Watershed Development Approach in Groundwater Augmentation in Nawapada District of Orissa

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Abstract: Watershed or a drainage basin is a unit draining runoff water to a common point. In Nawapada district of Orissa the average annual rainfall is 1378.2 mm and it falls in the rain shadow region. The rainfall is erratic. The district is chronically affected by drought. Integrated watershed development programme has been implemented on micro watershed basis in the district, which has given encouraging results. The Jharianala watershed of Tileijhar village is an ideal example. In this watershed area, different water conservation structures like contour bunding, minor pit, loose boulder check dams and check dams etc. are implemented. After implementation of the project, it was found that there is a rise in groundwater level, decrease in soil erosion and improvement of vegetation growth. People are also able to cultivate in summer season. This has stopped migration of labour and there is an overall socio-economic development of the area.

INTRODUCTION

Watershed or a drainage basin is a unit draining runoff water to a common point. Watersheds are divided into sub-watershed, mini-watershed and micro-watershed. Micro-watershed is the unit of development whose area is around 500 hectares. The term 'watershed' was first used by American foresters for an area of land, which drains water from rain through a single outlet. In watershed management various practices are followed to develop and exploit the optimum production potential of the resources of climate, land, water, plant, man and livestock, so as to produce abundant food in a sustained manner without deteriorating the existing resource base. Watershed development is nothing but a process of natural regeneration.

Nawapada district is located in western part of Orissa bordered by Chhatisgarh state in the west. The average annual rainfall is 1378.2 mm. The district falls in the rain shadow region, and the rainfall is erratic. Also the district is chronically affected by drought. The area presents conspicuous geomorphic variations comprising moderately high hills, isolated hillocks, undulating plains, intermontane valleys etc. The average elevation of the area is 700 m above msl. As major part of the rainfall goes as run

off the groundwater recharge is very less. To enhance groundwater recharge, watershed development is very important at microlevel.

STUDY AREA

The Jharia Nala microwatershed of Tileijhar village is a tributary of river Ong (District Nawapada, Orissa) of Mahanadi drainage system. The study area is bounded by longitudes 82° 35' to 82° 40'E and latitudes 20° 45' to 20° 50'N (Fig. 1). Figure 2 shows a detailed map of the watershed.

METHODOLOGY

The Soil Conservation Department of Govt. of Orissa carried out detailed field studies in Jharia Nala microwatershed of Tileijhar village. The impact of watershed development in the project area was studied. The scenario in the area before and after implementation of the project was compared. Interaction was made with the village people and the watershed committee regarding the benefits of the project.

RESULTS AND DISCUSSION

Physiography

The highest elevation in the Nawapada district is 1006 m above msl with an average elevation of 700 m above msl. The physiography is represented by structural hills, denudational hills, ridges, narrow intermontane valleys and escarpment. Lateritic uplands border the foothills. Also, the undulating terrain which varies in altitudes from 350 to 240 m above msl and borders the hilly tract has dissected patches of inselbergs and residual hills. The Tileijhar microwatershed area is composed of undulating tracts of high ridges and low valleys. The level difference between the ridge and valley is 3 to 10 m. The general slope of the area varies from 1% to 8% from west to east. The micro-watershed is surrounded by forest area which contributes to the internal drainage system of the project area. The undulating topography consisting of intermediate ridges and valleys creates reticulated drainage pattern.

Drainage

The district is mainly drained by the tributaries of the Tel and Ong rivers. The main tributaries are Indra, Udanti, Hatti, Sagada, Sundar, and Jonk etc. All these rivers, at places, follow a linear path and sometimes take a sharp turn indicating probable structural control over their courses. The general drainage pattern in the undulating terrain is dendritic to sub-dendritic. Dendritic drainage pattern is very characteristic in the granitic terrain. In the watershed area, the flow direction is from northwest to southeast.

Geology

Nawapada district of Orissa is underlain by hard rock like granite, gneiss, charnockite, khondalites etc. of Eastern Ghat Group and includes shales, quartzites, limestones etc. of Chhatisgarh Group.

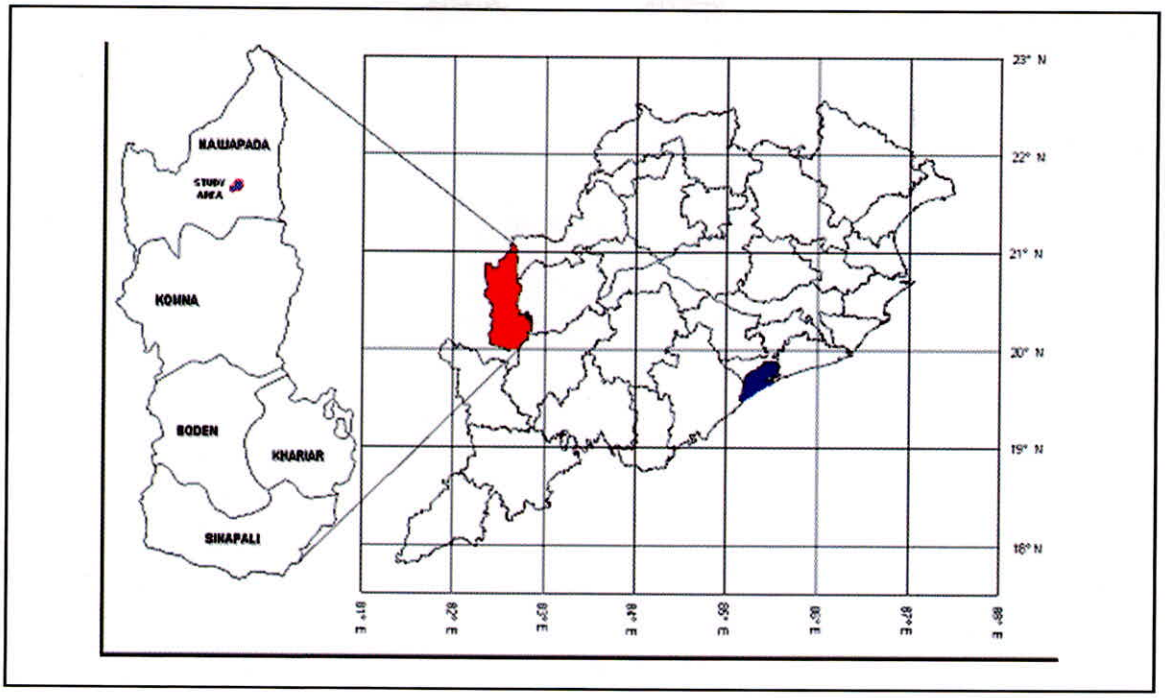

Fig. 1. Location of map of Jahrianala watershed of Tilejhar village, Nawapada District, Orissa.

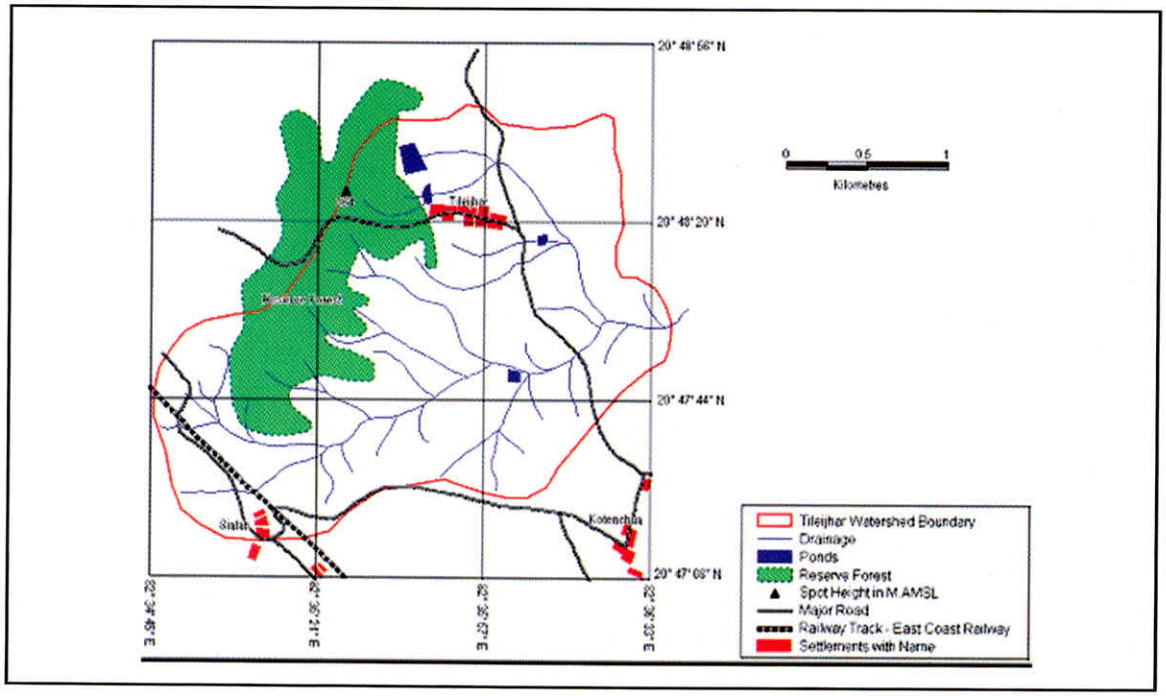

Fig. 2. Jharianala Watershed.

Salient Features of Jharia Nala Microwatershed of Tileijhar Village

The Jharia Nala microwatershed of Tileijhar village comes under the Nawapada block with total geographical area of 746.06 sq. km. The percentage of irrigation in the block is only 12.29. The total geographical area of the watershed is 592.67 ha with total treatable area of 406.35 ha. The present land use classification of village Tileijhar is given in Table 1.

Table 1. Land uses of Tileijhar village

Sl. No.	*Land use classification*	*Area in hectare*
1	Arable land Cultivated agricultural land (net area sown)	257.60
	A Upland	120.48
	B Medium land	46.41
	C Low land	90.71
2	Non-arable land	148.75
	A Current fallow	5.08
	B Forest	85.07
	C Pasture/Gochar	19.74
	D Culturable waste	34.26
	E Unculturable barren land	4.6
3	Total treatable area	406.35
4	Land under non agricultural use (nontreatable area)	37.63
	A Home stead land	12.5
	B Road and Path	9.48
	C River and Nala	1.04
	D Common land	2.62
	E Water bodies	8.25
	F Rock outcrops	3.74

Climate

The rainfall in the watershed area is highly uneven and erratic and average annual rainfall is 874.72 mm with total number of 69 rainy days. The rainy months are mainly July, August and September. The distribution of rainfall is highly irregular characterised by long dry spells. Due to early stoppage of rain and late setting of rains, which hampers crop production badly, every second or third year is a drought year. There is great variation in groundwater table between pre-monsoon and post-monsoon periods. The project area comes under western undulating agroclimatic zone. The climate is hot and dry and often the temperature rises to 44 °C. The temperature normally varies from 12.7 °C to 44 °C. Relative humidity is generally high from June to November. The lowest value is 27% during the month of March and highest recorded value is 79%.

Soil

The soils of the project area come under that of moist-sub-humid eco-sub-region. The soils in the area are heteregenous in nature. The soils developed on upper reaches are moderately deep to deep, and well drained with severe erosion hazards. The texture varies from gravely sandy loam to sandy clayey loam. The soils developed on valley are deep to very deep. Colour is dark grey with low to moderate

erosion hazards. The eroded soils from higher reaches have been transported and deposited in lower reaches. Process of soil formation i.e. illuviation and elluviation of soil minerals have not properly taken place.

Vegetation

The watershed is geographically situated in the subtropical, subhumid area. The vegetation of the area can be termed as northern tropical dry mixed deciduous forest. The common species found in the watershed area are as follows:

Sl. No.	*Common Name*	*Botanical name*
1.	Sal	*Shorea robusta*
2.	Mahul	*Madhuca latifolia*
3.	Babul	*Acasia arabica*
4.	Char	*Buchanaria latifolia*
5.	Teak	*Tectona grandis*
6.	Kendu	*Dispyrus melanoxilana*
7.	Piasal	*Piterocarpus marsupium*
8.	Mango	*Magnifera indica*
9.	Paalash	*Bute frondosa*
10.	Neem	*Azadirachtai indica*
11.	Jamun	*Begunia jamblore*
12.	Arjun	*Terminalia arjuna*

Why Watershed Approach

The need of the hour is to urgently regenerate the natural resources that are degraded through land mismanagement in the last 50 years or so. A shift from exploitation-oriented development to regeneration-oriented development is highly essential. We cannot think of regeneration without conserving what we have. Conservation of basic natural resources is the first step in the process. Since soil and water conservation are inseparable, the best way is to choose a hydrologic unit i.e. watershed. Watershed is a natural unit with its boundaries defined by topography and not by man-made parameters. A watershed as a living system is governed by natural laws and it is necessary to go close to nature in order to correct the man-made mistakes. Our development process has so far neglected the upper reaches of a catchment. Watershed approach enables us to take care of this neglected lot of people, land, water, forests and other elements of the ecology.

No two watersheds are similar in nature – no matter how big or small they may be. The upper, middle and lower reaches of a watershed are associated with different kinds of life support system. They behave differently to flow of rainwater. They demand specific types of management practices and provide economic returns in specific ways. Watershed development is not a recent theory of development. In ancient times, our resource use was based on the principles of the modern-day watershed approach. Sustainable management of natural resources with water as the nucleus is the central theme of watershed.

Objectives of Watershed Management

- The integration of technologies within the natural boundaries of a drainage area for optimum development of available natural resources such as land, water and plant to meet the basic needs of people and animal in a sustainable manner.
- Effectively conserve soil, rainwater and vegetation and harvest the surplus water to create water resources in addition to groundwater recharge.
- Promote sustainable farming and stabilize crop yields by adopting suitable cropping and land management systems.
- Cover the non-arable area effectively through afforestation, horticulture and pasture land development based on land capability class.
- Enhance the income of individuals by adopting alternative enterprises.
- Restore ecological balance within the watershed boundary.
- A framework for an integrated, viable and decentralized pattern of development of people living in a degraded area where water is scarce and mismanaged resource and where exploitation of resources and people have resulted in overall degradation leading to growing poverty, inequality and inability to cope with stress.
- Sound watershed management means controlling floods in rainy season, droughts in dry seasons and reducing soil erosion and sediment accumulation.

Programmes in Watershed Management

1. Resource Regeneration: Rain water harvesting, soil conservation, afforestation and dryland farming etc.
2. Resource Conservation: Water management, land-use planning and alternative energy sources.
3. Welfare Programmes: Rural sanitation, community health, extension education vocational training and women empowerment.

Principles of Watershed Management

1. Utilising the land according to its capability.
2. Adequate vegetation cover during the rainy season.
3. Conserving as much rain water as possible at the place where it falls.
4. Draining out excess water with a safe velocity and diverting it to storage ponds for future use.
5. Avoiding gully formation and checking at suitable intervals to control soil erosion and recharge ground water.
6. Maximising productivity per unit area, per unit time and per unit water.
7. Increasing cropping intensity and land equivalent ratio through intercropping and sequence cropping.
8. Safe utilization of waste and marginal lands through alternative land use system.
9. Ensuring sustainability of ecosystem benefiting the man-animal-plant-water complexes.
10. Maximising the combined income from the interrelated and dynamic crop-livestock-tree-labour-complex over the years.
11. Stabilising the total income and cutting down risks during aberrant weather conditions.
12. Improving infrastructure facilities with regard to storage, transportation and marketing.

Different Conservation Structures Implemented in the Project Area

Reach Point: The highest point of the watershed in the upper reach from where rain water starts flowing into the watershed is called the reach point. The different water harvesting structures in the project area are listed below:

Contour bunds: Earthen bunds are constructed along contours or with permissible deviations from contours. It only changes the length of the slope. Contour bund is practiced to intercept runoff flowing down the slope and reduce soil erosion. An embankment is built across the slope whose ends may be opened or closed to conserve moisture as well as to reduce soil erosion (Fig. 3).

Contour trenching: In contour trenching, trenches are excavated along a uniform level across the slope of the land in the top portion of the watershed. Bunds are formed downstream along the trenches with materials taken out of them. The main idea is to create more favourable moisture conditions and thus accelerate the growth of planted trees. Contour trenches break the velocity of runoff. The rain water percolates through the soil slowly and travels down, and thus benefits the better type of land in the middle and lower reaches of watershed.

Minor Pit: These are small pits dug along the slope to intercept storm water and enhance recharge.

Gully plug: Gully plug is a structure, either temporary or permanent, constructed across a gully for checking stones runoff and thereby controlling further erosion (i.e. widening of the gully). Small gullies could eventually be reclaimed by cultural and vegetative measures. Gully plugs are made out of any locally available material like wood plants, rocks, logs, woven wire, rod or brushwood, earth etc. These are generally constructed in a series. These checks can either be temporal or permanent.

Fig. 3. Contour bunding in Jharianala watershed, Tileijhar Village, Nawapada District.

The size depends on the width, length and bed slope of the gully and anticipated run off. Functions of the gully plugging are mentioned below:

1. Erosion control.
2. Control of further deepening of gullies.
3. Reduction in velocity of storm water.
4. Increase in infiltration of water in soil and thereby improve groundwater recharge.
5. Encourage silting and improve in soil moisture regime for establishing plant cover.
6. They finally create microenvironment for establishment of plant cover.

Loose boulder check dams: In the middle reaches these are very effective. These are suitable where fieldstones are in abundance and in gullies of moderate slopes with small to medium size drainage areas. This type has an added advantage because its flexibility and weight help to hold it in contact with gully bottom. These are very good structures for reducing the rate of runoff, check erosion, restrict sediment losses etc. (Fig. 4).

Check dams: Check dams are structures constructed across the drainage in order to arrest and retain the flowing water. They are constructed using impervious material. Most common materials are soil (called earth-fill or earthen dam), stones or reinforced concrete (concrete dam). By definition, a dam is a bigger structure than gully plug and it is not pervious.

Project: This is constructed at the lower reach to intercept the runoff water. Depending on the total runoff and size of the gully it is made of the dug out material of earth or boulder. It impounds water which is used as pond by the villagers.

Fig. 4. Loose boulder check dam in Jharianala watershed, Tileijhar Village, Nawapada district.

Plantation of grass to check soil erosion: Grass is also planted in the watershed to check soil erosion which is very effective in the watershed area.

BENEFITS OF WATERSHED DEVELOPMENT PROJECT

After implementation of the watershed project the different benefits in the area are given below:

1. Conserve the runoff water in the field itself.
2. It checks soil erosion. When the volume of rainwater exceeds the infiltration capacity of soil, excess water flows down the slope causing sheet, rill and gully erosion. Erosive effects of rainwater are reduced by vegetation through cover crops or structures like bunds etc.
3. It has increased the quality of soil (texture/structure) merely because of availability of water.
4. Improves the vegetation in the watershed area. Plant cover controls splash erosion by intercepting the rain drops and absorbing their kinetic energy. Plant cover also protects the infiltration capacity of soil by preventing formation of tight surface layer by the impact of rain drops. Root systems affect soil properties, and vegetation density dominates the functioning of hydrological properties through modification of interception, infiltration, evapotranspiration, surface runoff, and groundwater recharge.
5. Increased moisture in soil helps the paddy/monsoon crops from dry spell due to erratic rain.
6. It enhances groundwater recharge. Dried wells/bore wells get recharged and there is 2 m rise of water level after implementation of the project.
7. Oil seeds are also planted in the watershed area which is collected by the self help group.
8. Different conservation structures like check dams stop further gully erosion and promote land reclamation and make it suitable for cultivation which was not possible earlier.
9. The project impounds runoff water which acts as percolation tank. Percolation tank helps water retention, serve as aquifer recharge structures, provide drinking water to bovine population as also to humans in many cases. In the project pisiculture is also done.
10. After implementation of the project people have started two crop system and cash crops in summer season also. People have started cultivation of vegetables like onion, potato, tomato by directly lifting water from the project or dugwells in summer.
11. Increase moisture regime in the soil led to oozing out of excess water in the medium/lower portion of the watershed area. Here one can dig a small pond to use it for various purposes which is called "chahala" in local language.
12. Increased moisture in soil helped the paddy/monsoon crops from dry spell due to erratic rain.
13. Land treatment of various types has helped generation of biomass (vegetative growth). It has helped to increase the fodder and fuel. There is increase in livestock population and also in their condition.
14. It controls both drought and flood.

WATERSHED COMMITTEE AND PEOPLE'S PARTICIPATION

Water can be conserved in different ways but the most appropriate practice is conserving by making watershed structures with the help of people at each stage. In this programme, emphasis is laid on mobilizing and organizing the community into functional groups such as self help groups and user groups and making them responsible for planning and implementation of watershed activities related to individuals and the entire community. It is further stressed to form an association of stake holders

of watershed area and to constitute a watershed committee for systematic participatory planning implementation and maintenance of developmental works and to handle the financial transactions. Participatory watershed management is necessary to make a project successful.

The development of natural resources and maintenance to create assets on a continuous basis is possible only through active participation of the beneficiaries living in the area. To create the feelings of belongingness and to be financially capable, the watershed community should plan and implement the development activities and make donations and contribution for the individual and community works in the form of cash, material and labour.

The watershed stakeholders have been empowered with decision making for development, administration, financial management of the project. The organization has full autonomy in deciding the various development works keeping in view the need of individuals and community for its implementation.

The beneficiaries and their groups have the freedom to adopt technology of their choice and engage local labourers or beneficiaries to accomplish the work successfully.

To meet the needs of the people for raising different seedlings of vegetables and horticulture plants etc. it is a necessity to establish a composite nursery. So a self-help group needs to be entrusted with the task to maintain the nursery.

Role of Women

Women play an important role in farming system and influence decision making of farmers in a significant manner. They participate in feeding livestock agriculture operation, cooking, collecting firewood, maintaining house, taking care of children and old men, fetching water and attending numerous household activities. Moreover, they play an important role in household industry and contribute to rural economy. Hence, it is important to involve women in project planning and implementation of project activities and they should be given representation on watershed committee. Special training courses would be arranged to train rural women in processing and handling bio-fertiliser and also to promote technical knowledge about different income generating activities like bee-keeping, mushroom cultivation, etc.

Leading States in Watershed Management

The average annual rainfall varies from about 150 mm in the southern deserts to about 600 mm in the northern hilly region of Israel. Both these values are less as compared to both the extreme values of annual rainfall in the Indian State of Rajasthan. Yet, Israel has enacted laws and implemented programmes for better water conservation and management which ensures minimization of wastage and thereby has improved the water use efficiency. Some of the techniques used are rainwater harvesting and drip irrigation. In India, Gujarat and Rajasthan are two leading states in rainwater harvesting. Water crisis is minimised in areas where rain water harvesting approach such as check dams etc. are implemented. Rajendra Singh, the winner of Magsaysay award, has been able to convert barren degraded land to land suitable for cultivation.

CONCLUSIONS AND RECOMMENDATIONS

- No two watersheds are similar and implementation of watershed development varies from place to place.

- Out of various treatments, one land treatment measure is called 30 × 40 model. Here unbunded uplands are made with plots of 30' width and 40' length (across the slope). In a treated plot one can see dense vegetative growth while a nearby untreated plot (of the same patch) is totally barren.
- Enhanced "carrying capacity" of the land. This refers to the capacity of a land mass to sustain the needs of the whole living system (need of human being, cattle population and other living being). For example, due to environmental degradation, the carrying capacity decreases and people are unable to get their sustenance and migrate for wage earning. Watershed has helped to increase the carrying capacity potential and encouraged people to come back to their area.
- Local population planning to migrate from village due to less rainfall and no crop production chooses to stay back after the watershed work and they are able to cultivate crop even in summer season.
- It gives livelihood to people and solve the unemployment problem.
- Involvement of women in the process which is very important in our society; also, they start earning on their own.
- Training should be an essential component under watershed development programme. Farmers, Mitrakisans, Gopals, selected villagers, officials engaged in watershed development, women in particular and even planners should be imparted training in relevant aspects of watershed related programmes.
- Watershed development project involves the social aspect, which contributes to sustainability of watershed development programme.
- Watershed management is an integrated programme and the major emphasis on soil and water conservation along with availability of food, fodder and fuel wood to the villagers.
- In India about 67% of the arable land depends upon in situ rainfall, contributing 46% of the national agricultural production. The sustainable agricultural production in the country is possible only through the efficient utilization of land and water resources and retarding the process of environmental degradation on watershed basis.

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