile-4. In profile-4, Mn-concretions are observed in deeper layers.

(3) The water holding capacity of the soil ranges between 32 to 40 % and available soil moisture is ranging from 11 to 12.5 % which is good for plant growth.

(4) All the soils except that of the 4th profile suffer from moderate to severe soil erosion due to (a) high slope (b) high intensity of rainfall (c) barren land with over grazing. The lower pediments are banded and cultivated thus reducing soil loss.

(5) All the soils are non saline and the soil reaction is slightly acidic to neutral. The total exchange acidity ranges from 0.215 to 0.435 me/100g of soils.

(6) The CEC values are low in upper pediments and medium in lower pediments.

- (7) The percentage of base saturation is from 68.52 to 78.56 and the content of exchangeable bases vary in the order of  $Ca^{++} > mg^{++} > K^{+} > Na^{+}$  .
- (8) All the soils contain low organic carbon.
- (9) The available N,P & K content are low in the soils of upper pediment but medium in that of lower pediment.
- (10) The soils have been classified as per soil taxonomy. The soils of profile 1 and 2 are less developed as they have no horizon other than ochric epipedon and therefore key out as Entisols. At family level they key out as a member of loamy skeletal mixed hyperthermic family of Typic Ustorthent. The soils of profile 4 are also classified as Ustifluvent and typic ustifluvent at great group and sub great group level respectively & fine loamy mixed hyperthermic at family level. Soils of profile-3 key out as a member of loamy skeletal, mixed hyperthermic family of typic UStochrept
- (11) The soils of the watershed have been classified into Land use capability Class IIc, IIIe & IV e on the basis of their ability to produce plants without deterioration for a long time. Capability class indicates the degree of the total limitations on the land use. Here the dominant limitation is soil erosion which can be controlled by intensive conservation measures.
- (12) Both the mechanical and Agronomic measures have been suggested to overcome the limitations on the land use. Mechanical measures include (a) Contour bunding (b) contour cultivation & Vegetative bunding (c) Diversion channel (d)

Gully control measures (e) Run off storage structure  
(f) Stream bank erosion control etc. Agronomic measures include (a) Land preparation (b) contour farming (c) Mixed cropping (d) Mulching (e) crop rotation (f) Strip cropping Besides the above measures, rehabilitation of degraded forest and Horticultural plantation with alternate land use system like Agri-Horti, Agro-Forestry and Silvi-pastoral have been recommended.

Modern soil conservation is based on sound land use and the treatment of land with those adoptable, practical measures that keep it permanently productive while in use. Therefore in last three plans, the concept of integrated land use planning on watershed basis was introduced. The soil characteristics as well as climate and site characteristics of watershed are studied to determine in what way it can be used for the greatest benefit to mankind, not only for the present but also for the future. In light of soil survey data and physicochemical characteristics of soils, the watershed are managed giving the relative importance on (a) integrated watershed development & especially that of water resources (b) the finances for implementing all the aspects of the projects (c) effective organisation (d) the people's participation. Soil conservation programmes will therefore, have to be tackled on a watershed basis, as a concerted action where all efforts reinforce and complement each other. The present study is an illustration of a case study in a specific watershed and the recommendations emerging from it can be collected and extrapolated to other watersheds in the state & elsewhere under similar agro-climatic conditions.

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