A STUDY ON WATER MANAGEMENT IN SOIL AND WATER CONSTRAINED TRIBAL AREA

THESIS

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In partial fulfillment of the requirement for

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In

AGRICULTURAL ENGINEERING

(SOIL AND WATER ENGINEERING)

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2016

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CERTIFICATE- I

This is to certify that the thesis entitled **"A Study on Water Management in Soil and Water Constrained Tribal Area"** submitted in partial fulfillment of the requirement for the degree of **MASTER OF TECHNOLOGY** in Agricultural Engineering in **Soil and Water Engineering** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafied research work carried out by **Mr. ASHOK KUMAR** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

All the assistance and help received during the course of the investigation has been acknowledged by him.

Place: Jabalpur

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Percentage
Agril.	:	Agricultural
Agril. Engg.	:	Agricultural Engineering
Agron.	:	Agronomy
CAE	:	College of Agricultural Engineering
cm	:	Centimeter
cm^2	:	Centimeter Square
Deptt.	:	Department
e.g	:	Exempli Gratia (for example)
FAO	:	Food and Agriculture Organization
Fig	:	Figure
g/cc	:	Gram per cubic centimeter
ha	:	Hectare
ha cm	:	Hectare centimeter
lps	:	Litre per second
I_c		Cumulative infiltration depth
i.e	:	That is
ICAR	:	Indian Council of Agricultural Research
J. Irrig. Drain. Eng.	:	Journal of Irrigation and Drainage Engineering
JNKVV	:	Jawaharlal Nehru Krishi Vishwa Vidyalaya
Govt.	:	Government
Kg ha^{-1}	:	Kilogram per hectare
Kg/cm^2	:	Kilogram per centimeter square
m	:	Meter
M.P.	:	Madhya Pradesh
m/s	:	Meter per second
m^2	:	Square meter
No.	:	Number
^oC	:	Degree Celsius
Sec	:	Second
SWE	:	Soil Water Engineering
t	:	Time
HP	:	Horse Power
Hr	:	Hour
Vol %	:	Volume percentage
vs	:	Versus
B	:	Bichhua
S	:	Sanjari

1.0 INTRODUCTION

The climate is continuously changing mainly because of change in ecosystem; as a result the temperature change is at alarming rate. Also, the duration of various seasons has been changed. The length of rainy season and winter season has been reduced, while the span of summer season has been expanded more than four months. The quantum of rainfall and the ground water recharge thereof has also been significantly reduced. (Garg, 2010). In response, at several places the ground water structures like tube well etc. have now been started to fail due to which area do not get water for domestic needs. Crop cultivation becomes impossible and reservoirs are drying. In brief, there becomes massive water scarcity. The government is investing huge amount of money for harvesting of rain water to dilute the problem of water shortage.

India is a tropical country and its precipitation varies considerably in frequency, intensity as well as in duration. The total precipitation occurs is received either as rainfall or as snow. Orographic precipitation is responsible for heavy rainfall in India. The mean annual precipitation of country is 119.4 cm. (Michael, 2011). The largest amount of precipitation (75% or so) falls as rain during June to September, 10-11% between October to December, 3-4% during January to February and 10-11% as pre-monsoon rains (CGWB, 2007).

It is estimated that about 30% area of the country receives an average annual precipitation of less than 750 mm where as 42% area receive in between 750-1250 mm. (Belsare and Sohoni, 2015). Rain fed area which about 72% of the total geographical area contributes only 44% to the national food basket

.

The competing demand for water in agricultural, industrial and domestic uses resulting in fast depletion of the country's water resources. The agricultural sector continues to utilize over 90% of water resources. The ever widening gap between supply and demand necessitates greater need for efficient water conservation and management to increase area under irrigation. Further poor resource especially in tribal areas which are deprived of technical knowledge also led lower crop and water productivity. Development by farmers along with scientific interventions are supposed to be the sustainable (Garg, 2010).

Tribal area undulated in topography, dominated with low soil depth and meager irrigation facilities. Agriculture economy of the block is rain dependent. Farmers are not aware of new crop varieties, appropriate machineries and water management. Improving the agronomic practices such as planting methods and soil water management practices definitely increase crops production of new cultivars with reduction of water losses and increase water availability (Kawdeti, 2015).

Scope for expanding the arable area (horizontal expansion) is rather limited, it becomes imperative to intensity biomass production under irrigated condition. There is a strong need for water budgeting, i.e demand and supply analysis from all sectors related to villages namely domestic, animal and agricultural sectors. Water available from all surface and underground sources i.e wells, tube-wells, hand-pumps etc. has to be estimated.

The basic motive behind the current resources is to discover prospective of water management on selected tribal areas. An attempt has been made on current study to investigate the demand and supply by water resources for the both the tribal villages.

The demand-supply deficit of water was analyzed and planning has been done to enhance the water availability. An optimum land and water use plan has also been derived considering current and proposed water resources availability for the efficient water utilization.

Water adequacy plan aims towards optimum use of water for getting optimum profit per unit of land area.

Keeping this in view a study is planned in tribal area with following objectives:

1. To assess demand of water use for domestic, livestock and agriculture purpose and availability of water from all surface and underground sources the selected area.
2. Water management planning for water adequacy of the area based on water deficit/surplus analysis.
3. To prepare land use plan for optimal water utilization.

2.0 REVIEW OF LITERATURE

2.1 General

It is necessary to emphasize here that the concept of performance is closely linked to the existence of goal and target for achievements. The goal may be explicit or implicit; but the choice of any parameter as a premise that enhancement of that parameter is a desirable thing. In recent past, there were several studies have been done on water balance its management, Water budgeting, Demand supply analysis for the efficient utilization of water resources. Many literatures were sited to get insight of past research pertaining to water management studies mentioned as following.

2.2 Water balance study

Sastri and Singh (1981) studied the water management of the various regions in the Jodhpur and Nagpur district based on the climatic water balance approach. The eastern regions of these two districts have better potentials for practicing water harvesting for successful crop production. The average surplus water from 50 to 100 mm in Jodhpur and above 100 mm during the month of August. The study revealed the possibility of utilizing the excess water for supplemental irrigation during periods of moisture stress within the Kharif season it stored in field and can also help for stabilizing the crop yield and augmenting the water requirement for Rabi crops. Even in severe draught year, the mean annual precipitation was four times of the total water requirement in Khandwa district (Rajesh, 2000).

Richard *et al.,* (2007) also studied on water budgeting for effective water resources its availability, determination and environmental management.

Schwartz *et al.,*(2008) estimated soil water balance components using an iterative procedure. They had quantified the hydrologic balance to evaluate field-scale management effects on soil water storage.

Singh & Singh (2011) also studied on Impact Assessment of Watershed Activities in Tribal area has clearly shown that watershed activities offer a viable solution to the irrigation problems in tribal area. This can lead to substantial improvement in the socio economic condition of the small and marginal farmers in tribal area. But it needs missionary zeal in implementing agencies and the beneficiaries. Such type of programme should be carried out in the people's participation mode and beneficiary families should make the decision regarding programme implementation in consultation with the technical experts of the various development agencies. After constructing the rain water harvesting need based structures, farmers should be educated to make judicious use of the stored water and various efficient water use technologies should be demonstrated in the farmer's fields to generate maximum impact of the invested resources.

Bahadur (2014) observed scenario based demand supply analysis in Harsi command for irrigation management. The observation found significant difference between the hydrology of small and large watersheds. For small watersheds the rates and amounts of runoff were influenced by the physical condition of soil and cover.

Bhaskar *et al., (*2014) carried out a study in tribal area of India conducted to assess the impacts of the Integrated Watershed Management Program (IWMP) in selected tribal areas of Gujarat and Chhattisgarh, India. The IWMP strives to bring together the ideals of natural resource management and rural development through a decentralized, people driven participatory approach. This has been implemented by conducting intensive ground level door-to-door surveys, village level meetings and participatory rural appraisal techniques. To obtain a holistic picture, the social, environmental and economic impacts of the watershed program have been studied. The findings show a definite positive link between watershed management and sustainable development in the tribal areas. The program has brought about positive impacts in soil and water conservation, reduction in excessive surface runoff and soil erosion and enhancement of ground water table. This has resulted in higher agricultural and milk productivity, introduction of water efficient and environment friendly agricultural practices, improved animal husbandry techniques and better availability of water for irrigation and other domestic uses. Livelihood interventions under the IWMP have also ensued livelihood enhancement and decreased migration rates. Special emphasis on women empowerment and upliftment of the landless have also led to improved participation and decision making in planning and equitable gains from the watershed program. To have a long-lasting impact, the program needs focus on institution and capacity building which would instill the principles of sustainable management of natural resources and achieve the desired environmental performance from the program.

Kawdeti (2015) carried out a study in tribal villages on water productivity. Study revealed that improved technology has higher water productivity i.e 0.91 to 1.32 kg/m^3 then farmers practices i.e. 0.82 to 1.22 kg/m^3 and it was found that water productivity depends on several factors like crop gentic material, water management practices and agronomic practices.

2.3 Development of Land and Water Resources Action Plan.

Land and water resources have become increasingly scarce calling for their efficient utilization. Review of studies on various approaches for development of land and water resources action plan is presented here.

2.3.1 Watershed based approach.

Wirodidjojo (1989) development a computerized watershed management model that maximized Net Present Value (NPV) subject to the constraints of permissible erosion, food demand, total budget and available land resources. The model used data from the Kontu Hulu River sub-Watershed of the Brantas watershed in East Java, which function as a water catchment area for the Seloredjo dam. Total area of this sub-watershed was about 23450 ha, of which

15450 hawas forest. Three types of land development unit were defined using criteria of soil type, slope class and agro climatic zone. These were land for perennial crops, agroforestry and for forest development respectively. Eleven planting pattern and three agroforestry types with high economic potential were selected. He reported that trhe model appeared to be useful in sloving the planning of optimal NPV. Location of land development areas, and land development schedules. He further noted that maximum values for erosion, water yield improvement, carrying, and compatible land allocation could also be determined. An economic interpretation of shadow prices was also obtained from the dual linear programming solution. The auther suggested change in use allocation for the sub-watershed namely land for food crop- an increase in irrigated rice from 2155 to 2382 ha, and a reduction in dryland for perennial crops from 2670 to 1853 ha: agro forestry, an increase from 1095 to 1685 ha; forest land, a reduction in protection forest from 15540 to 11490 ha and plantation forest introduction and development to 4050 ha; and other land use (2030 ha), no change.

Sopper and dewalle (2005) Suggested that watershed management is the application of principles, method and techniques based on a through knowledge of complexity of process that influence water yield from drainage basin under various condition of vegetation, soil, geology, physiography and climate.

Dhyani *et al.* (2006) studied the impact of integrated watershed development and land use dynamics on agricultural productivity and socio-economic status of farmers in central Himalayas. Evaluation of two watershed, Khootgad and Mohnagad in Uttaranchal, india, revealed that after implementation of watershed management project, significant changes in land use had taken place. Case crops replaced coarse millets, while increased irrigation facilities and improved crop demonstrations encouraged the farmer to adopt new crop production technologies which significantly increased the yield of crop by 21 percent in potato at Mohnagad to 126 percent in wheat at Khootgad. Total food grain production increased by 135 percent in Mohnagad and 41.4

percent in Khootgad. Fooder production also increased significantly by utilization of uncultivated rainfed and community lands. Milk yield increased by 116 and 132 percent in Khootgad and Mohnagad watershed, respectively, and thereby a perceptible improvement was observed in the quality of life. Authors observed that integrated watershed development approach in the fragile Himalayan zone can lead to greater environmental security, sustainable agriculture production and to reduce income disparities in the Himalayan region.

Das and Mandal (2006) water management as a critical component of low land farming system in eastern India. His reported that initially farmer in west Bengal were reluctant to allot portions of their land. However their reluctance vanished after the benefit of the technology were demonstrained.

Shubhaiah (2008) carried out studies in the command area of Yamuna western canal in Haryana. He found storage rainfall over rice field in alkali soils was the most cost effective way of managing rain water followed by fallow alkali land storage and artificial recharge. Storage of rain water in farm pond for life saving irrigation was however not economical compared to growing rice, but storage of runoff volume in farm pond was profitable compared to induced ground water recharge. He noted that 80% of runoff could be accommodated in ponds for better rainwater management.

Singh (2010) published a bulletin on farm pond with the objective of providing life saving and the pre pre- sowing irrigation. He worked out with the selection of dimension of farm pond by duly consideration the factor such as selection of catchment, selection of site, deciding the size design of embankment and earth work, Yield of catchment, lining materials and economics analysis of the pond.

Tyagi and Dhruvanarayana (2011) reported that reclamation of alkali soil modifies the water balance of an area. Hierologically the soils under reclamation remain in a transient state over a long period of time because of the progressive improvement in their physio-chemical properties. The major component of the water balance that undergoes change is the groundwater recharge from cropland. A procedure to estimate the rate of the charge in recharge from cropland is presented and applied to typical alkali condition in the command area of the western jamuna canal. The value of groundwater recharge from this composite watershed, having normal and alkali soils in the ratio of 70 to 30, respectively, show an increase of about 17.5% of the recharge value before reclamation for the optimal cropping pattern over a period of 20 years.

Kumar (2012) pointed out that water balance technique have been extensively used to make quantitative estimates of water resources. It is possible to make a quantitative evaluation of water resources and its dynamic behavior under the incidence of means activities.

2.3.2 Climate based approach

Verma *et al.* (1994) in their study on rainfall analysis for rainfed crop planning in mid-hills of H.P observed that analysis of the lowest assured weekly rainfall at different probability levels using the incomplete Gamma distribution was found suitable for planning rainfed crop and related rainwater conservation measure for hilly regions of Himachal Pradesh. They noted that annual, seasonal and monthly rainfall analysis was not adequate for planning rainfed farming. Analysis of the rainfall record for 1973-19992 for palampur, Kangra District, revealed that the probability of getting adequate rain for a good Kharif crop of maize was very high in july and aug. when excess rain water can be stored in the soil profile and tanks. The chances of drought increased in Sep. for kharif crops. Oct. and Nov. had very low reliability of getting adequate rain for good germination of rabi wheat, requiring a presowing irrigation from tank water. They suggested that in-situ water conservation measure like deep tillage and mulching in a standing kharif crop to take care of short- duration drought during monsoon and moisture deficiency in the seeding zone for rabi sowing. The authors observed that short duration varieties of maize and drought resistant varieties of wheat were suitable for the region.

Tyagi et al. (1996) identified a various components, which influence the ground water balance equation, in the study area. While all other components except rainfall recharge have been calculated independently by analyzing the relavant data, the recharge from rainfall was calculated during monsoon using the water balance approach. Based on the monson rainfall, the recharge coefficients were calculated.

2.3.3 Cropping pattern:

Laxminarayana *et al. (*1978) suggested that optimization techniques can be used for deciding cropping pattern for an agricultural land. Alluvial tract between two river in northern India were considered for such a study. Total water resources of the basin i.e. surface water and ground water are used in determining optimal cropping pattern and optimal water release policy from canal and tubewells during various months in a year for maximizing the next benefits.

Kale (1982) Carried out study on watershed at Indore. He studied the water table behavior with respect to time for 6 years in monsoon period. The study shows that water level in the well rises late, which are situated at comparatively at lower reaches and also at lower rate of initial 3-4 week compare to well situated at upper reach. He also concluded that cropping intensity in kharif has definite impacts in water table fluctuations.

Irrigation water management related with water sources, climate condition, water requirement, and water distribution etc. during the irrigation season these data are changed dynamically. Therefore the decision – making support system for irrigation water management was developed with dynamic features by collecting, recessing information dynamically (Zhayi, 2003).

2.4 Infiltration characteristics and factors affecting infiltration

2.4.1 Soil infiltration Characteristics

Anonymous (2001) Studies infiltration at (Table 2.1) of soil profile indicating upper limit for irrigation application rates on various soil texture in the river. More accurate reading can be obtained in field measurement of actual infiltration rates, as they are known to vary between soils of similar texture.

Table (2.1) Indicative infiltration rate for soil textures

Texture	Infiltration rate mm/hr
Sand	13
Loamy sand	12
Sandy loam	10
Light sandy clay loam	7
Sandy clay loam	5
Clay loam	5
Light clay	4
Medium clay	3

Kenneth C.Ames, *et al* (2001) Assessed the infiltration rates and effect on water quality of selected infiltration media. They found that the infiltration rates of all fourteen dry media were faster than the corresponding wet media; dry media ranged from 7 to 179 in/hr and wet media ranged from 3 to 81 in/hr. Because wet conditions were more prevalent in field situations.

Bauder (2004) studied on the available water holding capacity of soil is afunction of texture. This is the amount of water that would and could be made available to plant after the soil has been irrigated (Table 2.2)

Table 2.2 Available water holding capacity of soils

Soil Texture moist	Inches of water per cubic
Sand and fine sands	0.75
Very fine sands. Loam sands	1.00
Sandy loam	1.50
Loam	1.90
Silt loam, silt	2.20
Silt clay loam	1.90
Clay loam, Sandy clay loam	1.70

The one of the important property of the soil is its infiltration characteristics. The infiltration rate is useful in designing the farm irrigation system under field conditions and determining the time required to irrigate the given plot the required depth. The following studies have been done on infiltration.

Prabhakar *et al*. (2005) carried out the studies on the rate of infiltration in different soil type. They concluded that the infiltration rate increases in three different types of soil with application of gypsum at a rate of 5 ton/ha. But the improvement in intake of water in these types of soils was for more than through the application of 10 rons of farm yard manure and digging to a depth of 30 cm.

Michael (2011) suggested the double cylinder infiltrometer test to measure infiltration rate. The cylinders are made with smooth tough steel sheet. Inner cylinder having the diameter of 30 cm, while outer one is of 60 cm diameter. The depths of the cylinders are about 25 cm. The cylinders are driven into the ground to be 10 cm with the help of hammer striking on mild steel bar placed at the top of the cylinder so that soil remains undisturbed. Water is poured into the inner cylinder first then outer one by container keeping jute cloth or leaf on the soil surface such that the surface soil is not disturbed. Water is pounded initially to a depth of 10 cm and fall of water level is noted using point gauge. A stop watch is used to note the time interval for the amount of water to be infiltrated. The depth of water in the inner and outer 4 cylinder are kept same during observations.

2.5 Application of RS and GIS technology

Remote sensing is the quantative approach, with the introduction of remote sensing both from aerial and space platforms; a better means of data acquisition system is now available which provides an accurate, reliable and updated database on land and water resources. This has been shown by various works.

Swain an Dawis (1978) defined remote sensing as the science of deriving information about an object from measurement made at a distance from the objects i.e. without coming in contact with it.

2.5.1 Use of digital elevation model

Giles (1998) conducted study on geomorphologic signatures, classification of aggregated slope unit object from digital elevation and remote sensing data in Southwest Yukon, Canada. By analyzing digital elevation and remote sensing data, concept of geo-morphological signature was developed for classifying and mapping slope units. Slope units were extracted from Digital elevation model using break of slope rule on down slope profiles.

Jones (1998) carried out studies on a comparison of algorithm used to compute hill slopes as a property of DEM. A comparison is made of 8 frequently used slope calculation algorithm for digital elevation model matrices. The synthetic surface was differentiated analytically to give true gradient and aspect values and these were used to compare the algorithms.

3.0 MATERIALS AND METHODS

The present chapter deals with the description of the project area, different sources of data collection and the methologies adopted to fulfill the objective formulated for the present study.

3.1 Description of the study area

3.1.1 Location

The study for current area was selected as Bichhua and Sanjari village of Kundam block of Jabalpur district about 24 km and 54 km from the headquarter respectively. The area is having the latitude and longitude of 23°12'20.19"N and 80°8'04.36"E, at an altitude of 508.84 m and 23°14'24.75" N and 80°24'27.59" E, at an altitude of 579.57m (Fig. 3.1) The village is covered in toposheet no. 64 A/4 , 64 A/8 published by Survey of india.

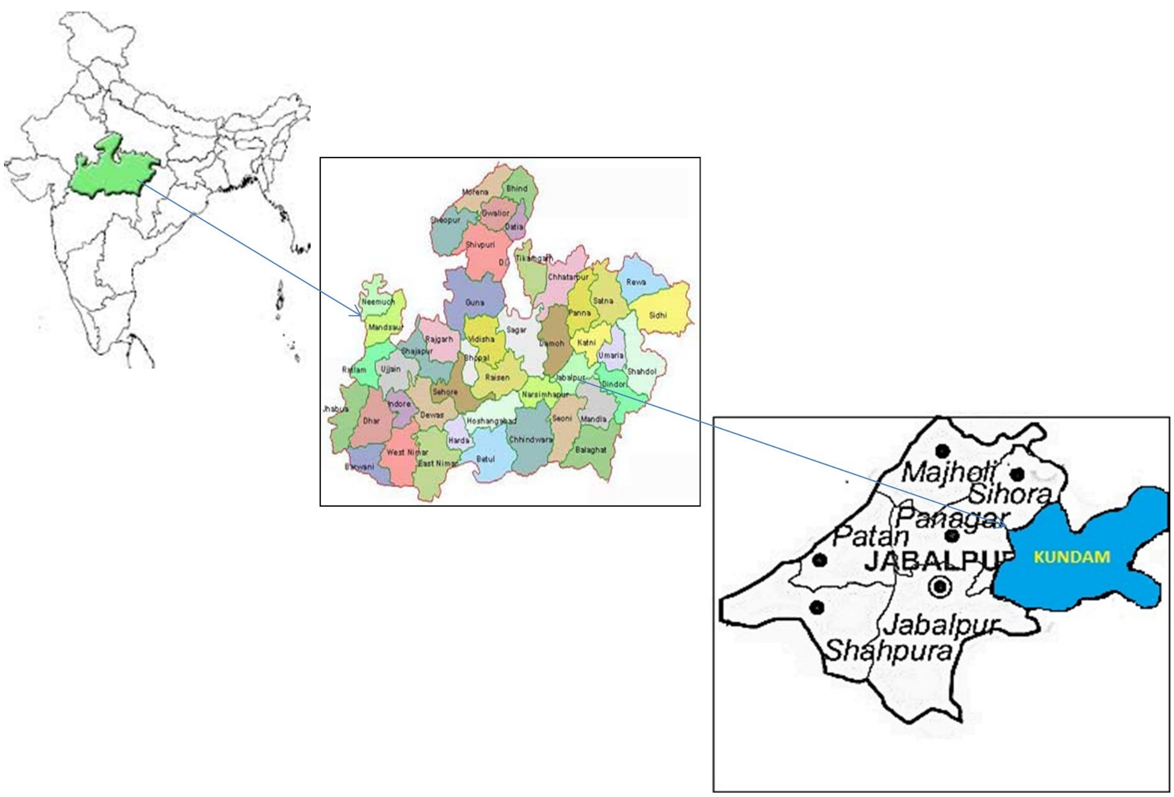


Plate 3.1 Location of study area

3.1.2 Climate and weather condition

The climate of the locality is characterized as typically semi-humid and tropical which is featured by hot dry summer and cool dry winter. It is classified as “Kymore plateau and satpura hills” agro climate zone as per norms of National Agricultural Research Project and is Known as rice-wheat crop zone of M.P. As per classification of National Bureau of Soil Survey and Land Use Planning this area belongs to agro ecological region no.10 named as hot sub-humid (dry) ecological (Malwa plateau, Vindhayan scrapland and Narmada valley, (Dept. of agri. Govt. of M.P.)

The weather data were obtained from the Department of Physics and Agro meteorology, College of Agricultural, Engineering, JNKVV, Jabalpur. The mean annual rainfall of Jabalpur, based on last 31 years data, is 1390 mm which is mostly received from south-west monsoon between mid June to end of September with little occasional rainfall of 67.9 mm during other months. The mean monthly temperature varies between 5.3 to 6.1°C in December and January and maximum temperature varies between 42 to 40.2°C during May and June respectively. Generally humidity remains very low during summer (20 to 23%); moderate (60 to 75%) during winter and it attains high value (80 to 95%) during rainy season

The average wind velocity varies from 8.3 kmph to 2.3 kmph in December. The total mean monthly pan evaporation varies from 387.5 mm in May to 77.5 mm. in December with annual average of 1986.8 mm, the average possible sunshine hrs. ranges from 13.6hr per day in June to 10.7 hr per day I December and the mean bright sunshine hrs. ranges from 9.9 hrs per day to 3.4 hr per day in July.

3.2 Determination of Physical and chemical properties of soil:

The soil samples were taken from different farmer’s fields and after collection of samples, determination of physical and chemical properties of soil samples like pH, EC,Organic Carbon available, N,P,K, and micronutrient done by department of Soil Science and Agricultural chemistry, College of Agriculture, J. N. K. V. V., Jabalpur.

Soil are mainly clayey to loam in texture with calcareous concretions invariably present. They are sticky and, due to shrinkage, develops deep cracks in summer. They generally predominate in montmorillonite and beidellite type of clays. In rest of alluvial area is mixed clays, blackish brown to reddish brown in colour, derived from sandstone and trap is observed which in sandy clay in nature with calcareous concretions. Light yellow to yellowish brown soil are noticed which were deposited the recent past. These soil were clayey to silt in nature (Gajbhiye et al. 2013)

3.2.1 Bulk Density of the Soil

Soil sample were collected from both villages Bichhua and Sanjari in the field of crop area. Sample were analyzed by mechanical analysis method i.e with the help of core cutter and result obtained are presented in table (4.1) under result and discussion section.

3.2.2 Determination of infiltration characteristics of soil:

The most important and representative property for irrigation is the infiltration characteristics of the soil. Infiltration is the downward entry of water into the soil and is largely controlled by surface conditions of ground. The infiltration rate of the soil was determines with the help of double ring infiltrometer. This consists of pounding of water in an open bottom cylinder and observing the rate at which the level falls in it. Locations were selected in the farmer’s fields of the village. Precautions were taken at the time of selecting a site that it must be free from shrinkage, cracks and vegetal matters.The equipment used for infiltration test were; double cylinder infiltrometer, driving plate, driving hammer, point gauge, stop watch and container of known volume. The water level in the inner cylinder was read with a plastic scale or hook gauge.Water was added to the inner cylinder from a container of known volume and a graduated jar. A stop watch or wrist watch was used to note the instant the addition of water begin and the time water reaches the desired level.

Plate-3.2 Infiltration characteristics of soil

The difference between the quantity of water added and the volume of water in the cylinder at the instant it reached the desired point was taken as the quantity of water that infiltrates during the time interval between the start of filling and first measurement. The plate 3.3 shows the infiltration measurement test.

3.3 Survey of Villages farmers and rural people for present status

The Survey of tribal both villages Bichhua and Sanjariwas done with farmers on the basis of their size of land holding, awareness about new technologies, source of irrigation andtype of crop taken in rabi and kharif season, water availability from all sources and willingness to do according to the new concept and ideas. Farmers were contacted personally (Plate 3.2) to collect the desired information in Performa prepared for survey. A copy is presented in Appendix A

Plate 3.3 Personal contact with farmers collect resources information

Plate -3.4 Google map of Bichhua village

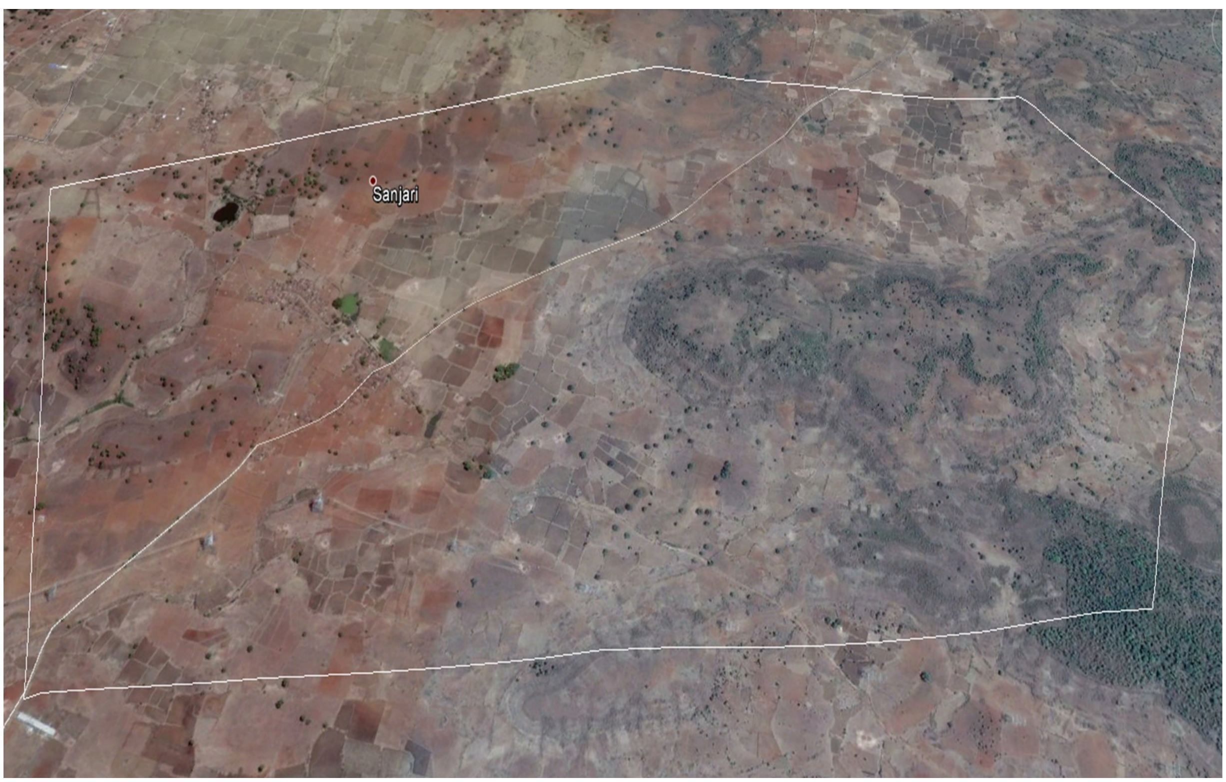


Plate -3.5 Google map of Sanjari Village

3.3.1 Topography data and Existing Crop area data.

These areas comprises of undulating lands in Bichhua village, mostly plain land in sanjari village The land area data below the table (3.1)

	Name of Village	
	Bichhua	Sanjari
Total area of Village (ha)	200	380
Cultivated area (ha)	120	185.13
Kharif Crop Season area (ha)	120	185.13
Rabi Crop season area (ha)	80	65.77

Source- Tehshil office (Revenue inspector) Kundam block Jabalpur.

3.3.2 Door to door survey for seeking information as per questionnaire.

A detailed baseline surveywas undertaken which involved household census survey, Bio-physical survey and Villagelevel data collection. Household census survey includes a detailed questionnaire whichwas been filled by visiting each and every household in the village. To understand thefamily dynamics of watershed community, household survey often play a key role in theprocess of planning. Community based information was assessed through questionnaire., which givesthe family based information. Census survey is adopted to collect the data in this project.

Door to Door baseline survey was carried out through the Neighbour Hood Groups using structured questionnaire. The questionnaire covered the following areas.

- Demographic Information
- Socio Economic Information
- Agriculture its marketing
- Animal Husbandry activities
- Water sources location and Condition.
- Land ownership
- Land use
- Irrigation (water availability)
- Crops and productions

Bio-physical survey was undertaken to identify various natural resources availablein the village. It included the soil typology, well in the area, crop taken in the field,Cropping pattern, fertilizer used and various sources of irrigation in the field.

3.3.3 Reconnaissance survey and transect walk for understanding the area and important features.

Transect walk is a kind of exploratory walk, under taken by me with the villagers to collect information on the soil type, land use pattern, cropping pattern, existing resource etc., In order to identify the areas to be treated, proposed work sites and assess the feasibility, the experts carried out a reconnaissance survey through transect walk. The sites were marked and the different treatment measures required for the treatment of the area were also recommended. During the exploratory walk the present status of the village is observed along with their problems. The water sources is observed and analyzed by the me during the summer and winter. The transect walk also enables inthe understanding of the rabi and kharif crops grown in the village area Livestock populations are also accounted.

3.4Assessment of water demand for domestic, livestock and agriculture and assessment of water availability

Door to door survey through the seeking information as per questionnaire for different sectors water demand given a table 3.2 and Livestock water demand on the available in the village and crop water requirement given in (Appendix-B.) all crop rabi and kharif season in available in the villages

Table-3.2 Average domestic water requirement for human beings

Average Domestic Water Requirement	
Use	Consumption in litre/day/person
Drinking	5
Cooking	5
Bathing	45
Washing of clothes	20
Washing of utensils	15
TOTAL	90

(Sources- Text book of Hydrology and water resources Engineering by Garg SK.)

3.4.1 Measurement of discharge

The discharge of hand pumps, centrifugal pumps and tube wells were measured by volumetric method. Volume of container 8.5 liters was used for the discharge measurement of hand pumps and a container of 15 liters was used for the discharge measurement of centrifugal pumps and tubewell. Time required to fill the container is noted and discharge can be calculated by using the formula :

Dischare (liters/sec)= Volume of container (liters)/Time required to fill the container (sec)

S.No.	Name of Village	Type of Source	Hp	Bucket Capacity (Litre)	Time Taken fiil the Bucke(Sec.)	Discharge (lps)
1						
2						
3						
4						
5						

Plate- 3.6 Measurement of discharge in available water sources in the villages.

3.5 Identify demand supply gap

On the basis of Demand and Supply of water from both the villages for different classified sectors (i.e domestic, livestock and agriculture) the Deficit was assessed and planning was done to overcome shortage of water resources. The demand- supply gap for both the villages as shown in table 4.16.

3.6 Planning optimal land and water utilization

3.6.1 Preparation various maps of villages.

The base map of the area was prepared using the toposheet 64 A/4, 64A/8 , of the Survey of India (SOI) on a scale of 1: 50000. The toposheet was imported on GIS platform using Arc GIS 9.2 Software.

3.6.1 Georeferencing the scanned toposheet-

For georeferencing of the raster image data, at least four control points of the location should be identified. The control points selected to be broadly at the four corners of the map. The control points chosen for the project are listed below:-

Control points	Longitude	Latitude
1	80.12	23.21
2	80.15	23.21
3	80.15	23.19
4	80.12	23.19

By using Geo-referencing tool in the main menu, and four control points at the four corners pf the map by using Arc GIS 9.2 Software. The procedure is as follows:

1. Zoom the known location, to the required extent.
2. Click on “Add control points” icon in Georeferencing tool

3. Click at the centre of the location and then immediately Right Click at the location,

Select the option input X and Y for that location.

4. Click OK

5. Click on full extent Icon to view full map.

Similarly follow the same procedure for other three control points. Finally a Georeferencing map is displayed on map window for digitization.

Click on “view link table” icon in georeferencing tool, to see the residuals of the map Registration, if you are satisfied with RMS error, save the link in text format.

6. Click on Save

7. Browse to E:\M.Tech. Thesis

8. Type file name as m.tech.thesis

9. Click Save.

3.6.2 Generation of digital elevation model

Procurement of Digital elevation model (DEM) was done from:URL: http://bhuvan.nrsc.gov.in The DEM information was utilized for both the tribal villages for preparing Contour map, slope map and other useful map.

3.6.3 Contour map

Contour map was prepared using Arc GIS 9.2 software and shownin Figure 4.1 Contour map is a useful surface representation asthey enable to simultaneously visualize flat and steep areas, ridges,valleys in the study area.

3.6.4Slope map

Slope is an important factor for understanding the nature of the terrain. The slope for different slope percentages derived from slope map. The slope map was generated using digital elevation model (DEM). Study area has been classified. The slope categories were designated as per Land Use Capability Classification on the basis of slope categories.

Table-3.3 Land Capability Classification of Village area

s.no.	Name of classes	Slope%	Land capability classes
1	Nearly Level	0-1	I
2	Gently Sloping	1-3.	II
3	Moderately Sloping	3-5.	III
4	Strongly Sloping	5-8.	IV
5	Moderately steep	8-12.	V
6	Steep	12-18.	VI
7	Very steep	18-25.	VII
8	Very very steep	>25	VIII

Plate-3.7 Village location and Boundary demarcation help by GPS

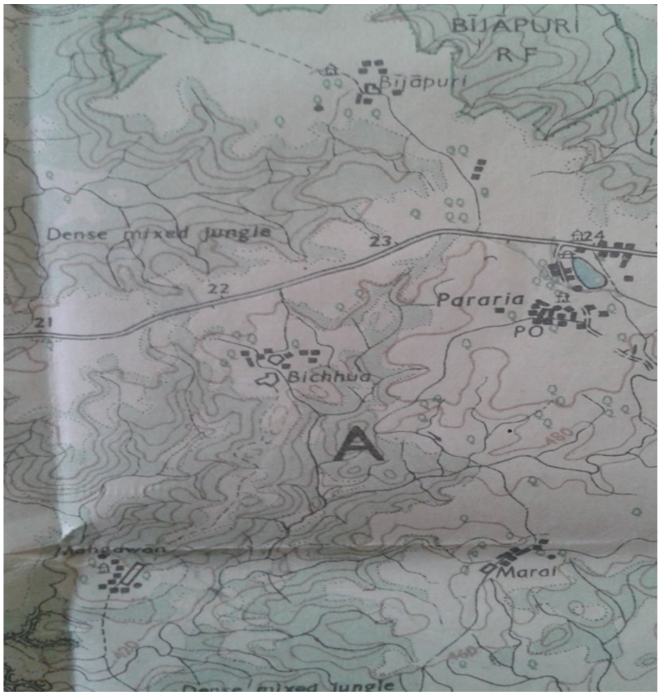


Plate-3.8Toposheet in Bichhua Village

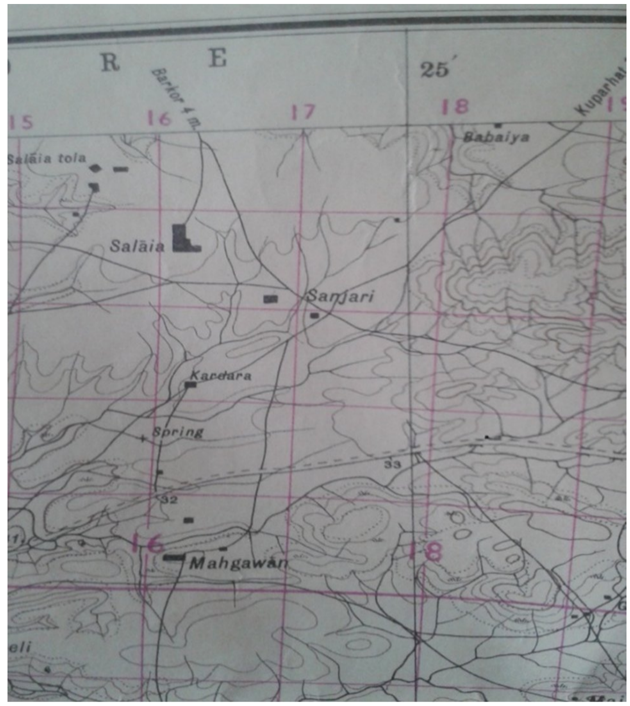


Plate-3.9 Toposheet in Sanjari Village

3.7 Propose Water Conservation Sources

Based on Topographical condition, the following water sources were proposed to overcome the deficit water condition for irrigation and other purposes.

1. Earthen dam
2. Farm pond
3. Open well
4. Tube well

3.8 Optimal planning for land and water utilization

A linear programming was performed to evaluate the optimal water requirement using the existing resource and considering proposed water sources and optimal planning was done to efficiently utilized the increase availability of water and cultivable land.

3.8.1 Water adequacy plan

Water is a limiting factor for higher productivity for all the crops. Its judious use must be ensured. The situation needs more attention when runoff water is required to be harvested as it is in the proposed study water adequacy plan was prepared keeping in mind the same objective for both villages transect through the area is rainfed and cropping intensity is very low, less some crop like Wheat and Gram have the potential to grow well if irrigation is provided, therefore these two crops are taken for preparation of water adequacy plan.

3.8.2 Optimization of Profit and optimal land water utilization

3.8.2.1 Linear Programming

Linear programming deals with the optimization (Maximization or Minimization) of a function of variables known as objective function subjected to a set of linear equalities and I or in equalities known as constraints.

Linear programming use linear algebraic relationship to represent a firm's decision given a business objective and resource constraints. The objective function may be profit, cost, production capacity or any other measure of effectiveness, which is to be obtained in the best possible or optimal manner. The constraints may be imposed by different sources such as market demand, production process and equipment, storage capacity, raw material availability etc. By linear is meant a mathematical expression in which the variables do not have powers.(Hadley G.,1962).

3.8.2.2. Linear programming using by Graphical method

If Z is a function of two variables then the problem can be solved graphically. In this method use in both condition existing and after propose resources.

(1)Objective Function – To maximize the net profit

$$Z_{max} = C_1X_1 + C_2X_2$$

Where,

C_1= is represent Net profit per unit ha for Wheat crop (Rs/ha)

C_2= is represent Net profit per unit ha for Gram crop (Rs/ha)

X_1 = Crop area for wheat crop (ha)

X_2= Crop area for Gram crop (ha)

(2) Resource Constraints

(i). According to Water requirement of crop, crop area and water availability

$$= W_1X_1 + W_2X_2 \leq S$$

Where,

W_1 = Water requirement for wheat crop (cm)

W_2= Water requirement for Gram crop (cm)

S = Total Water Availability in the village (ha- cm)

(ii) According to crop (land) area

$$= X_1 + X_2 \leq A$$

X_1 = Crop area for wheat crop (ha)

X_2= Crop area for Gram crop (ha)

A = is represent for existing crop area for rabi season (ha)

(3) Non- negativity constraint

$$= X_1, X_2 \geq 0$$

3.8.2.3 Water requirement of crop

The water requirement, the depth of water application of irrigation required for good crop growth is given table -3.4

Table-3.4 Water requirement of rabi crops

S.NO.	Name of crop	Total water required (cm)
1	Wheat	45
2	Gram	15

3.8.2.4 Cost of cultivation:

The cost of cultivation of proposed crop in presented in table 3.5

Table- 3.5 Cost of Cultivation and Return (Existing)

S.No.	Name of crop	Name of Varieties	Yield (q/ha)	Cost of Cultivation					Selling Price (Rs/q.)	Profit (Rs/ha)	Net profit Rs/ha
				Seed rate (kg/ha)	Fertilier	Ploughing sowing etc.	Labour	Total cost (Rs/ha)			
1	Wheat	LOK-1, WH-147, Deshi	10	100 Kg@25 Rs	2000	4000	3000	11500	1500	15000	3500
2	Gram	JG-62, Deshi,	5	70 kg@50 Rs	1500	2500	3000	10500	4500	22500	12000

4.0 RESULTS AND DISCUSSIONS

This chapter deals with results obtained from the survey of villages Bichhua and Sanjari for understanding and estimating the water demand- supply, the gap and quantification of water resources.Thischapter includes tables, graphs, figures, maps etc to illustrate the results of the research done on the study area.

4.1 Soil sample analysis

Soil sample of farmers field were analyzed at the department of Soil science and Agricultural Chemistry for determination of chemical properties of soil i.e. N: P: K and micronutrient present in the soil. These are as follows (Table 4.1):-

Table- 4.1 Soil sample analysis

S. No.	pH	EC	OC	Av. N	Av. P	Av. K	Av. S	Zn	Fe	Mn	Cu
		(ds/m)	(g/kg)	(kg/ha)					(mg/kg)		
1	6.98	0.15	5.2	202	25.9	340	-	-	-	-	-
2	7.18	0.09	4.4	189	42.0	291	13.9	0.63	5.3	3.98	2.88
3	7.07	0.16	6.5	243	31.8	345	-	-	-	-	-
4	7.04	0.10	5.3	204	30.1	265	-	-	-	-	-

4.1.1 Bulk density of the soil

Soil samples were collected from the both villages field of different land cover and land use of the problematic area the bulk density was determined by taking undistorted soil sample of known volume with help of core cutter from a depth of o to 15 cm. the values of bulk density obtained from different location are presented in table 4.2.

Table 4.2 Bulk density of soil of the different locations of the study area

S.No.	Location	Name of village	Bulk density g/cc
1	Gyan singh -Field	Bichhua	1.46
2	Gulab singh- Field	Sanjari	1.51

The bulk density in the both villages field was found in crop area as Bichhua village is 1.46 g/cc and Sanjari village is 1.56 g/cc.

4.1.2 Infiltration characteristics of the soil

Double ring infiltrometer was used formeasurement of infiltration rates at all the sites. Inthis two concentric rings were used with 25 cm deep and diameter of 30cm for inner ring and 60cm forouter ring. The rings were driven at about 15cm deepin soil by using falling weight type hammer strikingon a wooden plank placed on top of ring uniformlywithout or undue disturbance to soil surface.Water was poured into the rings to maintain depth of7 to 12 cm and the quantity of water was added tomaintain this depth at regular time interval of 5, 10,20, 30 min. up to getting a constant infiltration rate.The observations for infiltration rate were carried outon inner ring with field type point gauge and stopwatch etc.

Cumulative infiltration and time has been correlated for the soil at 4 locations and are as follows:

Where,

I_C = Cumulative infiltration depth in cm and

t = Elapsed time in min.Relation between cumulative infiltration and elapsed time for the soil at study location has been shown in the Fig.4.1, 4.2, 4.3,and 4.4.

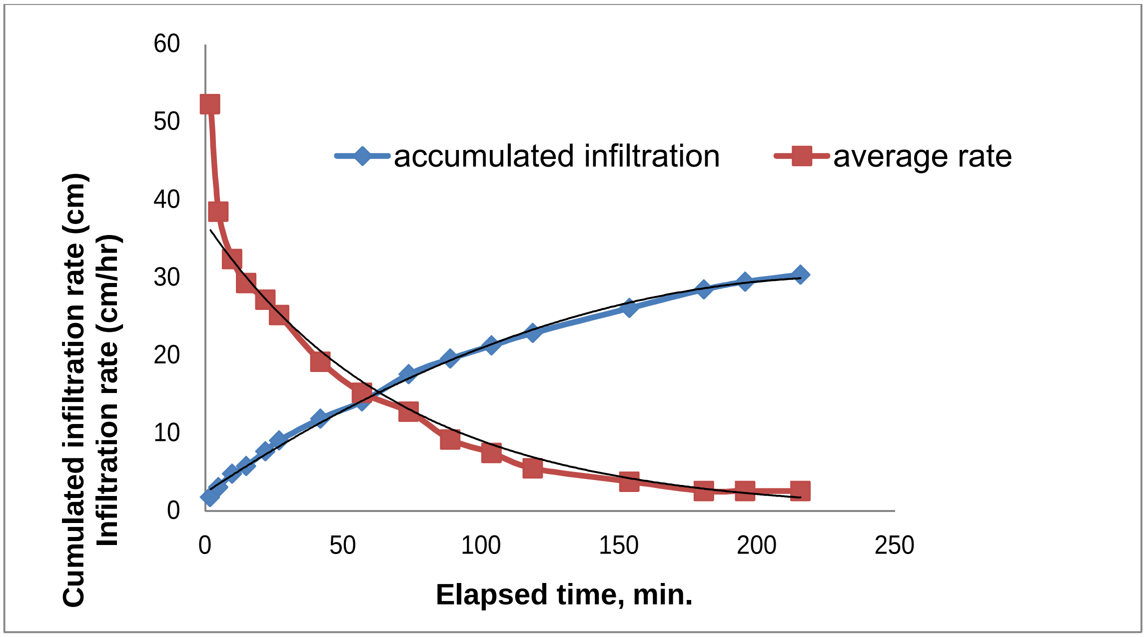


Fig .4.1 Infiltration Characteristic Curve at Village Bichhua –Field 1

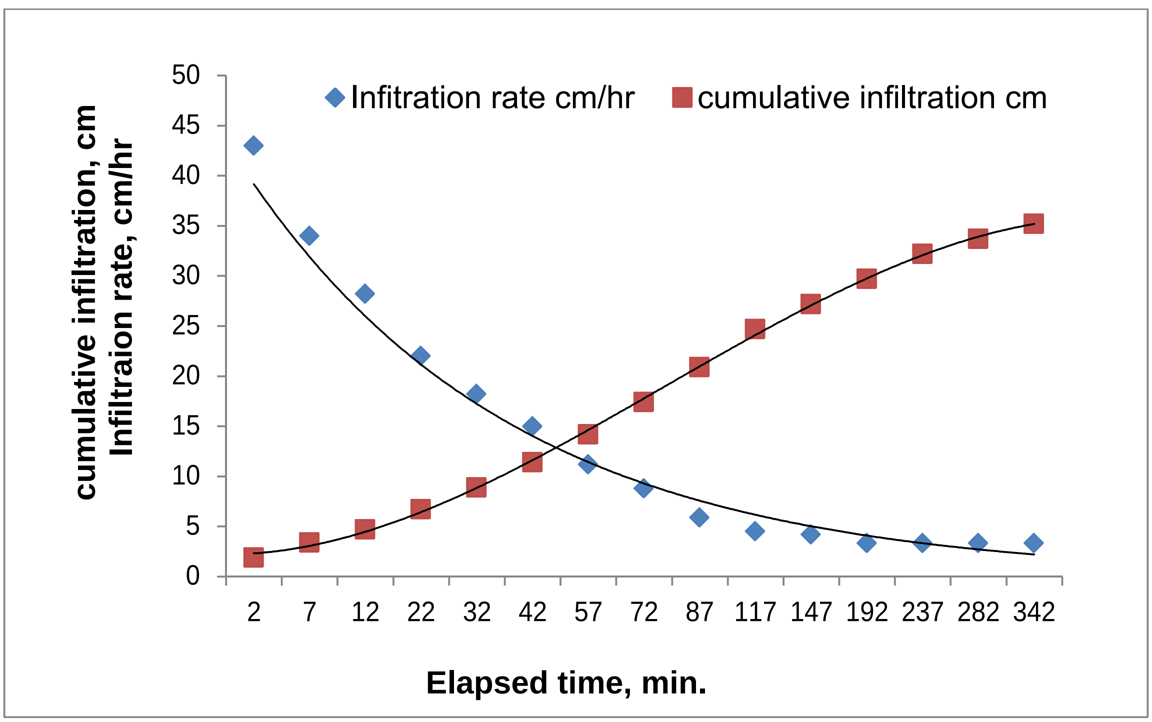


Fig. 4.2 Infiltration Characteristic Curve at Village Bichhua –Field 2

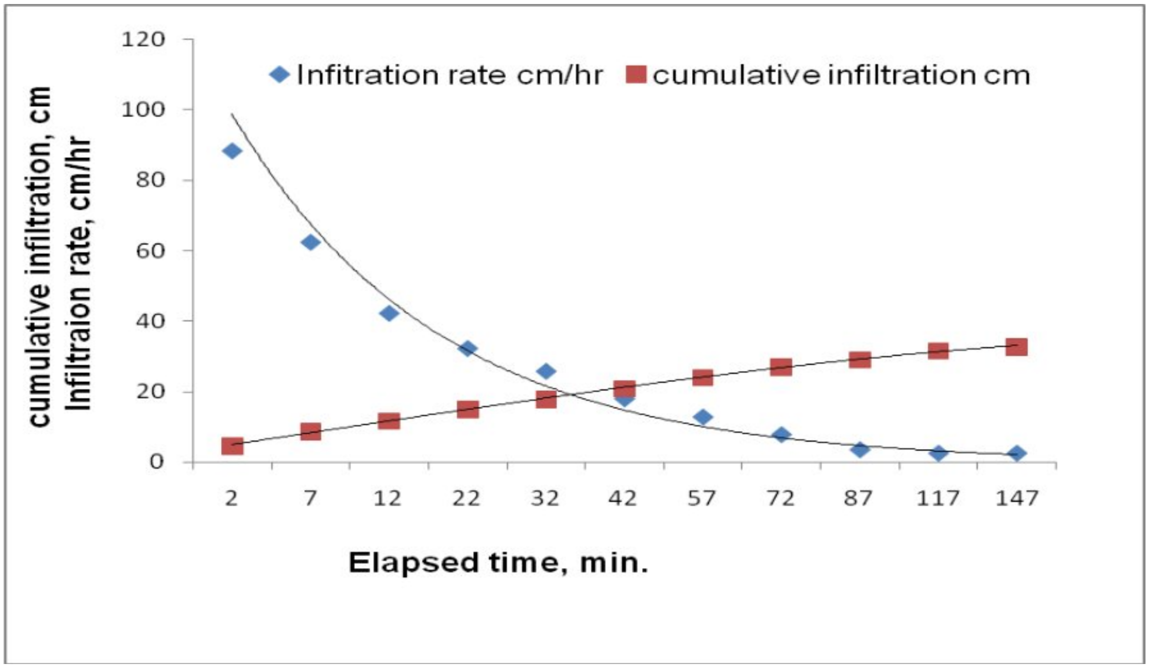


Fig. 4.3 Infiltration Characteristic Curve at Village Sanjari –Field 1

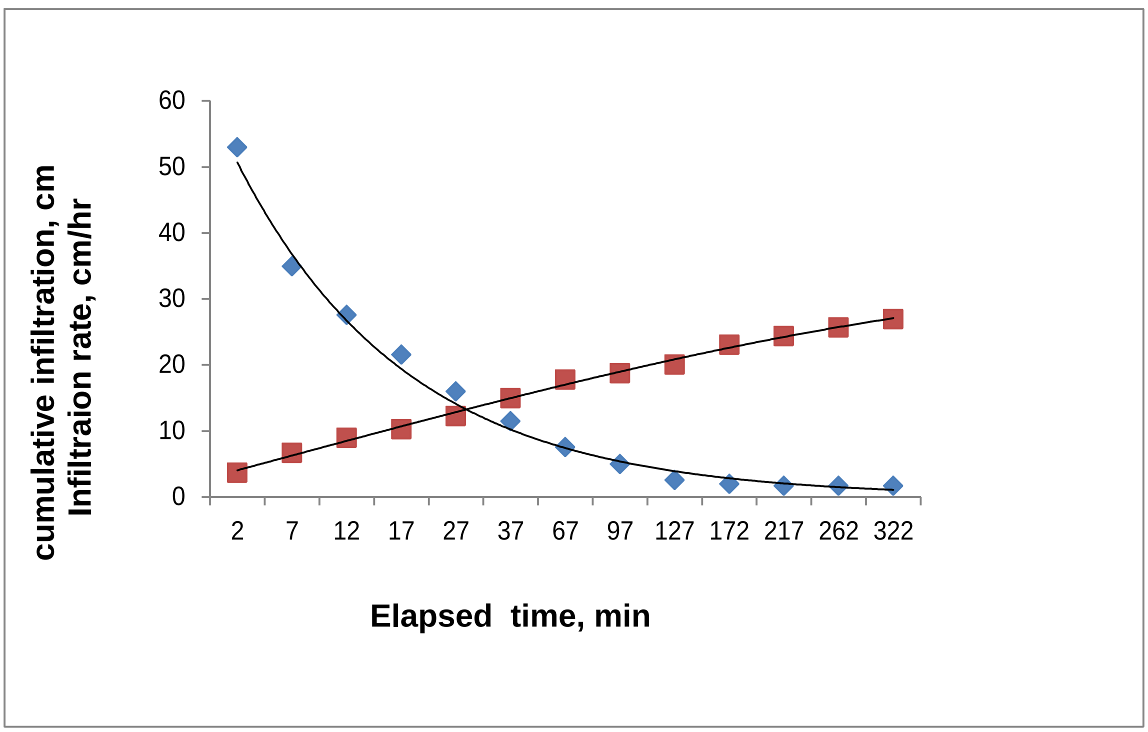


Fig. 4.4 Infiltration Characteristic Curve at Village Sanjari –Field 2

4.2 Requirement of water at village level

On the analysis of data obtained through the questionnaire illustrated in previous chapter, following informations were gathered for villages Bichhua and Sanjari.

4.2.1 Domestic water requirement

In Bichhua, village the total population is of 432 people including 187 children. As per specification given in fig. 4.5. The water demand on daily basis was computedanalysis as29530 Lit./day and presented in table 4.5.

Table 4.3 Estimation of Domestic water requirement.for Bichhua village

S.N.	Name of village- Bichhua			Water Demand
	Particulars	No.of Population	Water Requirement (Litre/Day/person)	
1	Male	140		12600
2	Female	105	90	9450
3	Children	187	40	7480
	Total	432	litre/Day	29530

Similarly for Sanjari village thetotal population is of 500 people including 150 .children.As per specification given in fig. 4.5. The water demand on daily basis was computed analysis as 37500 Lit./day and presented in table 4.4

Table 4.4 Estimation of Domestic water requirement for Sanjari village

S.N.	Name of village- Sanjari			Water Demand
	Particulars	No.of Population	Water Requirement (Litre/Day/person)	
1	Male	190		17100
2	Female	160	90	14400
3	Children	150	40	6000
	Total	500	litre/Day	37500

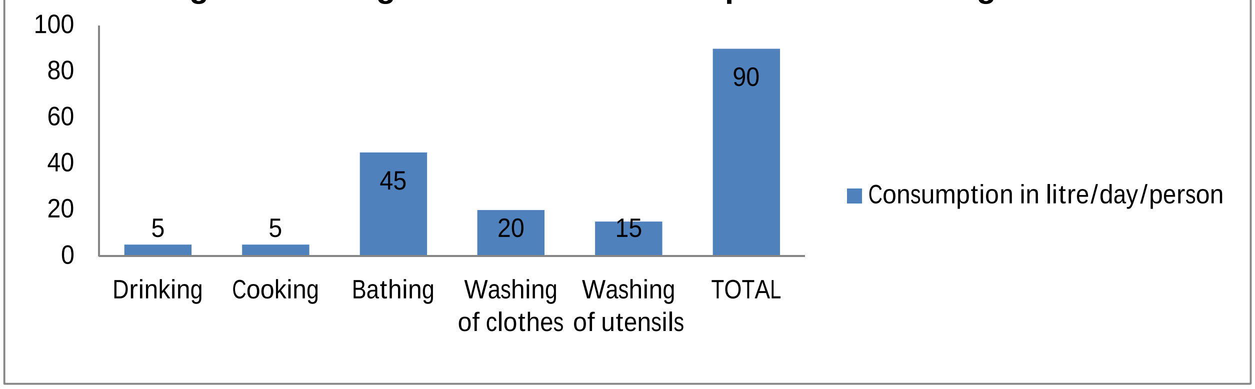


Fig- 4.5 Average Domestic Water Requirement in village level

4.2.2 Water demand of livestock/animals

The survey of study village Bichhua,revealed that there were 150 cows, 20 buffaloes, 100 goat, 1000 hen, 30 ox and dog 4 reared in village bichhua. Their total water requirement was estimated as 12681.lit./day.The details of water requirement towards livestock/animal are given in table 4.5

Table-4.5. Estimation of Water Requirement for Livestock- Bichhua village

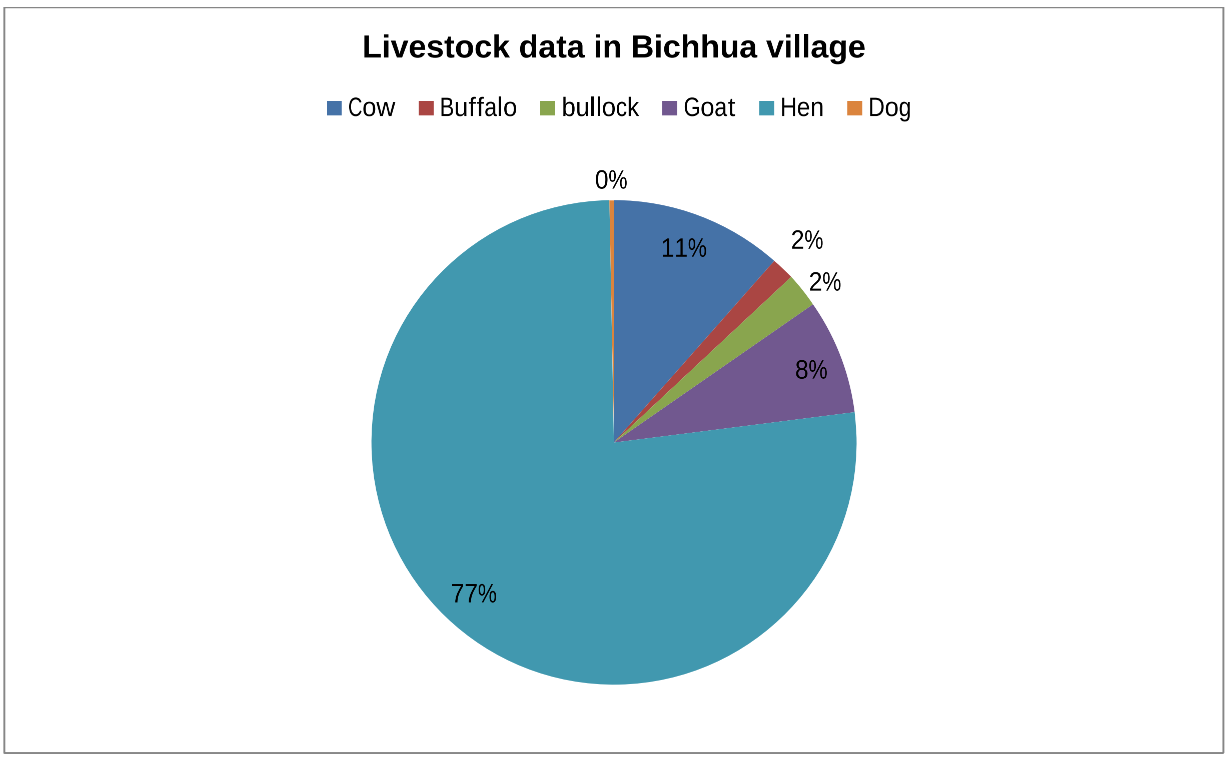
S.No	Particulars		Birds and Animals No. of population	Water Requirement Litre/Day	Water Demand
1	Cow	Dry	65	41	2665
		Milch	85	60	5100
2	Buffalo	Dry	13	80	1040
		Milch	7	90	630
3	Ox		30	50	1500
4	Goat		100	15	1500
5	Hen		1000	0.23	230
6	Dog		4	4	16
		Total	Litre/Day		12681

Similarly survey of village Sanjari, provided information that there were 110 cows, 13 buffaloes, 75 goat, 350 hen, 22 ox, 7 dog and pig 15 reared.Their water demand was estimated as 8817.5.lit./day.The details of water requirement towards livestock/animal are given in table (4.6)

Table-4.6Estimation of Water Requirement for Livestock- Sanjari village

S.No	Particulars		Birds and Animals No. of population	Water Requirement Litre/Day	Water Demand
1	Cow	Dry	69	41	2829
		Milch	41	60	2460
2	Buffalo	Dry	5	80	400
		Milch	8	90	720
3	Ox		22	50	1100
4	Goat		75	15	1125
5	Hen		350	0.23	80.5
6	Dog		7	4	28
7	Pig		15	5	75
		Total	Litre/Day		8817.5

In total the domestic and Livestock/animals water demand for Bichhua village was42211.litres per day while it was46317.5 litres per day in Sanjari village.



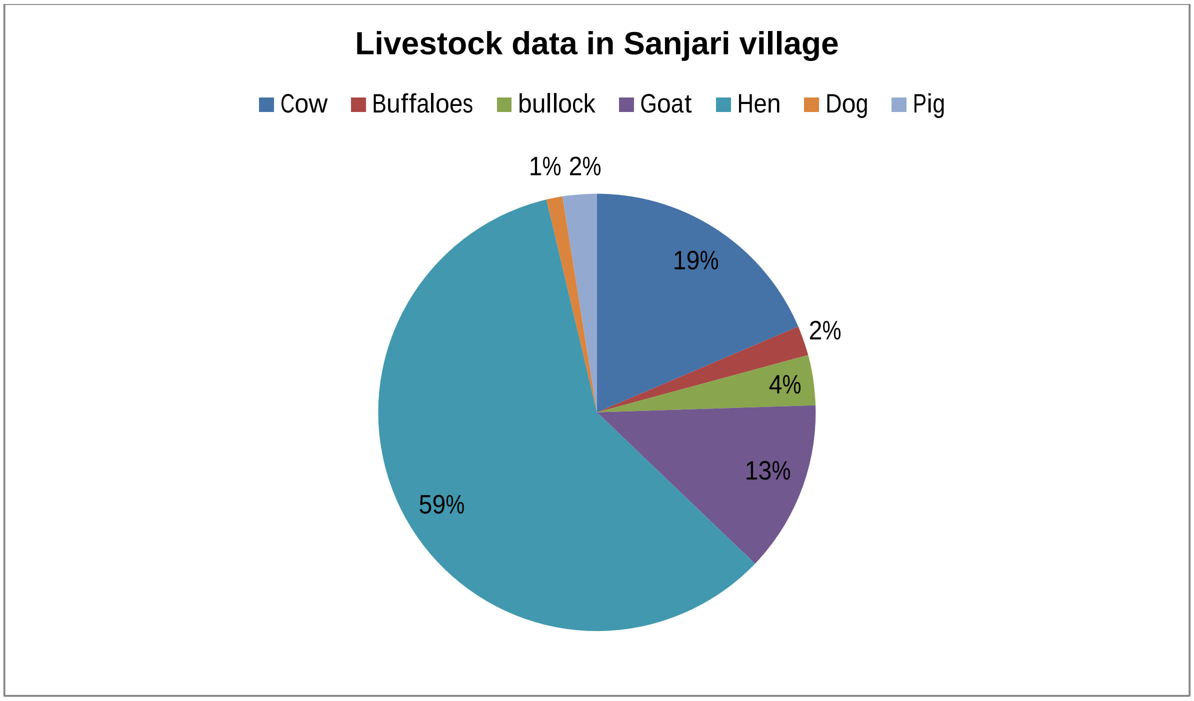


Fig- 4.6 Livestock data both villages

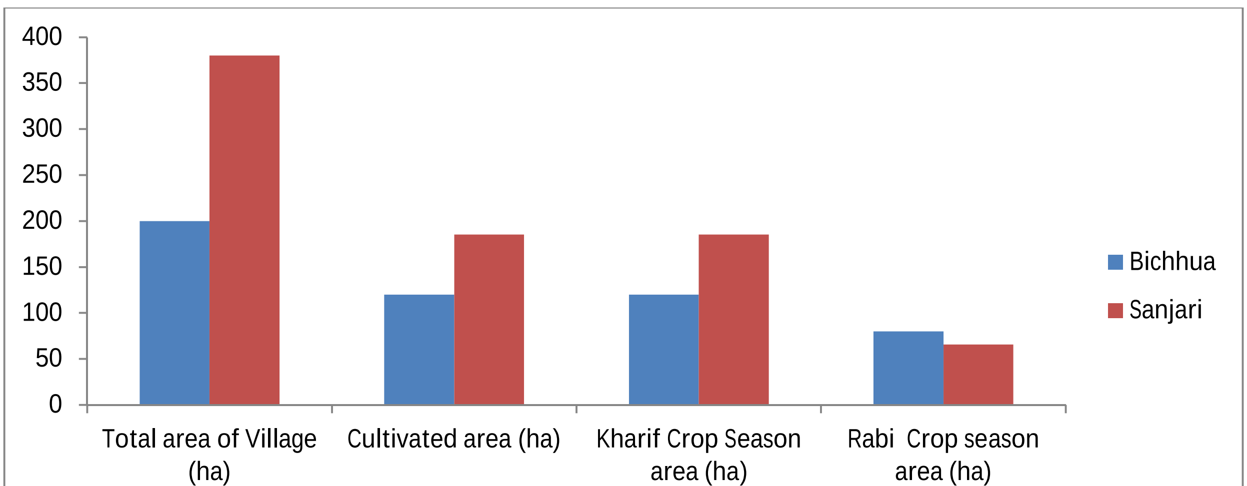


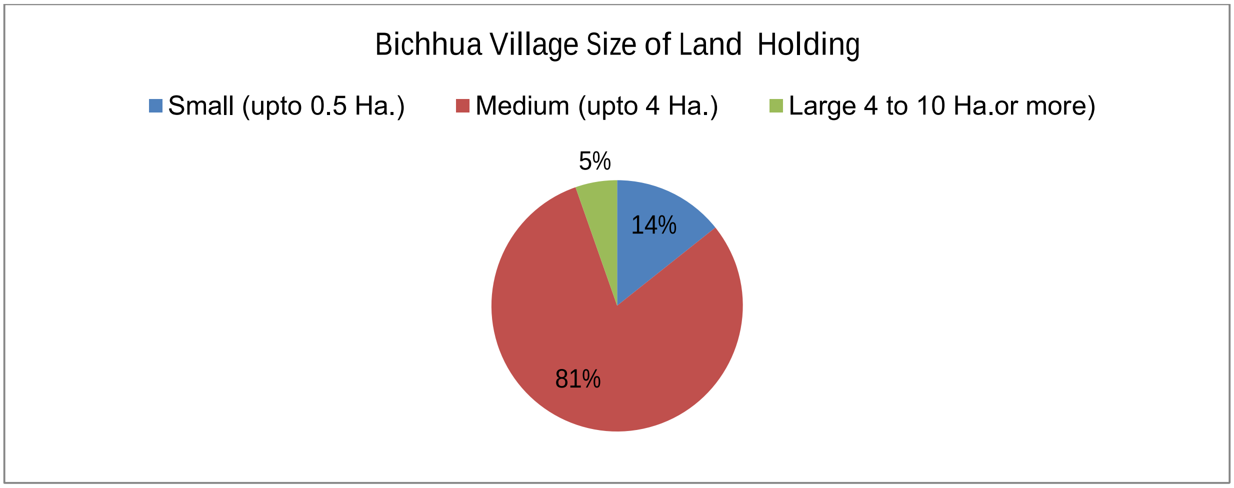
Fig- 4.7 Study total and crop area information both villages

4.2.3 Farmers survey and Size of Land Holding

Farmerssurvey was done forboth tribal villages Bichhua and Sanjari considering the size of land holding categorized small, medium and large land holding as shown below in table 4.7 and fig. 4.8.

Table- 4.7 Farmer categories on basis of size of land holding

S.No.	Size of Land Holding	No. of Farmes in the Villages	
		Bichhua	Sanjari
1	Small (upto 0.5 Ha.)	8	17
2	Medium (upto 4 Ha.)	45	80
3	Large 4 to 10 Ha.or more)	3	13
4	Landless Family	30	15
	Total	86	125



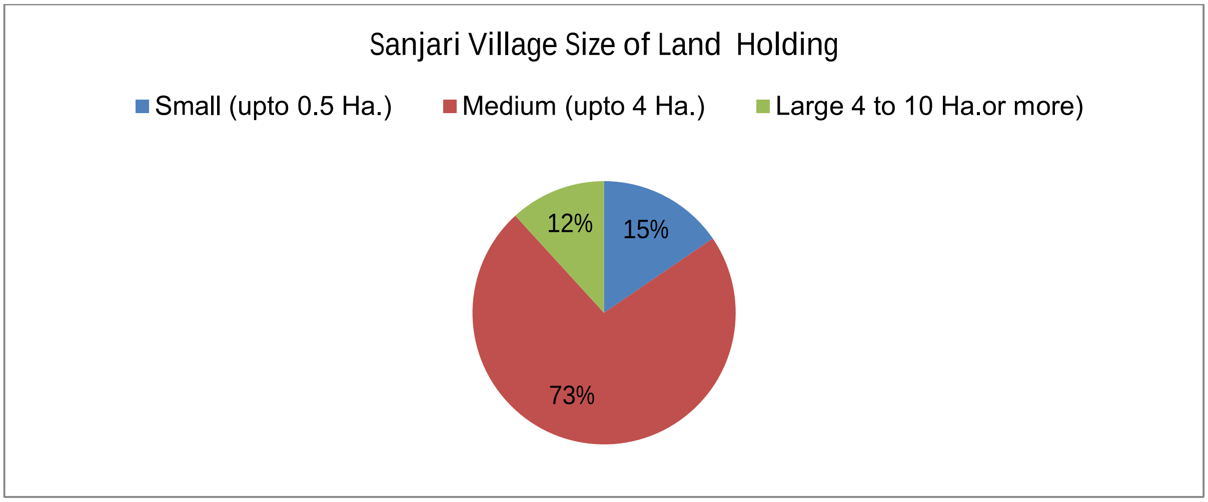


Fig.- 4.8 Farmer categories on basis of size of land holding

4.2.4Calculation of Water demand considering existing crop requirement

The total area of Bichhua village is 200 ha. and suitable for cultivated area is 120 ha. As per the survey year i.e. 2015-16, the kharif crops were cultivated in about 120.ha., (Fig 4.7) out of which paddy crop was taken in 75 ha and the rest of cultivated area used for of other crops like maize, pegean pea, black gram etc. Approximately 80 ha. area was brought under cultivation in rabi 2015-16. Wheat and gram were the major crops grown in Bichhua village.

Considering the water requirement of paddy, maize, black gram, til, juwar Bajra pigeon pea, wheat, gram, as 125, 45, 30, 30, 45, 30, 30, 45, and 15, cm. respectively. The water requirement of agricultural crops of village Bichhua was estimated and presented in table 4.8

Table- 4.8 Estimation of requirement of water for agricultural crops

(Bichhua village)

S.N.	Type of Season	Type of Crop	Cropped area (ha)	Depth of water for irrigation(cm)	Total water demand (ha cm)
1	Kharif season	Paddy	75	125	9375
		Maize	5	45	225
		Black gram	6	30	180
		Til	6	30	180
		Juwar	10	45	450
		Bajra	5	30	150
		Pigeon pea	13	30	390
					(kharif crop) 10950 ha cm
2	Rabi Season	Wheat	45	45	2025
		Gram	35	15	525
				Total	2550 ha cm

Similarly the total area of Sanjari village is 380 ha. and suitable land area for cultivation is 185.13 ha. As per the survey year i.e. 2015-16, the kharif crops were cultivated 185.13.ha. (fig 4.7) out of which paddy was taken in 99.98 ha. and other crop like maize, pegean pea, black gram, etc.grown in remaining area. Approximately 65.77 ha. area was brought under cultivation in rabi 2015-16. Wheat and gram were the major crops taken in Sanjari village.

Considering the water requirement of paddy, maize, black gram, til, juwar bajra, pigeon pea, wheat, gram. The water requirement of agricultural crops of village Sanjari wereestimated and presented in table 4.9.

Table- 4.9Estimation of requirement of water for agricultural crops *(Sanjari village)*

S.N.	Type of Season	Type of Crop	Cropped area (ha)	Depth of water for irrigation (cm)	Total water demand (ha cm)
1	**Kharif**	Paddy	99.98	125	12497.5
		Maize	25	45	1125
		Black gram	12.45	30	373.5
		Til	15.2	30	456
		Juwar	12	45	540
		Pigeon pea	20.5	30	615
				Total	**15607.00 ha cm**
2	**Rabi**	Wheat	22	45	990
		Gram	43.77	15	655.55
				Total	**1646.55 ha cm**

4.3 Availability of water at village level supply

4.3.1 For domestic and livestock purpose

There were 4 hand pumps available in village Bichhua. The measured discharges of two sample handpump area presented in table 4.10. The table also shows the estimated quantity of water available from these pumps. Generally, the peak demand of water for domestic purposes is in morning and evening hence, the measurement of water was taken in the morning. The average

Table –4.10 Available of water from Hand Pumps- *Bichhua Village*

							Wa
Date	**Time**	**Sample No.**	**Time Required to fill the container (Sec.)**	**Container Capacity (Liter)**	**Discharge (lps)**	**Avg. Discharge (lps)**	.
4 Jan 16	8.30 am	B1	26	8.5	0.326		
		B2	24	8.5	0.354		
		B3	27	8.5	0.314		
		B4	22	8.5	0.386		
21 March 16	10.00 am	B1	26	8.5	0.326		
		B2	25	8.5	0.34		
		B3	28	8.5	0.303		
		B4	22	8.5	0.386	0.3423	345
					TOTAL (Liter/Day)		**345**

discharge of hand pump was estimated at 0.34 lps which on working of all 4 hand pumps p 34503.84 litres of water in seven hours.

The demand of water for domestic and livestock purpose has been worked out for Bichhua village as 42211 litres/day which cannot be easily satisfied from the hand pumps available in the village. Because some family are use for domestic and animal purposes water through tube well. In Bichhua village 3 tube well are available about 10 to 15 minutes are daily working and average discharge rate is 3.73 lps. Every day water supply in tubewell is about 8065 litres/day than water need for domestic and animals purposes which can be easily satisfied from the hand pumps and tubewell available in the village.

Similar there were 5 hand pumps available in the Sanjari village. The average discharge of the sample hand pumps are presented in Table 4.11. Total water available from all 5 hand pumps for seven hours were 46355.4 litres. It has been calculated that the water demand, towards domestic purpose and for animals, was 46317 litres per day. This demand can be easily met by hand pumps operation of seven hours.

Table - 4.11 Available of water from Hand Pump- *Sanjari Village*

							W 5
Date	**Time**	**Sampl e No.**	**Time Required to fill the container(Sec.)**	**Container Capacity (Liter)**	**Discharge (lps)**	**Av.- Discharge (lps)**	**7**
4 Jan16	10.30 am	S1	21	8.5	0.404		
		S2	24	8.5	0.354		
		S3	25	8.5	0.34		
		S4	22	8.5	0.386		
		S5	22	8.5	0.38		
21 March 16	8.00 am	S1	22	8.5	0.386		
		S2	25	8.5	0.34		
		S3	26	8.5	0.326		
		S4	21	8.5	0.404		
		S5	24	8.5	0.35	0.3679	4
					TOTAL (Liter/Day)		**4**

4.3.2 For irrigation purpose:

There were 3 tubewell, 4 open well, and one pond available in the village Bichuua. In all wells and tube wells five horse power pumps were installed. The discharge came to be tube well 3.8 lps , open wells 7.5 lps and pond 11.2 lps. As per schedule of electricity supply in the state Madhya Pradesh, the electricity availability hours for irrigation (3 phase) in only six hours. The details of total estimation is presented in Table 4.12.

Table- 4.12 Estimation of water availability from well ,pond and tubewell- *Bichhua Village*

Type of source	HP	Discharge(lps)	Time (hrs.)	Water Available in (ha cm)
Tubewell	5	3.8	6	0.8208
openwell	5	7.56	6	1.63296
pond	5	11.2	6	2.4192

Table- 4.13Total Available of water for irrigation purpose- *Bichhua Village*

Name of village	**Type of Source**	**Numbers**	**Water available per day (ha cm)**	Water Availability Per Year **Rabi crop100 days** (ha cm)
Bichhua	Tubewell	3	0.8208	246.24
	Openwell	4	1.63296	653.184
	Pond	1	2.4192	241.92
Total				1142 ha cm

In Sanjari village there were 5 open wells, 2 tube wells and one pond available. In all sources a 5 hp motor pumps was installed. The details of total estimation are presented in Table 4.14.

Table-4.14 Estimation of water availability from well,pond and tubewell – *Sanjari Village*

Type of source	HP	Discharge (lps)	Time (hrs.)	Water Available in (ha cm)
Tubewell	5	4.033	6	0.871128
openwell	5	7.2	6	1.5552
pond	5	11.6	6	2.5056

Table- 4.15 Total Available of water for irrigation purpose -*Sanjari Village*

Name of village	Type of Source	Numbers	Water available per day (Ha. cm)	Water Availability Per Year **Rabi crop100 days** (ha cm)
	Tubewell	2	0.871128	174.2256
	Openwell	5	1.5552	777.6
Sanjari	Pond	1	2.5056	250.56
Total				1203 ha cm

In other words, for a period of 100 days of irrigation, water available through wells, tube wells and pond in village Bichhua is 1142 ha cm and Sanjari village is 1203 ha cm. The details of the estimation is presented in table 4.13 and 4.15.

4.4 Gap between demand and supply of water:

In previous paragraphs the demand of water for domestic and animal use was calculated on daily basis while crop water requirement was calculated on crop season basis. The demand- supply gap of for water, if any, is presented in Table 4.16. It is clear from the table there was no shortage of water for domestic and animal use either of villages.however, for irrigation purpose, a gap of 1808.4

ha cm was noticed for village Bichhua (about Rabi crop area 80 ha) and Sanjari village a gap of 978.4 ha cm (about 65.77 ha). But this gap seem to be apperent because the rainfall in kharif season can easily compensate demand.

The analysis done in table no. 4.3. 4.4, 4.5, and 4.6, revealed that, in present cropping pattern, the villages do feels shortage of water that causes equally important point is that, these villages were not utilizing their all field in all two seasons. Out of total cultivated area of 120 ha of Bichhua village, the area under Kharif was 120 ha, area under Rabi was 80 ha and in summer no cultivation was practiced.

Table-4.16 Summary of demand, Supply and Gap for Water for both villages

Name of Village	Demand		Supply		Gap Irrigation (ha cm)
	Domestic and Livestock (Litre/Day)	Irrigation (ha cm) Rabi crop	Hand pump and tubewell (Litre/Day)	Irrigation(well , tubewell, pond) ha cm	
Bichhua	42211	2550	42569.28	1142	-1408.65
Note: Not used Rabi crop season in 40 ha Area.					For 80 ha

Similarly in Sanjari village out of total cultivated area 256 ha Kharif cropped area was 185.13 ha and area under Rabi was 65.77 ha and in summer season area was not cultivated.

Name of Village	Demand		Supply		Gap Irrigation(ha cm)
	Domestic and Livestock(Litre/Day)	Irrigation (ha cm) Rabi crop	Hand pump (Litre/Day)	Irrigation(well, tubewell,pond) ha cm	
Sanjari	46317.5	1646.55	46355.4	1203	-443
Note:Not used Rabi crop season in 119.4 ha Area.					For 65.77 ha

An analysis of demand of water supply gap additional to meet out the gap, be done.

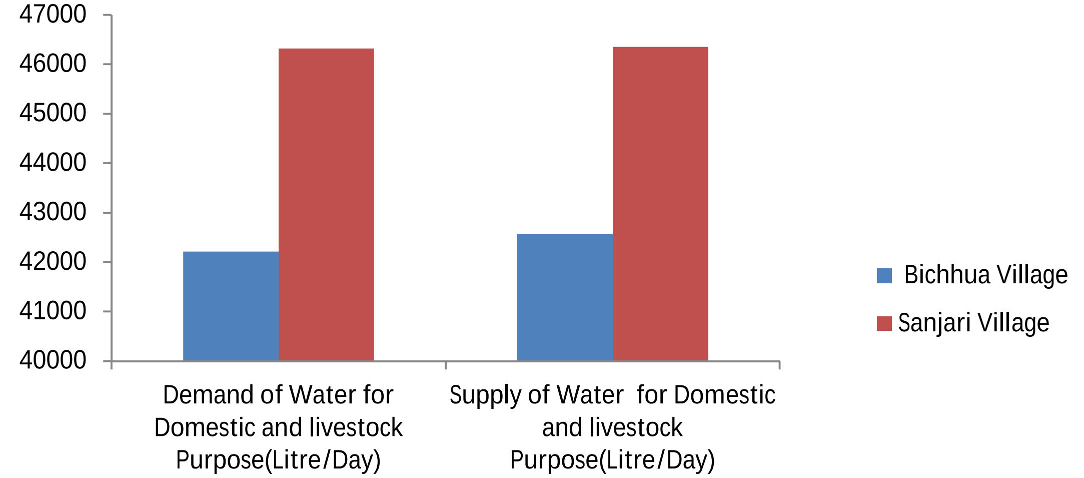


Fig. 4.9 Demand and supply of water for domestic and livestock

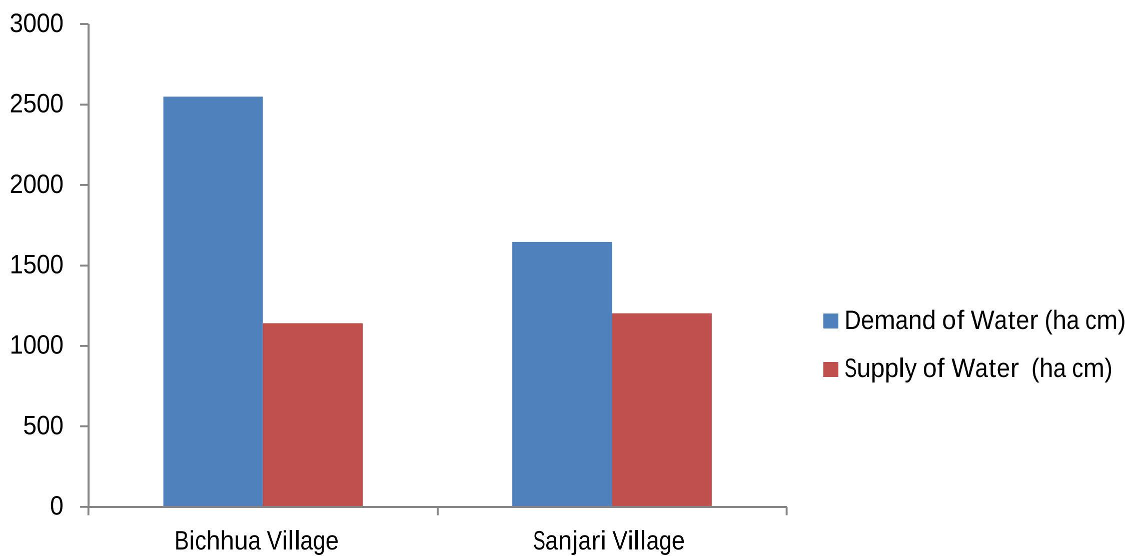


Fig.- 4.10 Demand and Supply of water for irrigation purpose in existing resources

4.5 Water management planning for water adequacy of the area based on water deficit analysis.

For both the tribal villages water demand in agriculture for irrigation purpose was found in deficit condition because water sources were very poor and lesswater available that causes very low rabi crop productivity for both villages

The total requirement of water towards irrigation in kharif and rabi crops is 13500 ha cm but kharif season water demand is 10950 ha cm is fulfilling by the rainfall is about 120 ha For the rabi crop season the water demand was found 2550 ha cm for 80 ha cultivated land however it was not enough fulfill the rabi crop cultivable area. Due to less water availability, the 40 ha land is not for use in rabi crop season in bichhua village.

Similarly sanjari village total requirement of water toward irrigation in Kharif and rabi crop was 17253 ha cm estimated the kharif water demand was 15607 ha cm which used to fulfill by the rainfall 185.13 ha land used for cultivation purpose rabi crop season the water demand was estimated 1646.55 ha cm which can 65.77 ha land but it was not fulfill the rabi crop area with available water sources. Village condition less irrigation facilities causes is about 119.36 ha area is not for use in rabi crop season in sanjari village.

4.5.1 Planning of deficit water and optimal land utilization

4.5.1.1 Preparation various mapsof villages.

The base map of the area was prepared using the toposheet 64 A/4, 64A/8 of the Survey of India (SOI) on a scale of 1: 50000. The toposheet was imported on GIS platform. The watershed boundary was delineated. The total area of the villages after delineation is found to be bichhua is 200 ha and Sanjari is 380 ha.

4.5.1.2 Digital Elevation Models (DEM)

A DEM is a rasterrepresentation of a continuous surface, usually referring to the surface of the earth. The DEM is used to refer specifically to a regulargrid of spot heights. It is the simplest and most common form ofdigital representation of topography. The Digital Elevation model forthe study area was generated from the contour map using SurfaceAnalysis tool of Spatial Analyst in Arc Map 9.2 show on the table-4.17

Table- 4.17 DEM values both villages

S.No.	DEM Value	Bichhua Village	Sanjari village
1	High value	515	654
2	Low value	449	550

4.5.1.3 Contour map

Contour map is an essential map to identify the topographic character of the area. The contour lines were delineated by overlaying the village boundary over the topographic sheet and delineating over the contour lines on the topographic sheet. It was found that contour line elevation is lying between Bichhua village is 500 m to 590 m. and Sanjari village is 390 m to 450 m.(Table 4.18 and 4.19)The elevation is higher at the extreme portions of the village and is decreasing towards the outlet of village and contour interval is 1m. The contour map is shown in Fig 4.11 and 4.12.

Table-4.18 Elevation category Bichhua village

Category	Contour Elevatiom (m)
1	up to 500
2	500-510
3	510-520
4	520-530
5	530-540
6	540-550
7	550-560
8	560-570
9	570-580
10	580-590

Table-4.19 Elevation category Sanjari village

Category	Contour Elevatiom (m)
1	up to 390
2	390-420
3	420-450

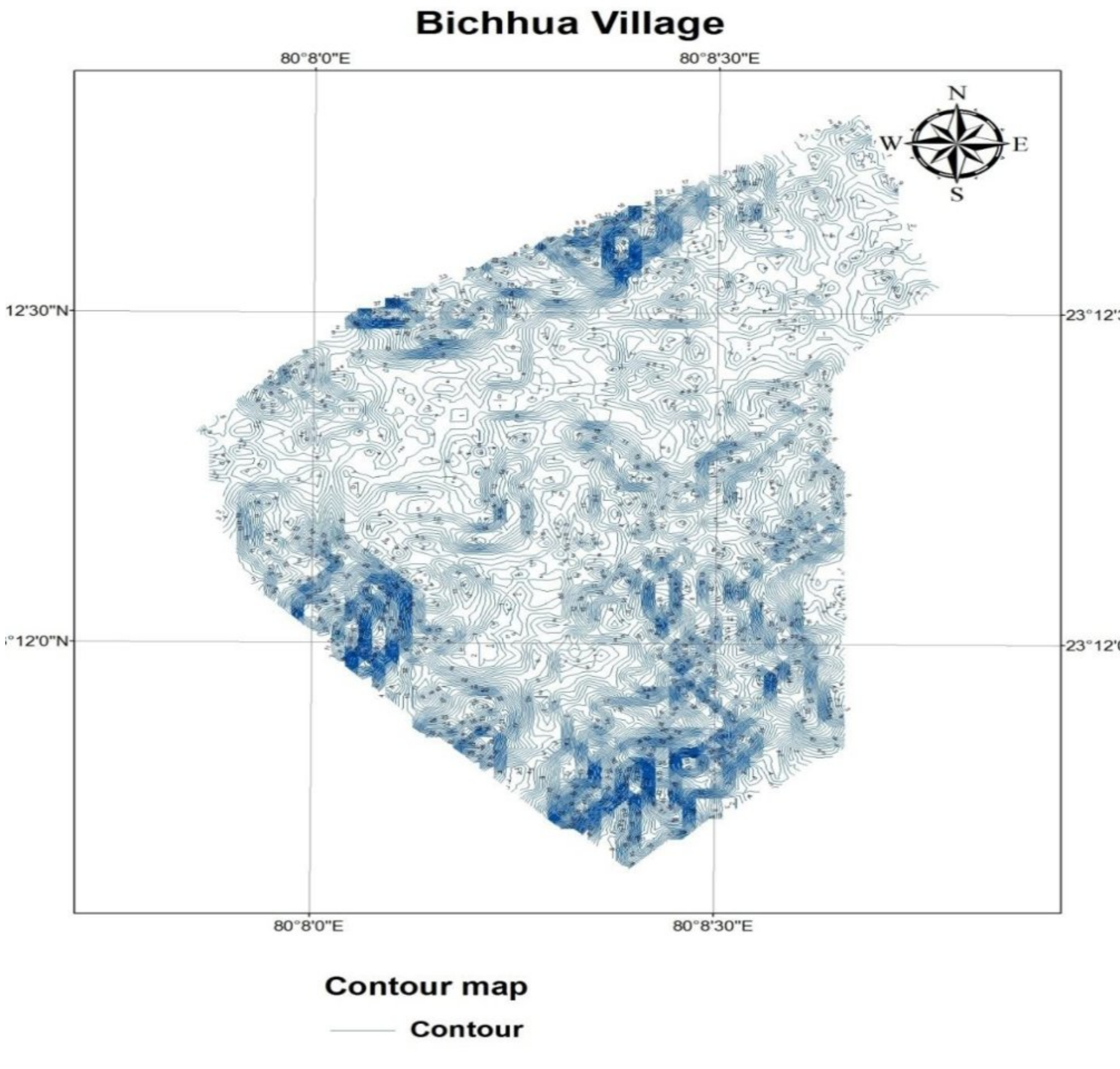


Fig.4.11 Contour map of Bichhua Village.

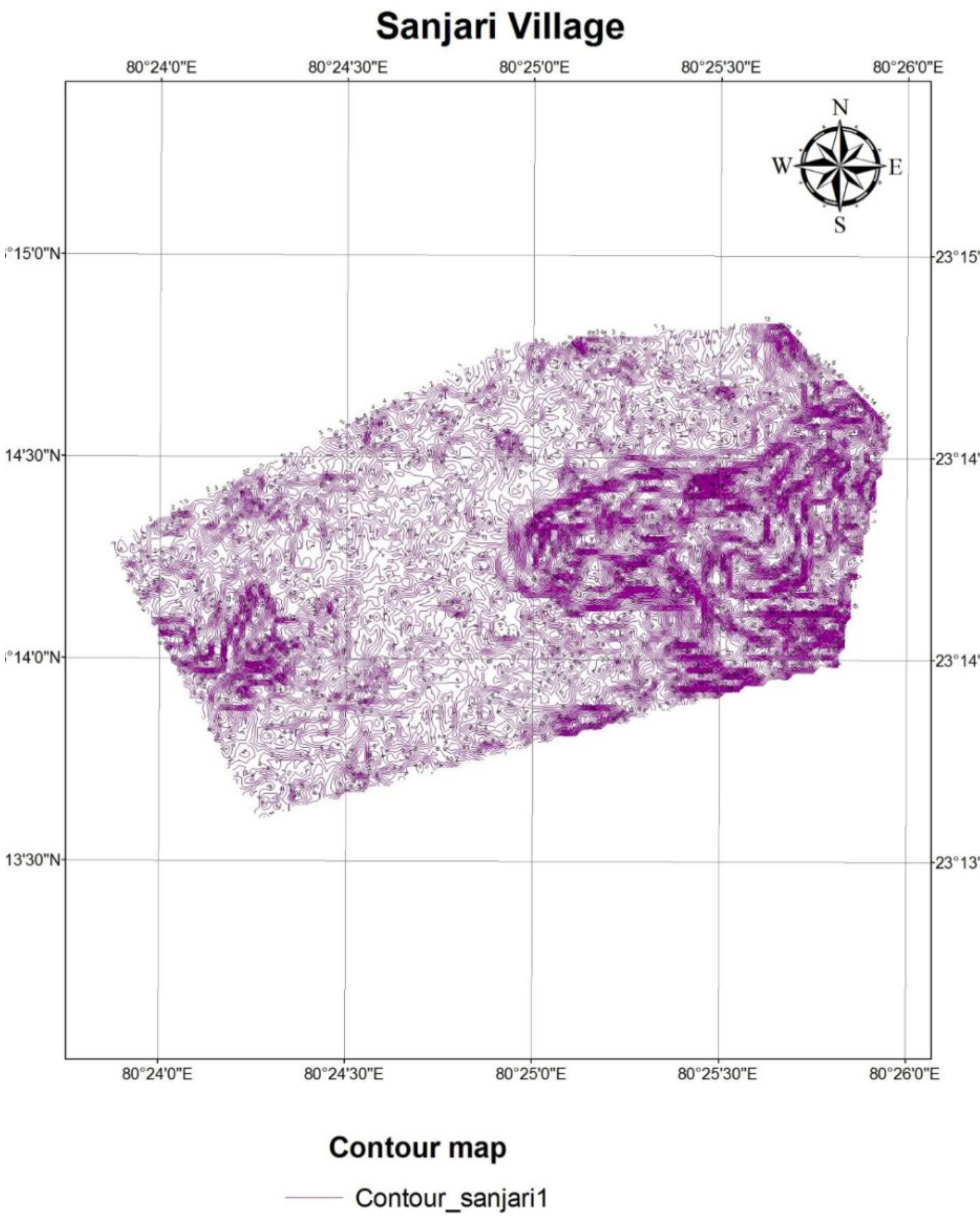


Fig.4.12 Contour map of Sanjari Village.

4.5.1.4 Slope map

Slope map was prepared using the DEM. The slope categories were designated as per Land Use Capability Classification (Suresh R, 2012) on slope categories. The results obtained from the slope analysis Bichhua and Sanjari Villages are shown in Table 4.2 and mapped in Fig 4.13 and 4.14.

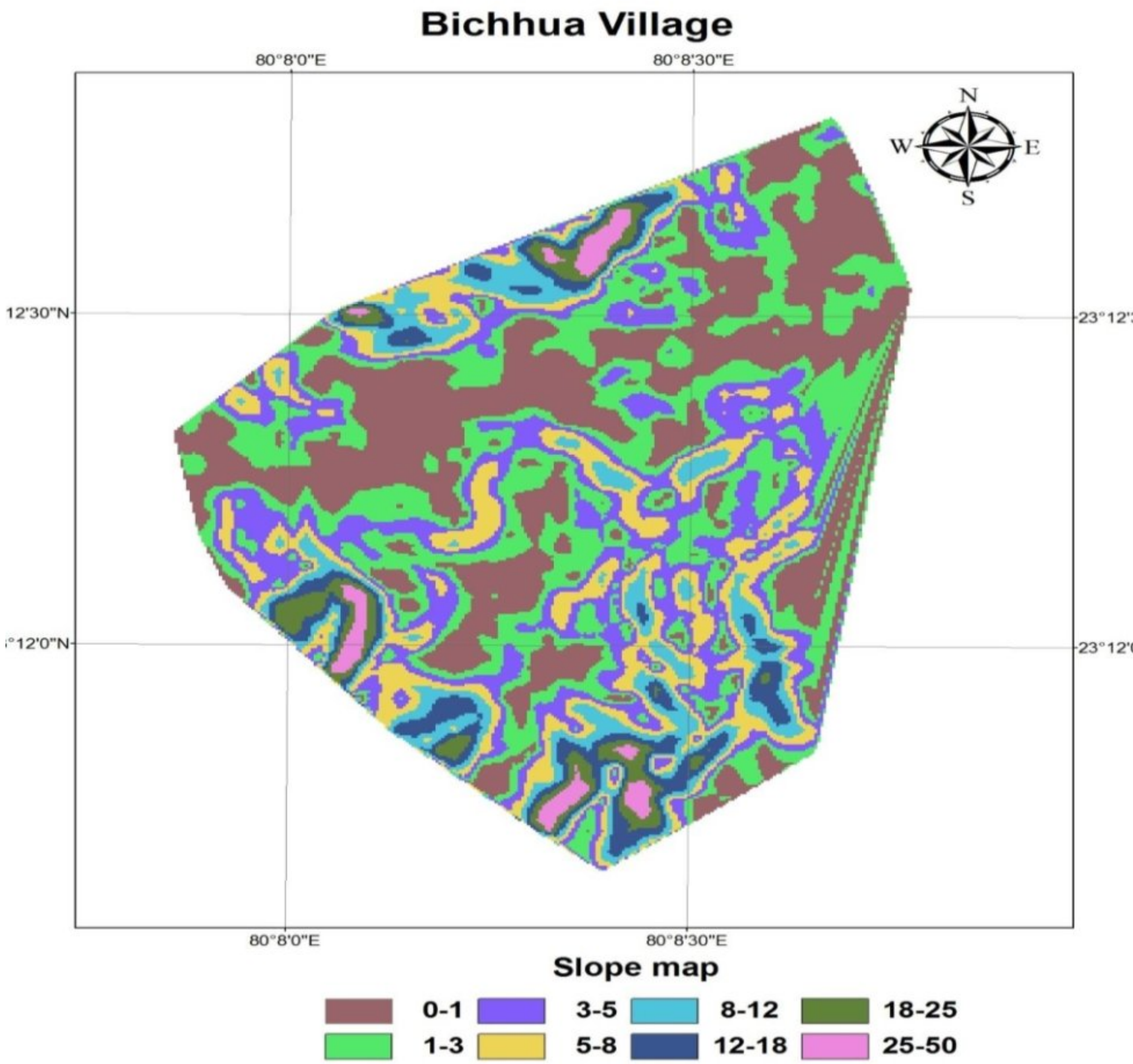


Fig. 4.13 Slope map of Bichhua Village

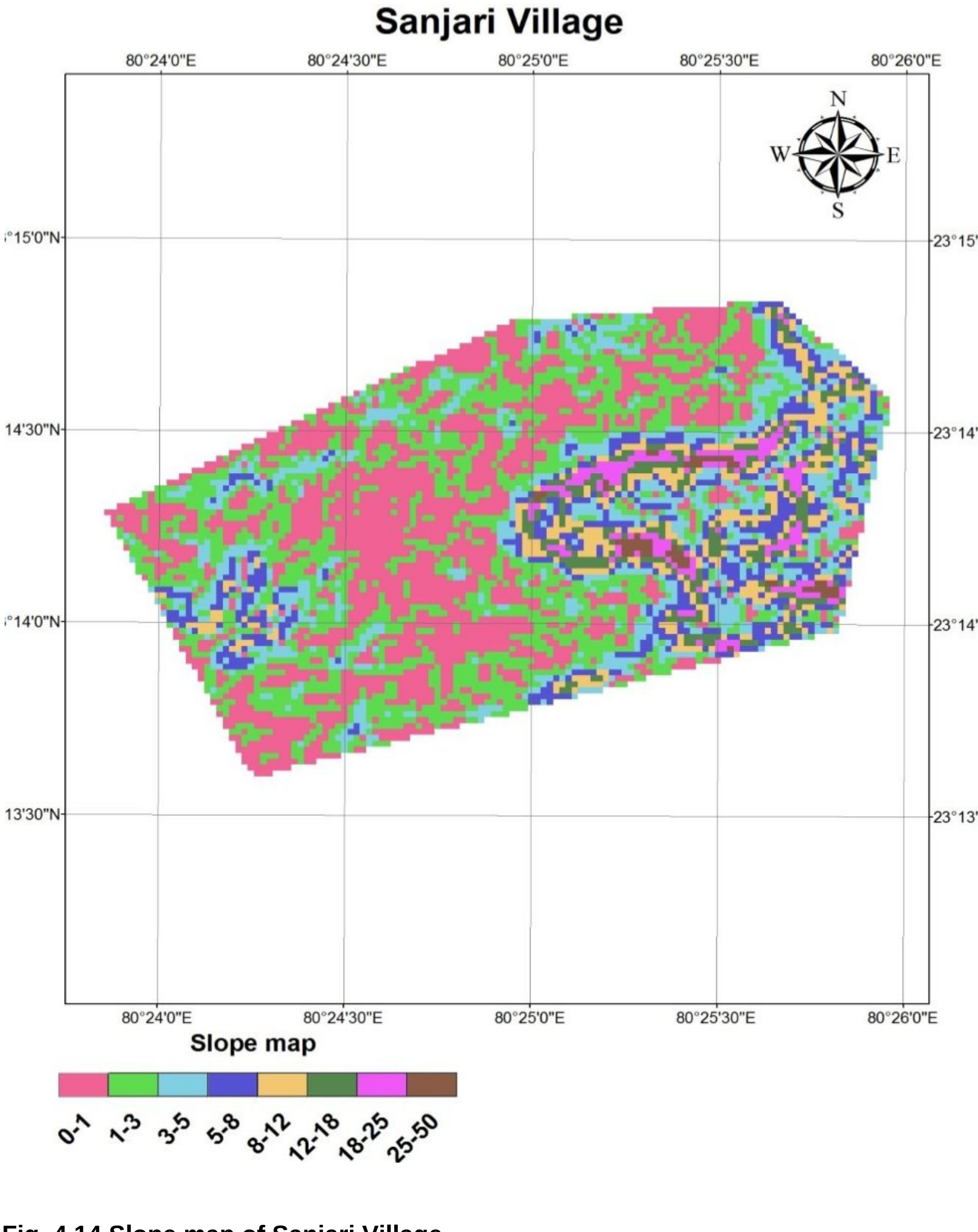


Fig. 4.14 Slope map of Sanjari Village

4.5.1.5 Land Use Capability Classification (LUCC) based on slope

These villages to classify LUCC based on slope, present observed slope % in Bichhua and Sanjari village, Bichhua village and Sanjari village classify 8 classes are listed below table 4.20 and 4.21

Table-4.20 Land Capability Classification of Village area *(Bichhua)*

S.No.	Name of Class	Solpe %	Land Capability classes	Area	
				Area (ha)	Area (%)
1	Nearly Level	0-1	I	9.72	4.86
2	Gently Sloping	1-3	II	51.63	25.815
3	Moderately Sloping	3-5	III	40.76	20.38
4	Strongly Sloping	5-8	IV	40.54	20.27
5	Moderately steep	8-12	V	26.98	13.49
6	Steep	12-18	VI	18.93	9.465
7	Very steep	18-25	VII	8.66	4.33
8	Very very steep	>25	VIII	2.78	1.39

Table 4.21 Land Capability Classification of Village area *(Sanjari)*

S.No.	Name of Class	Solpe %	Land Capability classes	Area	
				ha.	Percentage
1	Nearly Level	0-1	I	51.12	13.45
2	Gently Sloping	1-3.	II	177.02	46.54
3	Moderately Sloping	3-5.	III	43.42	11.42
4	Strongly Sloping	5-8.	IV	54.09	14.23
5	Moderately steep	8-12.	V	45.34	11.92
6	Steep	12-18.	VI	7.3	1.91
7	Very steep	18-25.	VII	1.6	0.42
8	Very very steep	>25	VIII	0.43	0.12

4.5.1.6 Drainage map:

These selected villages in drainage pattern in the area shown below fig. 4.15 and 4.16

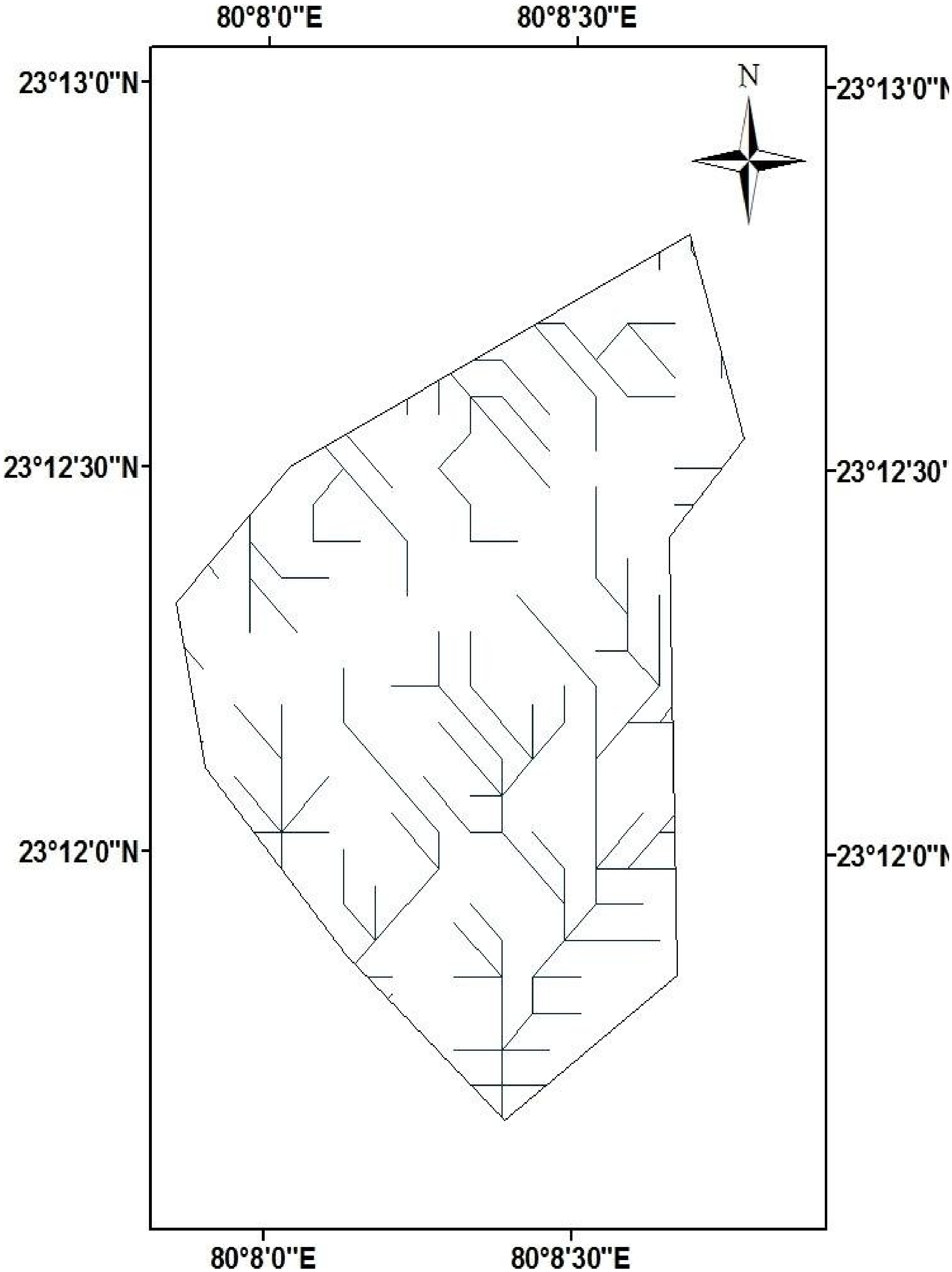


Fig.4.15 – Drainage map of Bichhua village

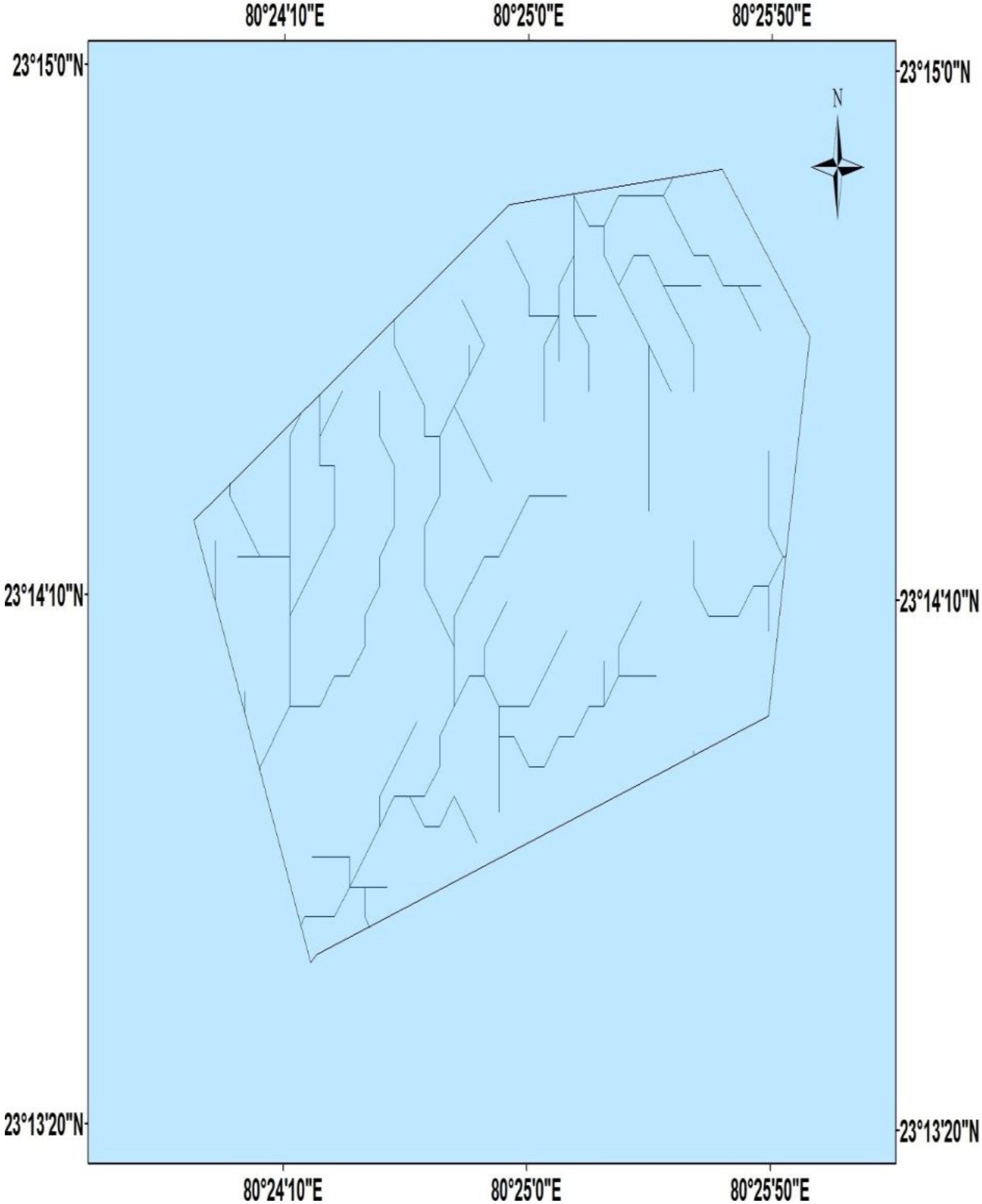
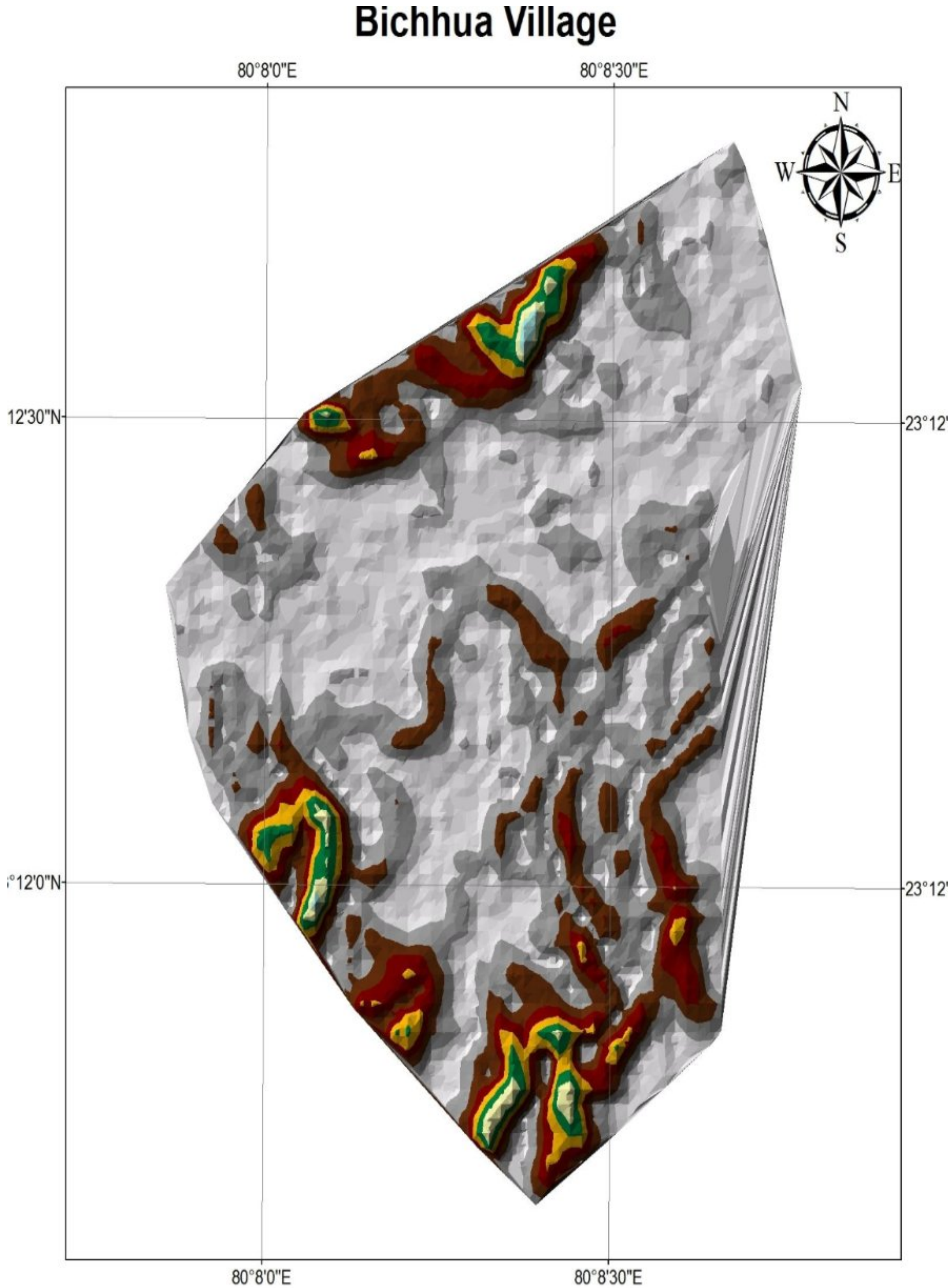
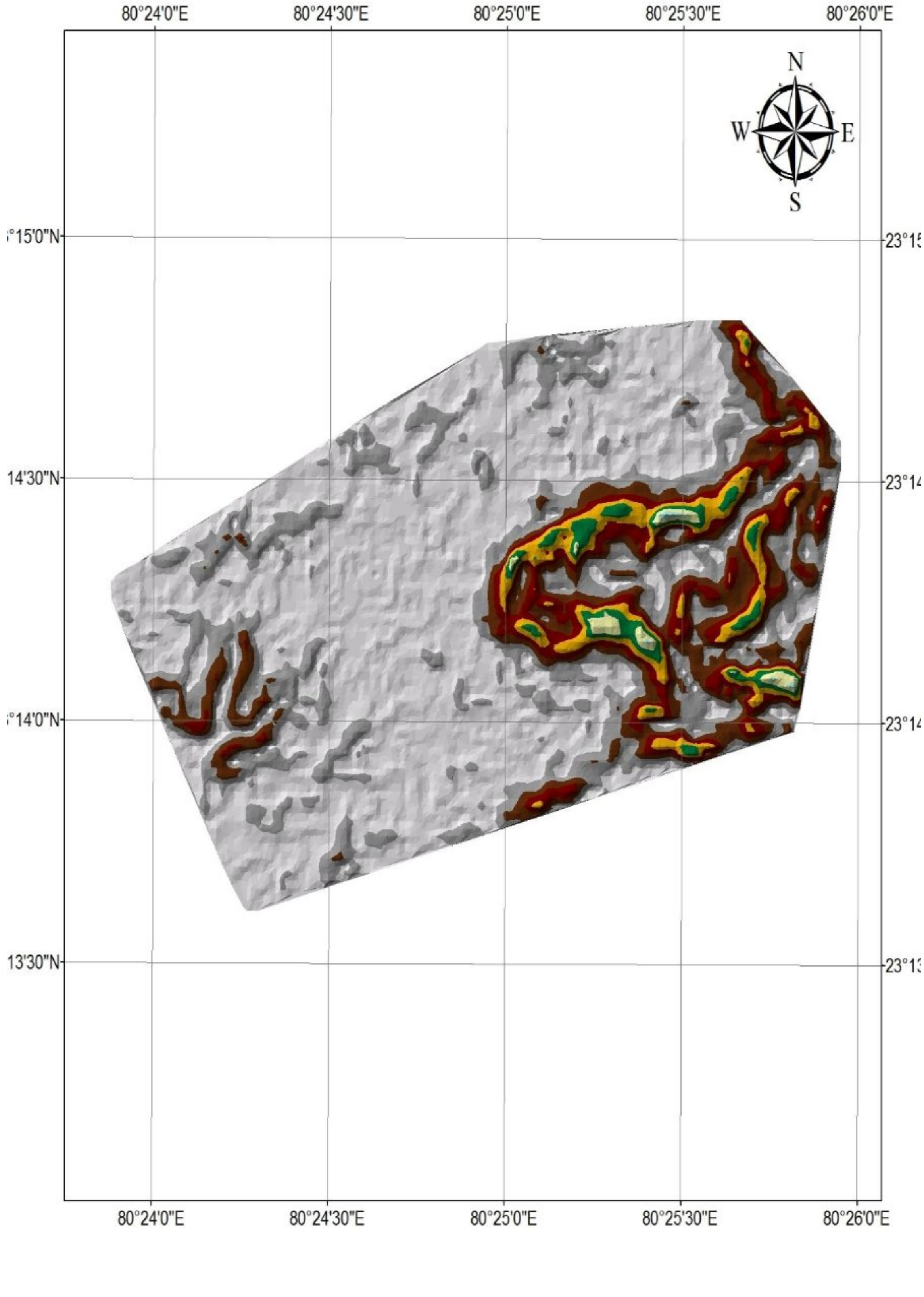


Fig. 4.16 - Drainage map of Sanjari village

Fig. - 3D map both villages



Sanjari Village



4.5.1.7 Planning of water adequacy of the selected village

1. Designing of Earthen dam

Earthen dam is propose in Bichhua village in some information and topographical analysis on the basis of map. Bichhua village is undulated topography and availability of nalla than the propose a earthen dam structure. (Table 4.23)

Now,

Total catchment area = 28 ha

Average annual rainfall from meteorological data (Av.Rainfall data 31 yrs) (Appendix-C)

= 139 cm.

Available water reach to the reservoir

= 28×139

= 3892 ha cm

Assume losses= 20%

Available quantity of water

= 3892x0.80

= 3113.6 ha cm

From the above calculation we get;

Taking top bund level510m

FTL(full tank level)510-1=509m(1m free board)

=282580 m^3

=2825.8 ha cm

Table- 4.22 Cummulative water storage in contour level

Contour. level	**Cummulative area of contour(m^2)**	**Average water storage(Cummulative Storage) (m^3)**
500	4085	4085
501	7042	5563.5
502	10994	9018
503	27266	19130
504	36633	31949.5
505	46995	41814
506	87840	67417.5
507	159305	123572.5
508	198304	178804.5
509	366856	282580
510	392348	379602

2. Designing of Farm pond

Farm pond design for Sanjari village dimensions shown in (Appendix-D)

The volume of the pond is calculated by using the prismodial formula:

$$\text{Volume of pond (m3)} = \frac{d(A0+4A1+A2}{6} = \frac{3.1(9800+4x10423.41+11066.04)}{6}$$

$= 32322.5\ m^3$

$= 323.22$ ha cm

$=$ 20% loss of water

$= 258.57$ ha cm

3. Open well and tubewell

The open well and tubewell have been proposed on the basis of availability of water resources in the sanjari village.The discharge rate and hp of motor were assessed in order to increase of water availability to full fill land and water requirementfor existing and propose land utilization. Table 4.24.

Table-4.23 Water conservation structure for Bichhua village (Propose)

Name of village	Type of source (Proposed)	Quantity	Availabilty of water (ha cm)
Bichhua	Earthen dam	1	2825.8

Table-4.24 Water conservation structure for Sanjari village (Propose)

Name of Village	Type of Source	Power (Hp)	No. of quantity	Availability of water (ha cm)
Sanjari	Farm pond		8	2068.672
	Well	5	8	1240
	Tubewell	5	5	435
			Total	3743.672 ha cm

An assessment was estimated on existing cropping pattern and availability water resources of the two selected tribal villages. The demand of water was calculated considering the following table 4.16

Table 4.25 Comparision of the Present land use versus the proposed land use (Bichhua)

S.No.	Particular	Status		Remark
		Present land use	Proposed land use	
1	Cropping intensity	166.66%	200%	Increase of 33.33 %
2	Water availabilty of all sources	1142ha cm	2825.8 ha cm	Total 3967.8 ha cm
3	Rabi Season Crop area	80 ha	120 ha	Increase Crop area 40 ha

Comparision of the Present land use versus the proposed land use *(Sanjari)*

S.No.	Particular	Status		Remark
		Present land use	Proposedland use	
1	Cropping intensity	135.40%	200.00%	Increase 64.54 %
2	Water availabilty of all sources	1203 ha cm	3743.67 ha cm	Total 4946.6 ha cm
3	Rabi Season Crop area	65.77 ha	185.13	increase Crop area119.36

4.6 Prepare land use plan for optimal water utilization

Considering the deficit condition for the villages, the optimal utilization of water resources is the need of time. So the optimal plan for land and water management was derived for efficient utilization using linear programming techniques.

4.6.1 Management planning for optimum utilization of existing resources plan and propose plan through linear Programming:

A linear programming was prepared to evaluate the optimal water requirement using the existing resources using Graphical method

For Bichhua Village Existing resources plan by using Graphical method:-

(1) Objective Function – To maximize the net profit

$$Z_{max} = C_1X_1 + C_2X_2$$

Where,

C_1= is represent Net profit per unit ha for Wheat crop (Rs/ha)

C_1= is represent Net profit per unit ha for Gram crop (Rs/ha)

X_1 = Crop area for wheat crop (ha)

X_2= Crop area for Gram crop (ha)

$$= 3500X_1 + 12000X_2$$

Condition for optimum solution in this area show on the fig. 4.17 the net profit on the water availability is poor than suggested two condition for net profit

1. Only wheat crop area X_1=25.37 ha

= 25.37x 3500

= 88795 Rs.

or

2. Only Gram crop area X_2 =76.13 ha

= 76.13x 12000

= 913560 Rs.

(2) Resource Constraints

(i) According to Water requirement of crop, crop area and water availability

$$W_1X_1 + W_2X_2 \leq S$$

Where,

W_1 = Water requirement for wheat crop (cm)

W_2= Water requirement for Gram crop (cm)

S = Water Availability in the village (ha cm)

$$= 45X_1 + 15X_2 \leq 1142$$

(ii) According to crop (land) area

$$= X_1 + X_2 \leq A$$

$$= X_1 + X_2 \leq 80$$

X_1 = Crop area for wheat crop (ha)

X_2= Crop area for Gram crop (ha)

A = is represent for existing crop area for rabi season

(iii) Non- negativity constraint

$$= X_1, X_2 \geq 0$$

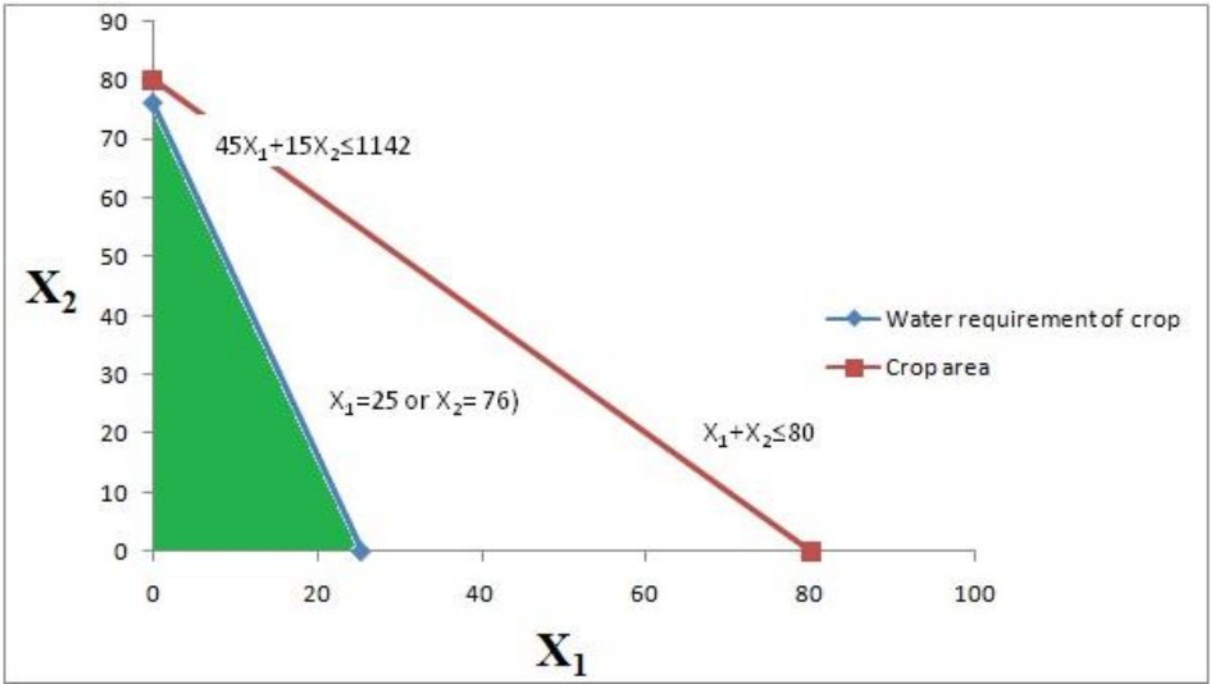


Fig-4.17 Existing resource plan for Bichhua village

For Sanjari Village Existing Resources plan by using Graphical method:-

(1) Objective Function – To maximize the net profit

$$Z_{max} = C_1X_1 + C_2X_2$$

$$= 3500X_1 + 12000X_2$$

Condition for optimum solution in this area show on the fig. 4.18 the net profit on

1. Only wheat crop area X_1=7.2 ha

2. Only Gram crop area X_2 =48 ha

$$= 3500x7.2+12000x48$$
$$= 601200 \text{ Rs}$$

(2) Resource Constraints

(i). Acc. to Water requirement of crop, crop area and water availability

$$W_1X_1 + W_2X_2 \le S$$

$$= 45X_1 + 15X_2 \le 1203$$

(ii) Acc. to crop (land) area

$= X_1 + X_2 \leq A$

$= X_1 + X_2 \leq 65.77$

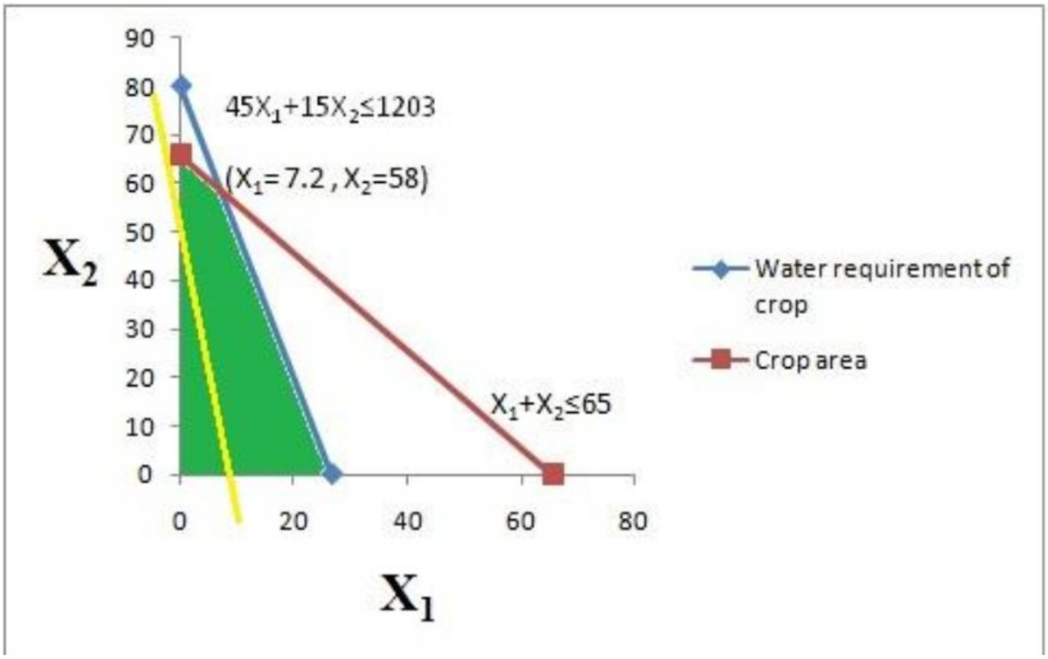


Fig. 4.18 Existing resource plan for Sanjari village

4.3.1.3 Proposed plan for increased total rabi crop area and land utilization

These proposed plan for selected villages on the basis of existing water availability and propose water availability both of the villages.

For Bichhua village:-

(1) Objective Function – To maximize the net profit

$Z_{max} = C_1X_1 + C_2X_2$

$= 3500X_1 + 12000X_2$

Condition for optimum solution in this area show on the fig. 4.19 the net profit on in120 ha area in rabi season.

1. Only wheat crop area X_1=72.13 ha

2. Only Gram crop area X_2 =48 ha

= 3500x72.13+12000x48

= 828455 Rs

(2) Resource Constraints

(i). Acc. to Water requirement of crop, crop area and water availability

$W_1X_1 + W_2X_2 \leq S$

$= 45X_1 + 15X_2 \leq 3964$

(ii) Acc. to crop (land) area

$= X_1 + X_2 \leq A$

$= X_1 + X_2 \leq 120$

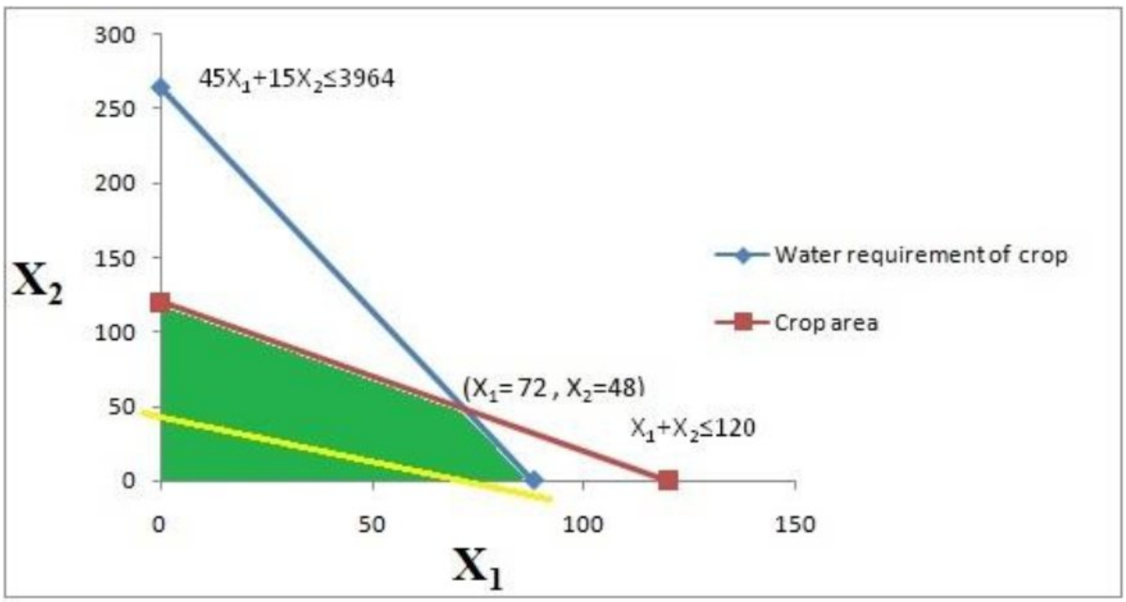


Fig-4.19 Propose plan for Bichhua village

For Sanjari village

(1) Objective Function – To maximize the net profit

$Z_{max} = C_1X_1 + C_2X_2$

$= 3500X_1 + 12000X_2$

Condition for optimum solution in this area show on the fig. 4.20 the net profit on in185.13 ha area in rabi season.

1. Only wheat crop area X_1=69 ha

2. Only Gram crop area X_2 =116 ha

= 3500x69+12000x116
= 1633500Rs

(2) Resource Constraints

(i). Acc. to Water requirement of crop, crop area and water availability
$W_1X_1 + W_2X_2 \leq S$

$= 45X_1 + 15X_2 \leq 4946$

(ii) Acc. to crop (land) area
$= X_1 + X_2 \leq A$
$= X_1 + X_2 \leq 185.13$

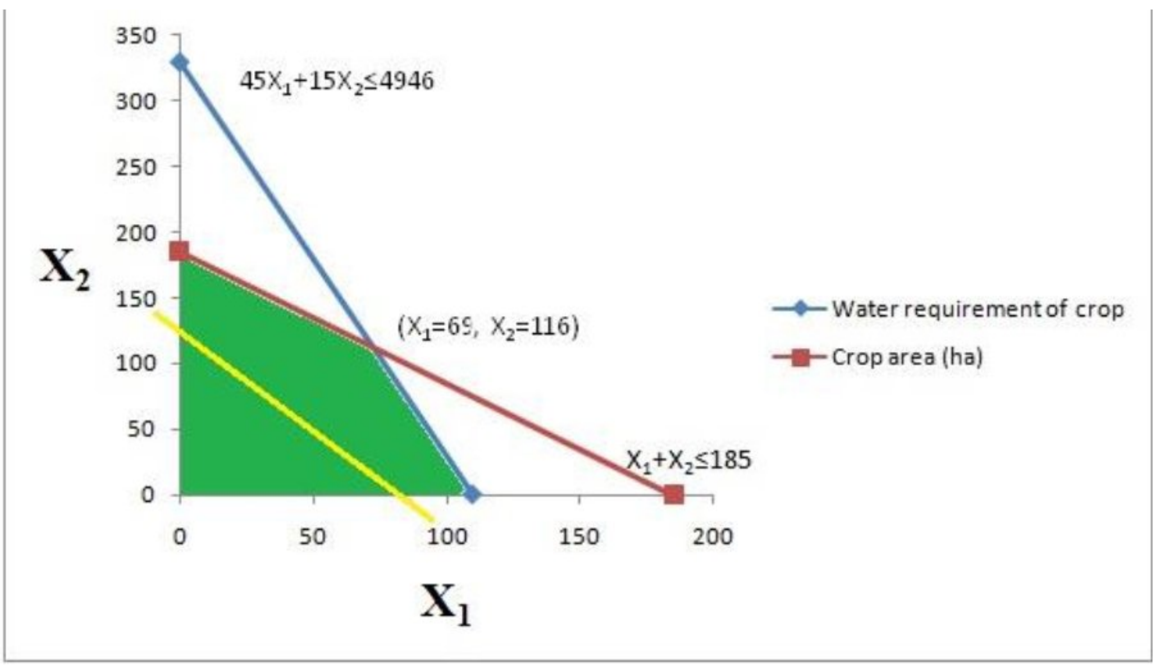


Fig.-4.20 Propose plan for sanjari village.

5.0 SUMMARY AND CONCLUSIONS

Computing demand for water in domestic, livestock and agriculture uses resulting in fast depletion of the country's water resources. A water resource is a crucial component of any development activity and is essential to human life. So that planning for its future use and protection is necessary.

Water budgeting and water adequacy plan help in optimization and profitable use of these vital natural resources. The study was carried out in two villages Bichhua and Sanjari of Kundam block district- Jabalpur.

In the present study various data for water budgeting (to find out demand-supply gap) was obtained from a questionnaires and by undertaking door to door survey. From the data analysis, it was found that total domestic and animal water demand is fulfilled by the existing hand pump and tubewell in both the villages and in present cropping pattern ,(Requirement of water for irrigation) the villages feels shortage of water. And equally important point is that these villages were not utilizing their all field in all two season out of total cultivated area. An analysis of demand supply gap additional provision to meet out the gap, be done

The additional water supply plan was made for both the villages (Bichhua and Sanjari) i.e. construction of earthen dam in Bichhua village and construction of farm pond and digging of tubewell, openwell in Sanjari village help in conserving the water and irrigation use of ground water. This water supply plan provides additional water for irrigation purposes, which help in increasing the cropped area ultimately, increasing the cropping intensity and also provides life saving irrigation for kharif season. The adequacy plan adequately meet out the competing demand of water for domestic and irrigation purposes as the population is increasing at the rapid rate. This also helps in improving the socio-economic condition of the rural peoples.

Based on the result obtained, following conclusions were drawn.

- The demand and supply analysis has been performed for selected tribal village Bichhua. The water demand for domestic and livestock purpose was assessed as 42211 litre/day and the demand for existing crops in Rabi season was found to be2550 ha cm. Availability of water resources for the domestic and livestock was 42569 lit/day which had fulfill the demand for domestic and livestockpurpose. However in case of existing cropping pattern in Rabi season, the supply was 1142 ha cm which is not enough to fulfill the crop water requirement. Based on the demand and supply analysis, the deficit of water was observed as 1408 ha cm which need to be fulfill to satisfy crop water requirement.

- Similarlythe demand and supply analysis has also been performed for selected tribal village Sanjari. In villageSanjari, it has been found that water demand for domestic and livestock purpose was 46317.5 litre/day and the demand for existing crops in Rabi season was 1646.55 ha cm. Availability of water resources for the domestic and livestock was 46355 lit/day which had fulfill the demand for domestic and livestock purpose. However in case of existing cropping pattern in Rabi season, the supply was1203 ha cm which do not fulfill the crop water requirement. Based on the demand and supply analysis, the deficit of water was observed as 443 ha cm.

- Based on the analysis the deficit water for irrigation in existing Rabi season, one earthen dam of capacity 2525.8 ha cm has been proposed in bichhua village in order to fulfill the crop water requirement. Similarly, in Sanjarivillage, total 8 openwell, 5 tubewell and 8 farm pond was proposed that would provide total water of 3743 ha cm by doing so total water supply increased to 3967 ha cm in Bichhua village and 4946 ha cm in Sanjari village.

- The water availability has been assessed for future use as per the proposed water conservation structureand it was found that the availability of water will be significantly increased to satisfy the water requirement for both the village. The cultivated land increased by 40 ha and 119.2 ha in Bichhua and Sanjari villages respectively. Hence the total cultivated area for Bichhua becomes 120 ha where for Sanjari it is 185.13 ha land available for Rabi season.

- An optimal land water management plan has been prepared for existing as well as future cropping pattern considering the proposed water conservation structure and results revealed that average income per capita will be increased in future for both the villages.

SUGGESTIONS FOR FURTHER WORK

- The detailed study of the project should be done in future including new parameter such as seepage analysis, water table behavior, ground water recharge.
- Similar project should be made for arid, semi arid and humid area of the country, so that agricultural production may be increased.
- Land shaping may improve the irrigation efficiencies.
- Capacity building with large scale field demonstrations and exposure units shall be planned and executed.

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Appendix-A

Performa for survey of farmer and existing cropping pattern

1. Name of farmer………………………………………………………………..
2. Size of land holding and Khasra Number…………………………………..
3. Existing cropping Pattern …………………………………………………..

Crop	Rabi	Kharif	Quantity
Variety			
Sowing time			
Seed rate			
Seed treatment			
Tillage practice			
Fertilizer use(kg/ha)			
No. of irrigation			
yield (q/ha)			

4. Source of irrigation

(i) well (ii) Tube well (iii) other

5. Enter culture operation

(i) Weeding (ii) wheel hand hoe (iii) sickle

6. Plant protection

(i) Pesticide (ii) herbicide (iii) other

7. Soil Type

(i) Clay (ii) clay Loam (iii) stony shallow depth(bharra) (iv) Sandy and sandy loam

8. Depth of soil

(i) Shallow (ii) medium (iii) High

8. Water used

Discharge Rate, lps	No of irrigation	Time of irrigation (hr.)	Depth of water(cm)

9. Method of irrigation

(i) Flood (ii) Sprinkler (iii) other

10. Do you have any mechanized implement? Which type of implement?

Answer: - Yes/No, Name of implement……………..

11. Do you know about modern Technology of cultivation?

a) line sowing
b) sprinkler irrigation and with its interval
c) fertilizer dose according to soil type
d) plant protection-pesticide/herbicide

Answer: - (a), (b), (c), (d).

12. Are you benefitted from improved cultivation with mechanized equipment?

Answer:-Yes/No

13. Crop rotation. ……………………………………………………………………..

3.3 Farmers Survey

Selection of farmer was based upon their size of land holding, awareness about new technologies, source of irrigation and willingness to do according to the new concept and ideas. Farmers were contacted personally to collect the desired information in Performa prepared for survey.

-**Performa survey key Question**

1. Do you have any mechanized implement? Which type of implement?
   Answer: - Yes/No, Name of implement……………..

2. Do you know about modern Technology of cultivation?

e) line sowing
f) sprinkler irrigation and with its interval
g) fertilizer dose according to soil type

h) plant protection-pesticide/herbicide

Answer: - (a), (b), (c), (d).

3. Are you benefitted from improved cultivation with mechanized equipment?

Answer:-Yes/No

The various data required are number of population of human beings animals population, types of crop taken and the sources of water available in both the villages. These data are collected by the questionnaires developed as:

Name of Village ----------------------

1. Head of family : (Name) ……………………………………….
   Total land holding : ……. .. irriagated :……………. Unirriagated : …………..
2. Family members :
   Males : ……………………………..
   Females :……………………………
   Children : …………………………..
3. Animal population :

S.No.	Particulars			Total number
1	Cows	Dry		
		Milch		
2	Buffalo	Dry		
		Milch		
3	ox			
4	Goat			
5	Hen			
6	Dog			
7	Pig			

4. Crop to be taken

S.No.	Kharif season		Rabi season		Summer season	
	Name of Crop	Cultivated land area	Name of Crop	Cultivated land area	Name of Crop	Cultivated land area
1						
2						
3						
4						

5.Water source and its location

Make and model : ……………………..

Mode of energy :……………………….. Pumping hours :……………………………

. Depth of water table :

Mansoon (may)	October	March

7. Repair and maintenance ; …………………………….

Appendix-B

1. Water requirement for animals:

S.No.	Particulars		**Consumption in litres/day/capita**
1	Cows	Dry	41
		Milch	60
2	Buffalo	Dry	80
		Milch	90
3	ox		50
4	Goat		15
5	Hen		0.23
6	Dog		4

2. Crop water requirement

S.No.	Type of Season	Type of Crop	Depth of water for irrigation(cm)
1	Kharif season	Paddy	125
		Maize	45
		Black gram	30
		Til	30
		Juwar	45
		Bajra	30
		Pigean pea	30
2	Rabi Season	Wheat	45
		Gram	30

(Sources- Text book of Hydrology and water resources Engineering by Garg SK.)

Appendix-c

Annual rainfall for 31 yrs (1985-2015)

Year	ANNUAL RAINFALL (mm)
1985	1755.4
1986	1348.4
1987	1213.27
1988	1013.1
1989	715.58
1990	1823.28
1991	1369.6
1992	1066.1
1993	1486.2
1994	1204.7
1995	1417.2
1996	918.8
1997	1483.5
1998	944.3
1999	1818.5
2000	1656.3
2001	1508.5
2002	1272.8
2003	1747.4
2004	1224.3
2005	1853.4
2006	1038
2007	1178.9
2008	1398.7
2009	1432.2
2010	1635.9
2011	1858
2012	1352.5
2013	2660
2014	1080.8
2015	823

Appendix- D

S.No.	Parameter			
	Assuming data for Farm Pond			
1	Bottom dimensions		100 m X 98 m	
2	Depth of farm pond		d = 3.1 m	
3	Side slope		Z= 1:1	
4	Type of Shape	Rectangular		
5	Top length	b+2dz	106.2	
6	Top width		104.2	
	: (A2)	106.2 x 104.2	11066.04	m2
7	Mid length	b+2xd/2x1	103.1	
8	Mid width		101.1	
	Area, (A1)		10423.41	m2
9	Area of Bottom (A0)	100x98	9800	m2
10	Volume of Pond			
		The volume of the pond is calculated by using the prismodial fc		
	Volume of pond (m3)	d(A0+4A1+A2		3.1(9800+4x10423.41+11066.04)
		6		6
				32322.5 m3
				323.22 ha cm
				20% loss of water
				258.57 ha cm

Where,

d = depth of pond (m)

A_0 = Area of the pond at the bottom m^2

A_2 = Area of the pond at the top m^2

A_1 = Area of the pond of d/2 depth below the top of pond, m^2

Appendix-E

Estimated time	Cumulative infiltration cm	infiltration rate cm/hr
2	2.0	46.80
5	2.30	37.20
10	3.50	32.30
15	5.80	27.20
22	8.20	23.30
27	10.20	20.20
42	12.90	16.20
57	15.10	13.20
74	17.60	11.10
89	19.60	8.20
104	21.30	6.20
119	22.90	3.50
154	28.10	2.80
181	28.50	2.60
196	29.50	2.60
216	32.40	2.60

Table- Infiltration characteristics field-1 Bichhua village

Estimated time	Cumulative infiltration cm	infiltration rate cm/hr
2	1.90	43
7	3.40	34
12	4.70	28.20
22	6.70	22
32	8.90	18.20
42	11.40	15
57	14.20	11.20
72	17.40	8.80
87	20.90	5.90
117	24.70	4.50
147	27.20	4.20
192	29.70	3.33
237	32.20	3.33
282	33.70	3.33
342	35.20	3.33

Table- Infiltration characteristics field-2 Bichhua village

Estimated time	Cumulative infiltration cm	infiltration rate cm/hr
2	4.50	68
7	8.70	52.20
12	11.70	42.30
22	15	32.30
32	17.80	25.80
42	20.80	18
57	24	12.80
72	27.10	7.80
87	29.10	3.50
117	31.60	2.50
147	32.80	2.50

Table- Infiltration characteristics field-1 Sanjari village

Estimated time	Cumulative infiltration cm	infiltration rate cm/hr
2	1.20	50
7	6.70	36
12	10.20	26.60
17	13.30	20.60
27	15.30	14
37	18.20	10.20
67	19.80	7.60
97	20.80	5.80
127	22.10	4.60
172	23	3.30
217	24.40	1.50
262	25.20	1.30
322	25.80	1.30

Table- Infiltration characteristics field-2 Sanjari village

CURRICULAM VITA

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