GROUND WATER MANAGEMENT FOR CROP PLANNING: A CASE STUDY OF BETUL MADHYA PRADESH

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the Degree

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MASTER OF TECHNOLOGY

in

WATER RESOURCES DEVELOPMENT

By

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CANDIDIATE'S DECLARATION

I hereby declare that the work carried out in this report entitled "**GROUND WATER MANAGEMENT FOR CROP PLANNING : A CASE STUDY OF BETUL MADHYA PRADESH**" is presented on behalf of the partial fulfillment of the requirement for the award of the degree of Master of Technology with specialization in Water Resources Development, submitted to the department of Water Resources Development and Management, Indian Institute of Technology, Roorkee, India, under the supervision and guidance of Dr. Deepak Khare, Professor, WRDM, IIT Roorkee, India and Dr. Pramod kumar Meena Assistant Agricultural Engineer district Betul, Madhya Pradesh India.

I have not submitted the matter embodied in this report for the award of any other degree of diploma.

Date: *04.05.2018* ……………………

Place: *Roorkee* **(Sagar Patel)**

CERTIFICATION

This is to certify that the above statement made by the candidate is correct to the best of my knowledge and belief.

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(Sagar Patel)

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ABSTRACT

In the Betul region of the Central Province of Madhya Pradesh (Central India), the cultivation of wheat and sugar cane in the groundwater basin during the winter season in the study area has led to a large influx of groundwater into the shallow layers, small deep wells and deep well networks. In particular, shallow wellbore owners using centrifugal pumps cannot lift groundwater in the winter due to the rapid drop in groundwater level caused by suction lift caused by small deep and deep well operators.

In order to develop long-term sustainable land and water management strategies for these issues in wet areas, local administrations recognize the need for crop planning and water resources management policies in a deterministic and stochastic system to maximize the research area's Net income considers the availability of groundwater for net irrigation water as the best level of water distribution. Taking into account all restrictions and restrictions, the proposed planting patterns and water allocation policies are considered socially acceptable and maintain the balance of the entire system. Agricultural systems pose many challenges and problems that can be considered as optimization problems. The main challenges are crop selection and irrigation planning. In other words, it is necessary to decide on proper crop cultivation and appropriate irrigation schemes. These decisions are to achieve certain goals, usually including maximizing net profit and/or minimizing water waste.

The problem is complicated by the existence of conflicting multiple goals. In addition, water resources management is one of the most critical issues facing national interests. Given that agricultural irrigation water accounts for 80% of the world’s water consumption, better management of agricultural systems can play a key role in the peaceful resolution of such crises. Groundwater Management There are three basic mechanisms for managing groundwater resources. These mechanisms are managed by local governmental agencies that are authorized by the local government. Many people are using "innovation strategies" and making progress in many areas including protection and transparency. Groundwater Management Overview Some local officials and groundwater users have been reluctant to allow the state government to play a greater role in groundwater management and are more inclined to local supervision. Allow local agencies to develop groundwater management plans and increase revenues to cover management costs. However, seeking public funding for state government funding of groundwater The project must submit a management plan to the Ministry of Water Resources. In addition, the joint use of groundwater and surface water by

partners has become more and more common. Groundwater Management Challenges Groundwater management discussions focused on which agency is responsible for management. However, determining who is managing is part of an ongoing debate. Sustainable groundwater management must be met by local and regional agencies rather than by centralized state regulation. “Locally controlled groundwater management is effective because it best responds to the special conditions and significant differences in groundwater basins across the state. “Local expertise and direct reliance on resources ensure immediate response to problems and trends, and Provides the most powerful foundation for regional collaboration methods. At the same time, the State Legislative Analysis Office advocates the establishment of active management areas. Where overdrafts and pollution are "seriously challenged", AMA will have the authority to limit groundwater exploitation. Even without state leadership, local water areas should also assume the challenge of groundwater protection.

CHAPTER 1

INTRODUCTION

1.1 General

The population is increasing at an unprecedented rate, which is a matter of concern. Moreover the increasing demand is leading to intensive farming and the unavailability if canal water in Central India puts entire food security under threat. This in turn puts the groundwater under high stress, as the farmers resort to pumping, which results in quantitative depletion of the ground water resources. As our country is still dependent on agriculture from socio-economic point of view. So it is very necessary to have an optimum cropping pattern and irrigation technique so that the maximum yield can be achieved. So it is necessary to establish a relationship between the yield and the water availability. Once the relationship is established, with changing water availability the corresponding change in the optimum cropping, irrigation methods can be recommended to the cultivators. Governments can also formulate appropriate best management practices (BMP’s) to ensure that the needs of the cultivators are met. There are numerous simulation and optimization model to formulate planning and operating strategies for irrigation systems. Most of agriculture circumstances are related with various crops cultivated in the same season.

For improving water management, the major advancements have taken place in the last decade. Many models have been developed and models with WHAT-IF condition, are required to come up with adaptation techniques which in turn will reduce the need for mitigation techniques. Groundwater management has been studied from different viewpoints. Water resources management is generally carried by water balance for crop planning. In the present study the optimal cropping pattern and area allocation with respect to availability of water resources (both surface and groundwater) were obtained for different seasons by developing an optimization model. Water adjust demonstrate has likewise been created utilizing the techniques for and considering mass adjust approach. Notwithstanding the objective water use, there is requirement for choosing financially practical editing design for a given zone with accessible assets.The investigation was embraced with a view to help with taking choices about product arranging and groundwater administration.

1.2 Research Gap

Area specific research of Betul district. Rainfall & ground water are main source for irrigation so water use efficiency is one of the points to consider. Using latest automatic weather data for finding consumptive use study. Farmer's survey helps in finding the impact of climate change on yield of crop.

1.3 Objectives

Following objectives are outlined for the present study

i. To asses net irrigation requirement of different crop by in the Betul district Madhya Pradesh.
ii. To determine Consumptive use of crops by Blaney-Criddle formula.
iii. To analyse the yield relationship with rainfall for soyabean and water depletion in rabi season with wheat yield.
iv. To assess ground water recharge and water used in non monsoon season.
v. To correlate actual soyabean yield with rainfall in 8 development blocks of study area & wheat yield with depletion in ground water in observation well.
vi. To conduct farmer survey to know about irrigation practices, crop and associated issues.

CHAPTER 2

LITERATURE REVIEW

2.1 Agricultural and Water Management

In several ground water management model study different indicator is used which include existing cropping patterns and crop returns, crop net irrigation requirement, water resources, water balance parameters, water and irrigation efficiency unit, water productivity and allowance for exploitation. These indicators were determined using standard methods and specifications followed by researchers.

The net return from the cultivation of the crops per unit area of farming was calculated by considering the potential crop yield, market price of crops and cost of production (excluding the cost of irrigation water). Study also presents the crop wise gross return and water productivity with respect to different seasons and type of agriculture's of the region. The required data for both the monsoon and winter crops were collected from the Departments of Agriculture, Statistics, and Economics at the Betul district offices, Government of Madhya Pradesh, India.

2.2 Net Irrigation Requirment

The monthly gross irrigation requirements of the crops were calculated based on the Existing crop calendar by the Penman-Monteith method consideringthe three probability levels of rainfall (80, 50 and 20%) defined by FAO (Smith,1992) as dry, normal and wet years. The effective rainfall for upland cropswas estimated by the evaporation precipitation ratio method (Doorenbos and Pruitt,1977) and for rice using the specified factor corresponding to the amount of rainfall, as used by the Asian Institute of Technology(1980) for the same project. The overall irrigation efficiency has been considered to be 65% for crops other than rice and fish pond, for which 90% overall efficiency and 1 mm day-' percolation rate have been considered.The monthly gross irrigation requirements of the crops at 80, 50 and 20% probability of rainfall are given in According to Dastane (1974), the monthly effective rainfall (Re) was considered as 70% of the average monthly rainfall for non-rice crops and 60% for the rice in the present study. The NIR of crops were calculated by subtracting Re from ETc. If the NIR values are negative (for Re, ETc), then the NIR of crop is considered as zero.

2.3 **Water Resources**

In pre monsoon and post monsoon there are almost 100 groundwater pumping irrigation structures which includes are government-owned deep well pipes (greater than 60 meters) and privately owned small deep (20 to 60 meters) and shallow (less than 20 meters) tube wells in different locations in study area. In the monsoon and winter, the average daily running time of government-owned deep well pipes and private small deep wells is 12 hours and 14 hours, respectively. In the monsoon season and the winter season, the average daily operating hours of private shallow wells were 10 hours and 12 hours, respectively.Irrigation requirements for crops Based on the current crop calendar, the Penman-Monteith method calculates the total monthly irrigation demand for crops, taking into account that the three FAO-defined levels of probability of rainfall (80%, 50% and 20%) are drought, normal and wet Of the year.

The groundwater and surface water availability of the study area was computed using the standard norms prescribed by the Groundwater Estimation Committee (1984) and followed by the past researchers (Panda et al., 1996; Delleur,1998; Nayak, 2001 and Sethi et al., 2002). Agriculture ground water abstraction, resulting in advancement of sea water intrusion front into the coastal aquifers. Intensive rice cultivation in the tubewell-irrigated coastal As a principal crop, farmers normally grow rice in most of groundwater basins of humid regions are constantly facing the cultivable area in monsoon season (June–September) and the problems of lowering of fresh groundwater table by rapid during winter season (October–January) only the tubewell irrigated areas are under rice cultivation whereas rest of the areas remain barren. The seasonal variation in cropping pattern is governed due to uncertainty of rainfall, food habits, availability of irrigation water, uncontrolled grazing by cattle, possibilities of theft of high valued crops and other socio economic constraints. To encourage farmers to go for cropping in the entire cultivable area in winter season, the government has declared 50% subsidy on the construction cost of shallow, and minideep tubewells. Government subsidy has encouraged individual farmers to install tubewells in their respective fields without knowing about well hydraulics, and interference. Therefore, farmers pump the groundwater extensively for growing wheat. It has resulted in rapid drawdown In addition, declining trend of water table is due to insignificance groundwater recharge from rain and base flow contributions from seasonal rivers/surface drains, which requires A groundwater balance study for determining the annual safe yield (Sethi et al., 2002).

Under these circumstances, there is an urgent need to change the existing cropping pattern and to regulate the allocation of surface water and groundwater optimally, which can prevent further deterioration of land and water resources of the region. So, it is imperative to develop a sustainable management of limited land and water resources of a groundwater basin in central India. To achieve this target, an optimal crop planning and water resources allocation scenarios under hydrological uncertainties need to be developed with respect to different agricultures (rainfed and irrigated) and seasons (monsoon and winter). The optimization packages are under development since 1970, but are not commonly used and accepted by water policy makers. Now a day, several researchers have applied a number of simulation and optimization models to derive planning and operating strategies for land and water systems.

In agriculture, where various crops are competing for a limited quantity of land and water resources, linear programming is one of the best tools for optimal allocation of land and water resources (Khepar and Chaturvedi, 1982; Kaushal et al., 1985;Panda et al., 1985; Vedula and Nagesh Kumar, 1996; Paul et al.,2000). Most of the studies of optimization on irrigation water management adopt simplified or linear objective functions to maximize the net benefits while selecting an optimum cropping pattern. Deterministic linear programming (DLP) is one of the best tools for optimum cropping pattern and irrigation programs for maximizing the economic return (Loucks et al., 1981; Khepar and Chaturvedi, 1982; Kaushalet al., 1985; Panda et al., 1996; Afshar and Marino, 1989; Mainuddin et al., 1997 and Sethi et al., 2002). However, chance constraints have been incorporated into the linear programming models to account for the stochastic variables. The chance aspect of irrigation water requirement results from the randomness in precipitation, evapotranspiration, and other similar climatic random factors of irrigated area. Hence, in real field situations, stochastic or chance constrained linear programming (CCLP) is most appropriate for conjunctive management of surface water and groundwater under different risk levels (Loucks, 1970; Eisel, 1972; Loucks and Dorfman, 1975; Maji and Heady, 1978, 1980; Houck, 1979; Datta and Houck, 1984; Panda et al., 1985; Tung, 1986; Morgan et al., 1993; Datta and Dhiman, 1996; Malek-Mohammadi, 1998;Nayak, 2001; Mohan and Jyothiprakash, 2003 and Peranginangin et al., 2004).Considering the aforementioned basic issues of the groundwater basin in Betul district Madhya Pradesh, India.

CHAPTER 3

STUDY AREA AND DATA DISCRIPTION

Betul district is one of the marginal areas of Madhya Pradesh State, covers an area of 10043 square Kilometers. It is located between Latitude $21^0$22'N and Latitude $22^0$24'N, Longitude $77^0$04'E and Latitude $78^0$33'E in India. 55 FJ .The area consists of the Chhindwara area of Khandwa in the east of Hoshangabad in the north and Khandwa in the south of the state of Maharashtra. The area can be reached by rail and road. Betul is headquartered on the Delhi-Chennai mainline and a waterfall on the Nagpur Itarsi section of the National Highway 69.

3.1 Study Area

3.1.1 General Information

District betul is study area with Geographical area (10043 km^2) which contain 10 Administrative Divisions Block, (8) Number of Tehsil and (553) Number of Panchayat (1409) Population (As per Census 2011) (15,75,247) and Normal Rainfall (1129 mm).

3.1.2 Geomorphology

Major Physiographic Units are Satpura plateau in the Tawa and Morand valleys, Satpura plateau in the central and southern and Tapi valley.
Major Drainage is Satpura plateau in the Tawa and Morand valleys, Satpura plateau in the central and southern and Tapi valley.
In study area Forest Area is (3967 km^2) and Net area sown is (4046 km^2) and Cultivable area: (4040 km^2). Major soil types are Black cotton whereas area under principal crops is Wheat, Rice. Jowar, Maize, Sugarcane etc.

3.1.3 Irrigation by Different Sources

Number of Dug wells are (53150) which irrigate area of (716 km^2) , and number of Tube wells/Bore wells are (3427) which irrigate area of (126 km^2), number of Tanks/Ponds (15) which irrigate(2 km^2) number of Canals (92) which irrigate (189 km^2) Other Sources which irrigate (126 km^2)Net Irrigated Area(1159 km^2).

Ground water monitoring wells as per CGWB the Number of Dug Wells are (100) and Number of Piezometers are (7). Predominant geological formations are Deccan Trap Lava Flows, Lameta beds, Upper and Lower Gondwanas and Archaeans.

3.1.4 Hydrogeology

Major Water Bearing Formation is Weathered & Fractured basalt, Weathered & Fractured sandstone, Weathered / Fractured granite, gneiss, amphibolites. Pre-monsoon Depth to water level 2.0 – 16.40 m. Post-monsoon Depth to water level (0.51 -9.75) m Long Term water level trend in 10 years (2001-2010) in m/yr ranges between (0.02-0.1) m fall during non monsoon and (0.02-0.09) m rise during the monsoon season.

3.1.5 Ground Water Exploration by CGWB

Depth Range (m) is (10-300m) Discharge (liters per second) is 0.75-20 lps, to 1-3 lps .Storativity (S) is(4.7xl0-5 to 6.5xl0-5) Transmissvity (m^2/day) is (1 .8-442.8 m^2/day).

3.1.6 Ground Water Quality

Presence of Chemical constituents more than EC- 262-1670, Nitrate- 1.3-156, permissible limit (eg EC, F, As. Fe) Fluoride - .09-.9.

3.1.7 Dynamic Ground Water Resources In MCM

Net Ground Water Availability 1139.70 MCM Gross Annual Ground Water Draft 536.22 Projected Demand for Domestic and Industrial Uses up to 2033 46.38 Stage of Ground Water Development 47 %.

3.1.8 Rainfall and Climate

The atmosphere of Betul is described as hot summer and generally dries, except for precipitation in the rainy season in the southwest. The year can be divided into four seasons. In the cool season from December to February, the first 7 days from March to June are the seasons in the middle of this year.

The period from the middle of June to September is the heavy rain season in the southwest. May is the hottest month of the year, with a temperature of 39.3^0C.10.3^oC. The normal temperature at the end of December is 30.7^oC. The typical annual average of 17.9^oC is the most extreme, with the lowest temperature being separate. Southwest rains began in mid-June and continued until the end of September. In October and November, the center formed a post-storm or retreat storm season. The annual rainfall in Betul is 1129.6 mm. About 86.6% of annual precipitation is obtained during the storm season. The annual precipitation is only 13.4% and occurs from October to May. April was the least wet. Changes in different seasons between 31% and 91%. Compared with before and after the storm, the speed of the breeze in the storm time range is higher. The wind speed in June was around 8.5 km/h, and in November it dropped to 3.8 km/h.

3.1.9 Physiology and Soil

There are four regional geography departments in the area: (i) the Satpur Plateau in Tawa and the Moland Valley; (ii) the Satepur Plateau in the centre and (iii) the southern part of the area (D) and Tati valley. The entire area is located at an average elevation of 365 meters above sea level on the Satepur Plateau. Kilendeo, which is 609 meters above sea level, is the highest peak in the northern and central parts of the region. The Tava Valley is located on a plateau 396 meters above sea level between the peaks of Kirandi and Bhogwangar. The overall range of the valley is towards the northwest.The country is mainly responsible for the residual small amount of hills, and because of the large number of streams connecting the high blocks on the secondary side of the area to the edge of the Valha River and the border areas of the Han River. Khamla's place is 1,137 meters above the national highest point, forming part of the Gwagarh Mountains.The drainage system in the area is diverted from the high levels in the eastern part of the Satpur Plateau to all directions. The northern and central parts of the region flow into Narmada in the north through Tawa, Machna Morand and Bhange. Tapti Bengh is basically a subsequent river that flows west to the west and the central part of the central Pune River. Mam and Wadha occupy a small part of the drainage system in the southern part of the area. In the area, there are five types of soils, namely Cali Soil, Moreland Soil, Matabal Soil, Badi Soil, and Halter Soil. The central and eastern parts of the area are covered by black cotton.

3.1.10 Ground Water Scenario

The Betul region consists of a variety of geological formations that form different types of aquifers in the area. The main geological units in the area are the Archean, Gondwana Lameta, Degan traps, red clay and soil. The occurrence and movement of groundwater in hard rock are mainly controlled by the secondary pores and primary pores in Gondwana and basalt basalts.

3.2 Data Availability

3.2.1 Meteorological Data

Meteorological Data is collected by automatic weathering station at Krishi Vigyan Kendra Betul information such as hourly rainfall, sun hours duration, soil moisture, temperature, wind speed observed. Automatic weathering station contains Thermometer for measuring temperature, Anemometer for measuring wind speed Wind vane for measuring wind direction ,Hygrometer for measuring humidity Barometer for measuring atmospheric pressure.

3.2.2 Ground Water Data

Ground water data is collect by state government of Madhya Pradesh in which 100 observation well with their location latitude and longitude and reduce level of well and height of measuring the ground water surface .the data is collect four times in a year in January –February ,June –July (pre monsoon), august, October –November (post monsoon). Water surface elevation is withdrawn from this data which help in finding recharge post monsoon water surface elevation minus pre monsoon water surface elevation.

3.2.3 Crop Production Data

Soyabean yield (Kg/hect) & Wheat yield (kg/hect) of different khasra number is available since 2011 to 2016 .Data is arranged accordingly in different development blocks which help in finding the relation between yield water used to produce.

CHAPTER 4

METHODOLOGY

4.1 General

The overall methodology described in the present chapter. The chapter presents following segments Consumptive use by blaney-criddle method, Net irrigation requirement using reference evapotranspiration, Rainfall and soya been yield trend, Ground water recharge using observation well, Ground water Depletion in rabi season, Net ground water recharge (hec-m),and Farmer Survey which revels Production ,climate change , method of irrigation.

4.2 Consumptive Use by Blaney-criddle Method

Blaney and criddle developed a simplified formula in which the primary objective was to estimate the Consumptive Use (C_u). The consumptive use was correlated to mean monthly temperature and sunlight hours. By multiplying the mean monthly temperature 't' by the mean monthly percentage 'p' of the maximum possible sunshine hours of the year, a monthly consumptive use factor 'f' is obtained by as f=(pt/100). The value of 'p' depends on latitude of the place and the period of the year. It also makes use of a crop factor which is determined differently by carrying out tests on each crop. The consumptive use of water for the entire crop season or the consumptive use of water for any given period is given by sum of the monthly consumptive use value

$$Cu = \frac{kp}{40}(1.8t + 32 \qquad \text{.........................4.1}$$

Where,

C_u=monthly consumptive use in cm ;

T=Mean monthly temperature in ^{0}C

K= Crop factor ,determined by experiments for each crop,under the environmental conditions of particular area.

P=Monthly percent annual day light hours that occure during the period.

4.3 Net irrigation requirement

NIR is the amount of water required to be delivered at the field to meet the evapotranspiration needs of the crop as well as other needs like leaching, pre sowing requirement etc.

$$NIR= C_u - R_e + P \quad \text{.............................4.2}$$

$$Cu=kc*Eto \quad \text{..4.3}$$

Here,

Et_o -Reference Evapotranspiration

K_c-Crop factor

E_t - Evapotranspiration

P – Percolation loss

R_e- Rainfall

NIR- Net Irrigation Requirement

4.4 Evapotranspiration (ET)

Evaporation and transpiration as a combined process is called Evapotranspiration. Factor affecting consumptive used are weather parameter which are solar radiation, air temperature and wind speed, crop factor which also depend on type of crop, ground cover and crop rotting characteristics, Management and environment condition soil salinity, poor land fertility, poor soil management plant density soil water content etc.The flow chart for evapotranspiration of crop is presented in the Figure 4.1

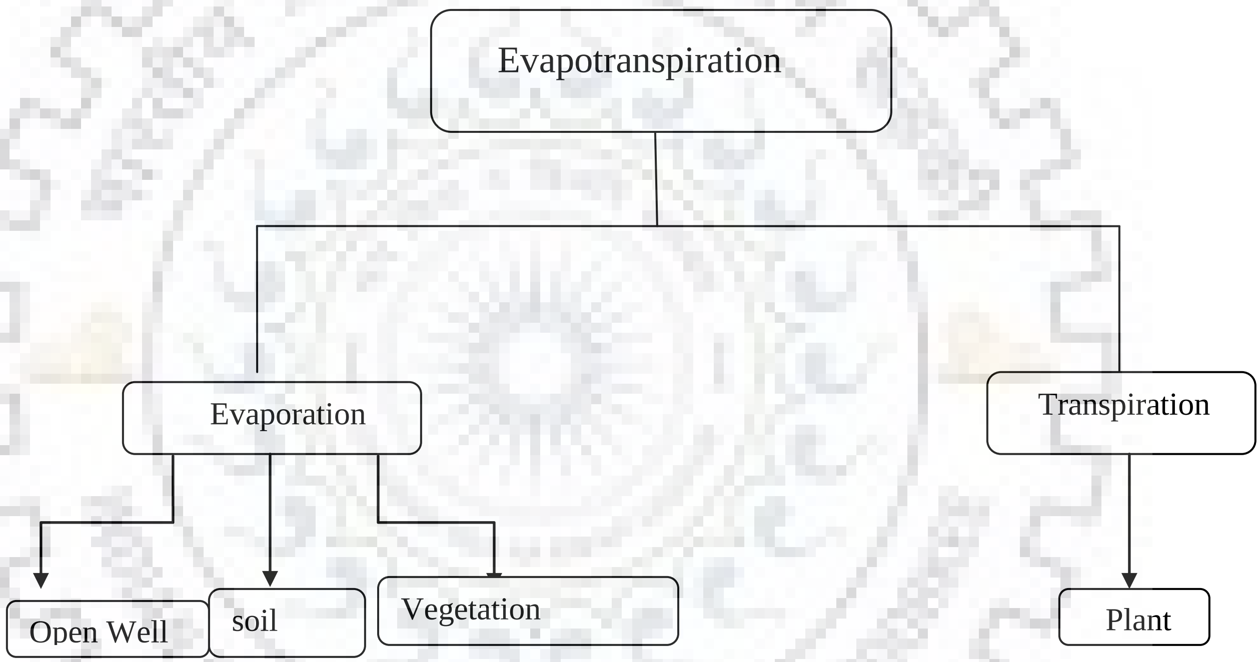


Figure 4.1 Evapotranspiration for an crop

4.5 Ground Water Recharge

Recharge= post monsoon water surface elevation (nov dec) – pre monsoon water surface elevation

The purpose of this report is to characterize residential ground-water use, ground-water recharge Factors other than geologic properties may affect recharge rates locally and temporally. Annual and long-term variability and timing of precipitation and subsequent runoff from a basin are very important in determining recharge rates.

Recharge = Post monsoon Elevation(Nov-Dec) – Pre monsoon Elevation(May)

In a typical year, ground-water levels begin to rise in October, because there is more recharge to the aquifer than discharge to streams. During the growing season, water levels typically follow a downward trend because of evapotransiration and depletion of soil moisture, despite temporary peaks caused by large rainfall events. A lack of precipitation during then on growing season can cause lower than normal water levels in the aquifer even in a year with above-normal precipitation during the growing season. In areas where the water table is at land surface, recharge is rejected as surface runoff.

Channelized or unchannelled surface runoff from till deposits may be another important source of recharge to glacial stratified deposits. The natural drainage patterns, the degree to which channelized flow takes place and the position of the water table during the no growing season may affect local recharge rates in any basin. Other factors that may affect natural recharge include slope, vegetation cover, and local variations in geology and soil moisture. It shows that areas with coniferous forestay have less ground-water recharge than areas with deciduous forest, due to retention and evaporation of rain and snow from the evergreen canopy.

4.6 Water Level Depletion during Rabi Season

Water depletion in rabi season is generally depends upon water consumption for rabi crop in the in season .the main issue is water defiance in end of the rabi season with affect the yield of the rabi crop if there is leak planning and or wrong interpretation in water availability then yield produce than expected.

Water Depletion in rabi season= Water surface elevation (Nov) –Water surface elevation (Feb-Mar)

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 General

Analysis of the study is divided into seven segment (1) Consumptive use by blanley-criddle method. (2)Net irrigation requirement using reference evapotranspiration. (3)Rainfall and soya bean yield trend. (4)Ground water Depletion in rabi season and wheat yield .(5)Ground water recharge using observation well.(6) Ground water Depletion in rabi season.(7)Farmer Survey.

5.2 Consumptive Use by Blanley-Criddle Method.

Blaney and criddle (1950) developed a simplified formula in which the primary objective was to estimate the Consumptive Use (C_u). The consumptive use was correlated to mean monthly temperature and sunlight hours. By multiplying the mean monthly temperature 't' by the mean monthly percentage 'p' of the maximum possible sunshine hours of the year, a monthly consumptive use factor 'f' is obtained by as f=(pt/100). The value of 'p' depends on latitude of the place and the period of the year. It also makes use of a crop factor which is determined differently by carrying out tests on each crop. The consumptive use of water for the entire crop season or the consumptive use of water for any given period is given by sum of the monthly consumptive use value, has been given in Table 5.1.

$$Cu = \frac{Kp}{40}(1.8t + 32) \quad \text{...5.1}$$

C_u=monthly consumptive use in cm ;

T=Mean monthly temperature in ^{0}C

K= Crop factor ,determined by experiments for each crop,under the environmental conditions of particular area.

P=Monthly percent annual day light hours that occure during the period.

Table 5.1 Monthly consumptive use by Blaney-Criddle

CROP	SUN DURATION (hr)	TOTAL SUN DURATION IN YEAR	P	K_C	$P*K_C$	$P*K_C*100/40$	(1.8Tmean+32)	Et (cm/month)
PADDY	979.36	3070.21	0.32	1.125	0.36	0.90	74.07	66.45
BAJRA	1216.36	3070.21	0.40	0.675	0.27	0.67	74.07	49.52
WHEAT	1216.36	3070.21	0.40	0.675	0.27	0.67	74.07	49.52
ARHAR/TUR	1216.36	3070.21	0.40	0.7	0.28	0.69	74.07	51.35
MUNG BEAN	979.36	3070.21	0.32	0.7	0.22	0.56	74.07	41.35
SOYABEAN	1216.36	3070.21	0.40	0.7125	0.28	0.71	74.07	52.27
GRAM	1216.36	3070.21	0.40	0.75	0.30	0.74	74.07	55.02
MASUR	1216.36	3070.21	0.40	0.7	0.28	0.69	74.07	51.35
PULSES	1216.36	3070.21	0.40	0.7	0.28	0.69	74.07	51.35
GROUND NUT	979.36	3070.21	0.32	0.7375	0.24	0.59	74.07	43.56
SUN FLOWER	946.64	3070.21	0.31	0.7	0.22	0.54	74.07	39.96
CASTOR	1633.09	3070.21	0.53	0.83	0.44	1.10	74.07	81.75
TORIA	1188.69	3070.21	0.39	0.775	0.30	0.75	74.07	55.56
MAIZE	1024.91	3070.21	0.33	0.7875	0.26	0.66	74.07	48.68
SUGARCANE	3070.21	3070.21	1.00	0.8	0.80	2.00	74.07	148.13
COTTON	1495.09	3070.21	0.49	0.8	0.39	0.97	74.07	72.14

5.2 Net Irrigation Requirement Using Reference Evapotranspiration

Net Irrigation Requirement NIR is amount of water required for crop plant .If the Net Irrigation Requirement is divided by water application efficiency it gives the field irrigation requirement which is used for water planning in water scary area. It provided idea which crop should be cultivated. The NIR for different crops is given in Table 5.2.

The Table 5.2 shows indicates the type of crop, the month of sowing and harvesting, reference evapotranspiration and transpiration, crop factor, percolation loss, rainfall excess and the net irrigation requirement. This gives us the information to determine the crop water demand.

Table 5.2 Crop water requirement for different crop

CROP	SEASON	SOWING	HARVESTING	Et_O (mm)	K_C	ET mm	P mm	Re (mm)	NIR (mm)
PADDY	KHARIF	JULY	OCT	563	1.125	633.375	900	652.4	880.975
BAJRA	KHARIF	JULY	NOV	691	0.675	466.425	900	697.6	668.825
WHEAT	RABI	OCT	FEB	650	0.675	438.75	900	107	1231.75
ARHAR/TUR	KHARIF	JULY	DEC	804	0.7	562.8	900	697.6	765.2
MUNG BEAN	KHARIF	JULY	OCT	563	0.7	394.1	900	697.6	596.5
SOYABEAN	KHARIF	JULY	NOV	691	0.712	492.337	900	697.6	694.7375
GRAM	RABI	OCT	FEB	650	0.75	487.5	900	107	1280.5
MASUR	RABI	OCT	FEB	650	0.7	455	900	107	1248
PULSES	RABI	OCT	MAR	829	0.7	580.3	900	107	1373.3
PEA	RABI	OCT-	MAR-	829	0.8	663.2	900	107	1456.2
GROUND NUT	KHARIF	JULY	OCT	563	0.737	415.212	900	697.6	617.6125
SUN FLOWER	KHARIF	AUG	NOV	558	0.7	390.6	900	611.2	679.4
SUN FLOWER	RABI	OCT	JAN	513	0.7	359.1	900	107	1152.1
MUSTARD	RABI	OCT	FEB-MAR	928	0.85	788.8	900	107	1581.8
TORIA	RABI	SEP	DEC-JAN	829	0.78	646.62	900	346.2	1200.42
MAIZE	KHARIF	JUNE-	AUG	655	0.83	543.65	900	479.2	964.45
SUGARCANE	LONG DURATION	OCT-APR	OCT-MAR 1	555	0.95	527.25	900	107	1320.25
COTTON	KHARIF	JUNE	NOV	1977	0.775	1532.175	900	825.4	1606.775
TOMATO	RABI	OCT	FEB	844	0.787	664.65	900	107	1457.65

Where,

Et_o -Reference Evapotranspiration

K_c-Crop factor

K_t - Evapotranspiration

P – Percolation loss

R_e- Rainfall

NIR- Net Irrigation Requirement

5.2.1 Evapotransipration of Different Crop in (mm)

ET is evapotransipration which is the water requirement for evaporation of water from water soil near plant and transpiration water used in development of plant. It depends on reference evapotranspiration which depend on environment and soil condition and crop factor which is different for different crop. The evapotranspiration for wheat 420 mm whereas for soyabean it is 500 mm. The ET for different crop is presented in Figure 5.1. Gives us a general idea about the optimum cropping pattern, which crops are to be planted and according to it irrigation policies can be formed.

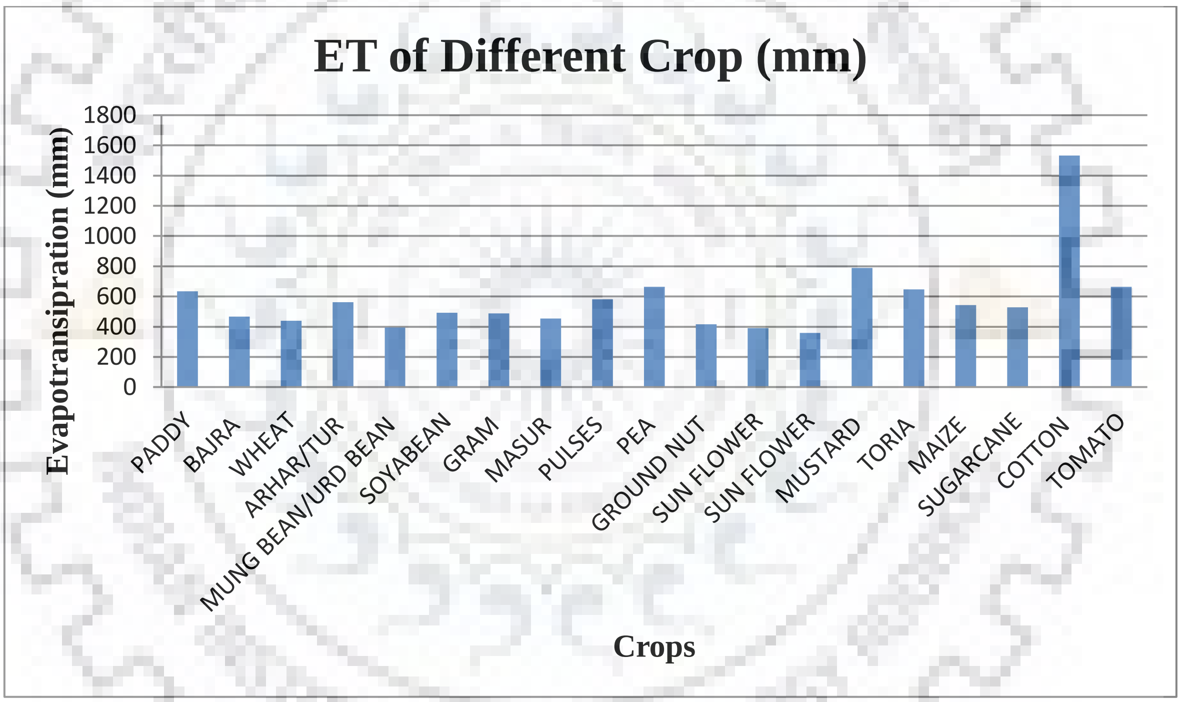


Figure 5.1 ET of different crop in (mm)

5.2.2 Net Irrigation Requirement of Different Crop (mm)

The Net Irrigation Requirement for different crops show in Figure 5.2, which also considers the effect of leaching and subtracts the precipitation. It represents exampling the water requirement by different in mm in which y-axis show the net irrigation requirement and x-axis show different crop in study area. The net irrigation requirement for wheat is 1210 mm and for soybean 625mm. For these calculations the percolation loss is assumed to be 900 mm.

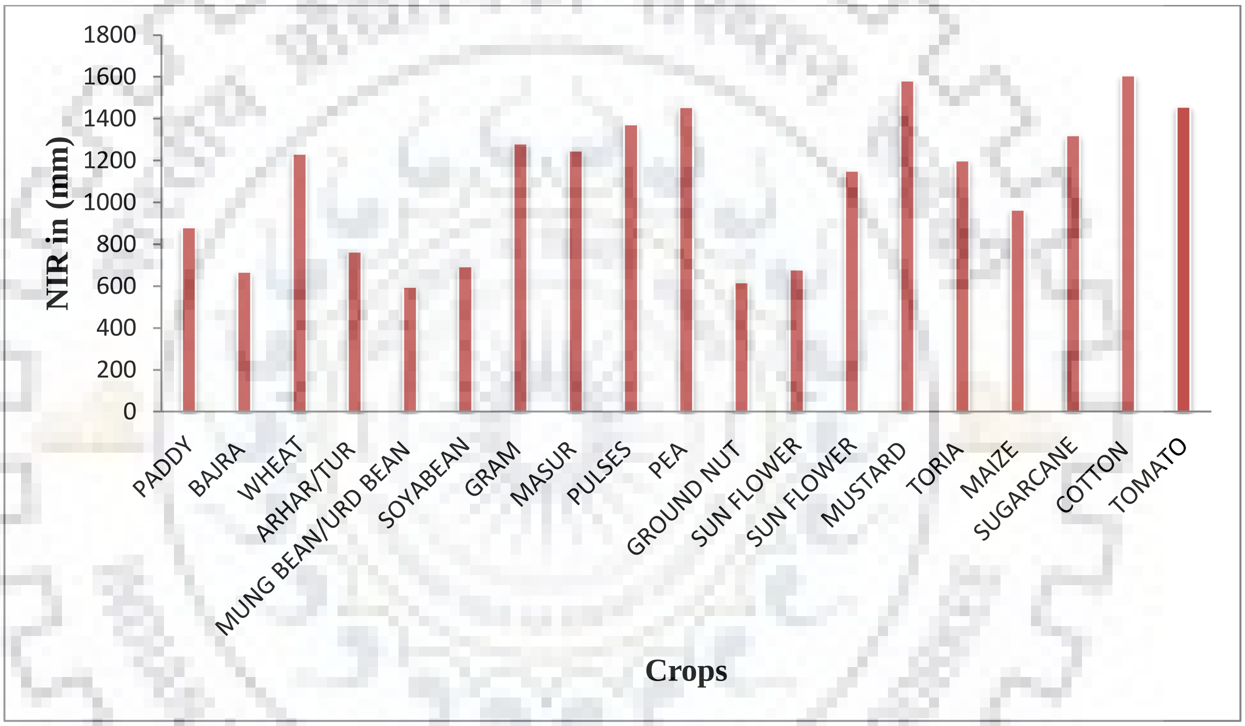


Figure 5.2 NIR of different crop (mm)

5.3 Rainfall and Soyabean Yield Trend.

5.3.1 Soyabean Yield

In present study soyabean crop yield is given in Table 5.3

Figure 5.3 shows the variation in the yield of soyabean from 2010 to 2016. Highest yield was 1324 kg/hect observed in the year 2016 and lowest of about 305 kg/hect in the year 2015.

Table 5.3 Soyabean yield in (kg/hect) from 2010 to 2016 block wise

YEAR	2010	2011	2012	2013	2014	2015	2016
ATHNER	1496	1584	1634	990	434	361	1282
AMLA	907	1314	1347	597	638	86	1373
BETUL	1200	1429	1247	380	900	212	1383
BHAINSDEHI	1229	1046	998	478	340	343	1259
CHICHOLI	1569	1231	1332	278	1058	170	1645
GHODADONGRI	869	1501	1270	286	438	80	1162
MULTAI	1252	1124	1148	594	386	157	1280
SHAHPUR	1303	1163	1361	255	850	1030	1210
AVERAGE	1228	1299	1292	482	631	305	1324

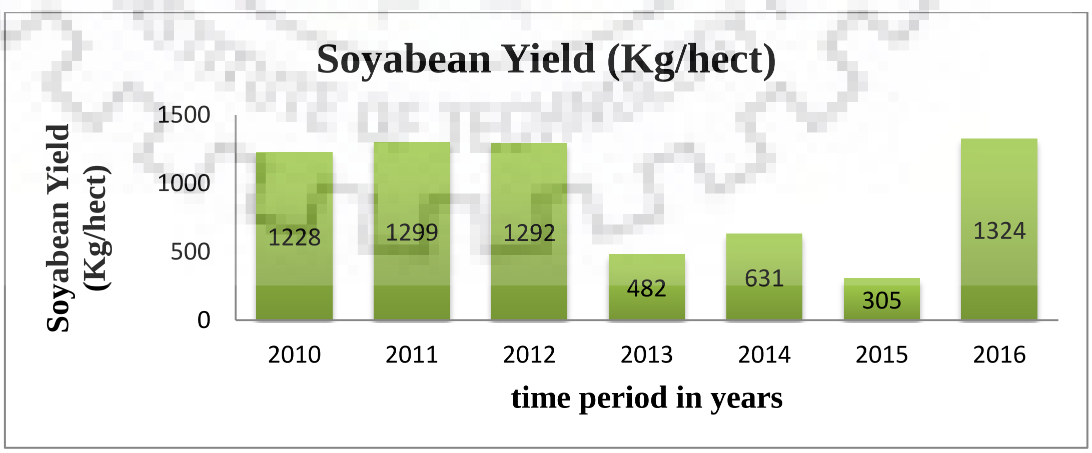


Figure 5.3 Soyabean yield (Kg/hect) from 2010-2016

5.3.2 Soyabean Yield Block Wise

There are eight block in Betul district.The soyabean average yield for all the eight from 2010 to 2016 in given Table 5.4 the average yield is prented on Figure 5.4.The yield block wise block wise having maximum in Athner block(1112 Kg/hect) and minimum in Ghodadongri (801 Kg/hect)

Table 5 .4 Seven year average soyabean yield (kg/hect) of Devopment Block.

YEAR	ATHNER	AMLA	BETUL	BHAINSDEHI	CHICHOLI	GHODADONGRI	MULTAI	SHAHPUR
2010	1496	907	1200	1229	1569	869	1252	1303
2011	1584	1314	1429	1046	1231	1501	1124	1163
2012	1634	1347	1247	998	1332	1270	1148	1361
2013	990	597	380	478	278	286	594	255
2014	434	638	900	340	1058	438	386	850
2015	361	86	212	343	170	80	157	1030
2016	1282	1373	1383	1259	1645	1162	1280	1210
AVERAGE	1112	895	964	813	1040	801	849	1025

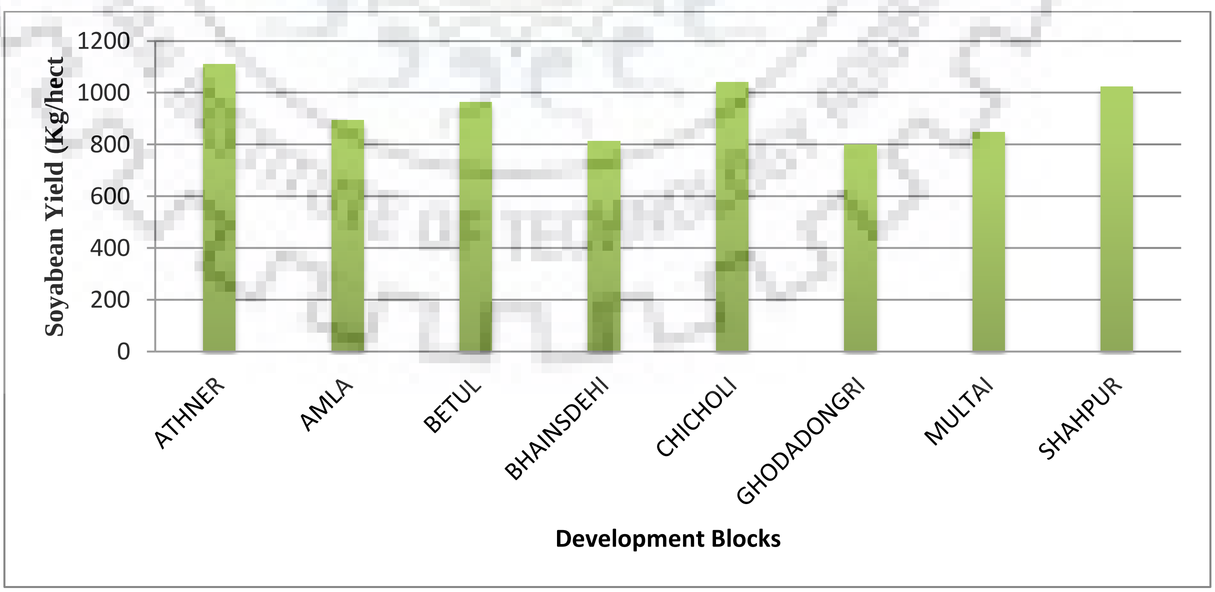


Figure 5.4 Soyabean yield (kg/hect) block wise

5.3.3 Rainfall

Most of the rainfall is during monsoon season kharife season for crop like soyabean rainfall is measure irrigation source so we are trying to identify a realtion between yield and rainafall.The average rainfall for the year 2010 to 2016 for all blocks of the study area are gives in Table 5.5.The average yearwise rainfall for the study area is presented in Figure 5.5.

Table 5.5 Rainfall from 2010 to 2016

YEAR	2010	2011	2012	2013	2014	2015	2016
ATHNER	1088.9	465.1	949.2	1165.7	950.5	711.2	691
AMLA	726	415.2	662.2	1261.1	743.1	490	840
BETUL	970	600	1316	1577.7	1040.8	748.9	926.3
BHAINSDEHI	989.2	498.2	1357.2	1182.9	977.6	915.1	1132.2
CHICHOLI	958.2	780.4	1917.6	966.6	691.1	725.22	1307.1
GHODADONGRI	1093.3	621.8	1704.8	699.1	816.9	976.41	1362
MULTAI	988.2	685.2	1311.6	691.16	525	596.1	795.2
SHAHPUR	951	732.6	1311.6	609.1	714.2	775.8	1277.8
AVERAGE	971	600	1316	1019	807	742	1041

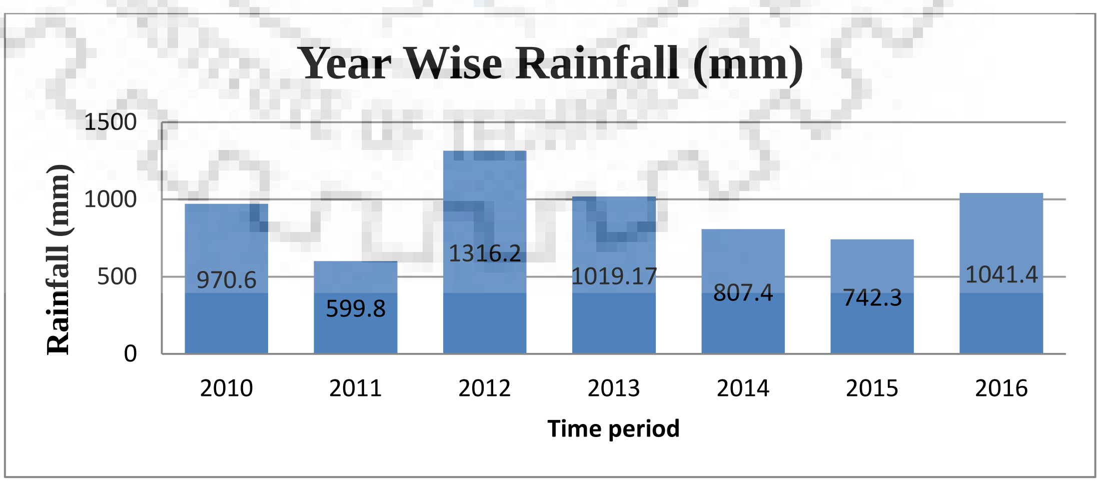


Figure 5.5 Year Wise Rainfall in mm

5.3.4 Rainfall Block Wise

The blockwise average rainfall is given in Table 5.6. Figure 5.6 shows rainfall is maximum 1049 mm in chicholi block and minimum in amla which is 734 mm.

Table 5.6 Seven year average rainfall of Development Blocks

YEAR	ATHNER	AMLA	BETUL	BHAINSDEHI	CHICHOLI	GHODADONGRI	MULTAI	SHAHPUR
2010	1088.9	726	970	989.2	958.2	1093.3	988.2	951
2011	465.1	415.2	600	498.2	780.4	621.8	685.2	732.6
2012	949.2	662.2	1316	1357.2	1917.6	1704.8	1311.6	1311.6
2013	1165.7	1261.1	1577.7	1182.9	966.6	699.1	691.16	609.1
2014	950.5	743.1	1040.8	977.6	691.1	816.9	525	714.2
2015	711.2	490	748.9	915.1	725.22	976.41	596.1	775.8
2016	691	840	926.3	1132.2	1307.1	1362	795.2	1277.8
AVERAGE	860	734	1026	1007	1049	1039	799	910

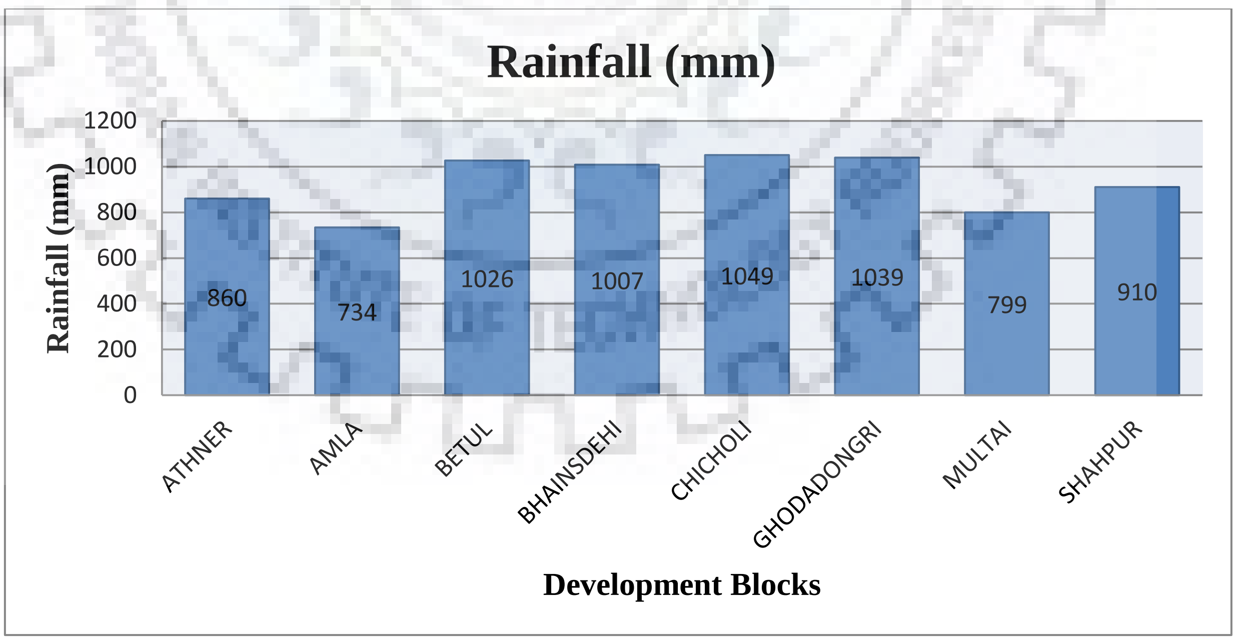


Figure 5.6 Rainfall Of Developmet Block in (mm)

5.3.5 Linear Soyabean Yield Trend

Equation 5.2 is a standard y= mx+c equation whose slope gives us the water productivity (kg/hect/mm). Data from 1984 to 2016 pertaining to soybean yield and rainfall has been used to develop this equation. The relationship of yield with rainfall for soyabeanis presented in Figure 5.7. The R^2 is 0.09, which indicates a linear trend, which shows lesser variation than other curves like quadratic, exponential.

$$y = 0.3066x + 622.52 \quad .....(5.2)$$

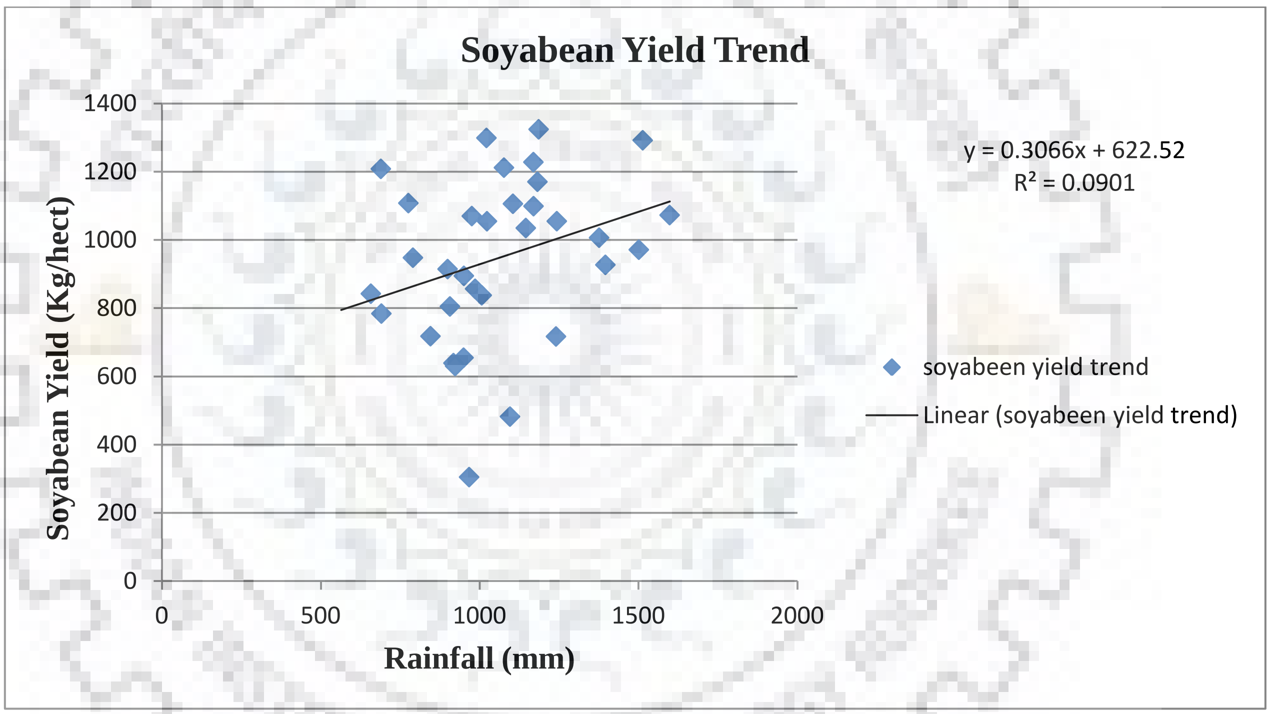


Figure 5.7 Soyabeen yield(kg/hect) linear relation with rainfall (mm)

5.3.6 Quadratic Soybean Yeild Trend With Rainfall

Equation 5.3 is a standard y = ax^2+bx+c quadratic equation. Same dataset of soybean trend and rainfall has been taken. Instead of a linear line a quadratic curve is considered and checked whether it fits better than linear(Figure 5.8). It was observed that there is no significant difference in between the R^2 values, but the R^2 is comparatively less.

$$\mathbf{y = 0.0003x^2 - 0.3174x + 953.33} \qquad .....(5.3)$$

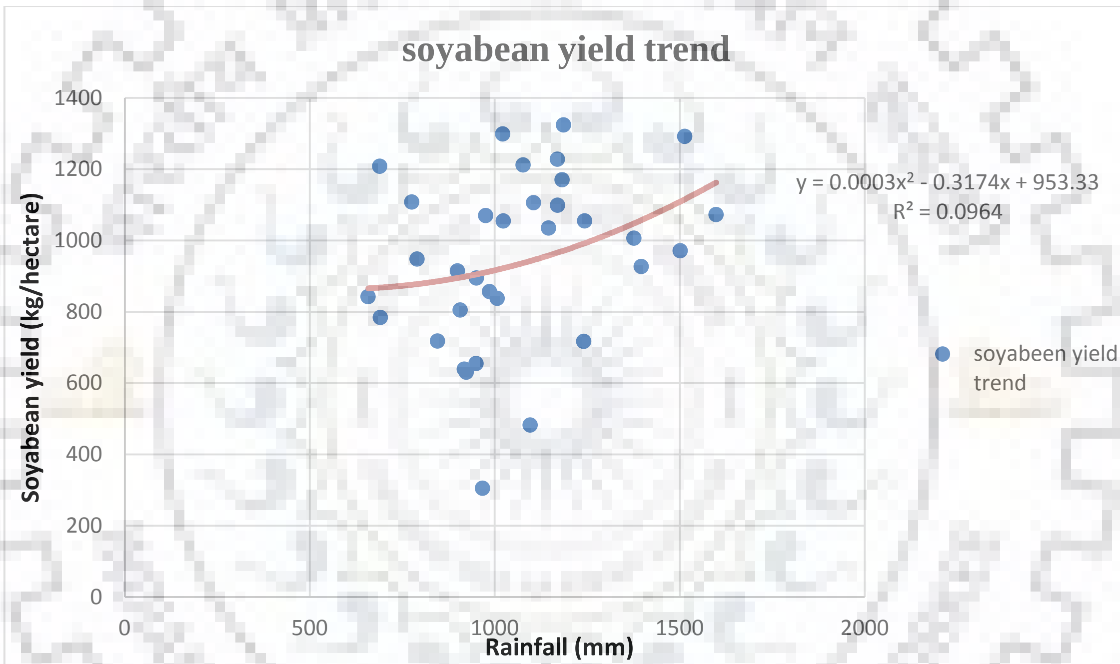


Figure 5.8 Soyabeen yield (Kg/hect) Quadratic relation with rainfall(mm)

5.3.7 Relation Between Rainfall and Soyabean Yield

In the present study a comparison study has been made between the yield and rainfall for soyabean crop.for all blocks analysis has been done. The Figure 5.9 to Figure 5.16 present rainfall (mm) and soyabean yield(kg/hect) for different development block Athner, Amla, Betul, Bhainsedehi , Chicholi, Ghodadongri, Multai, Shahpur respectively.

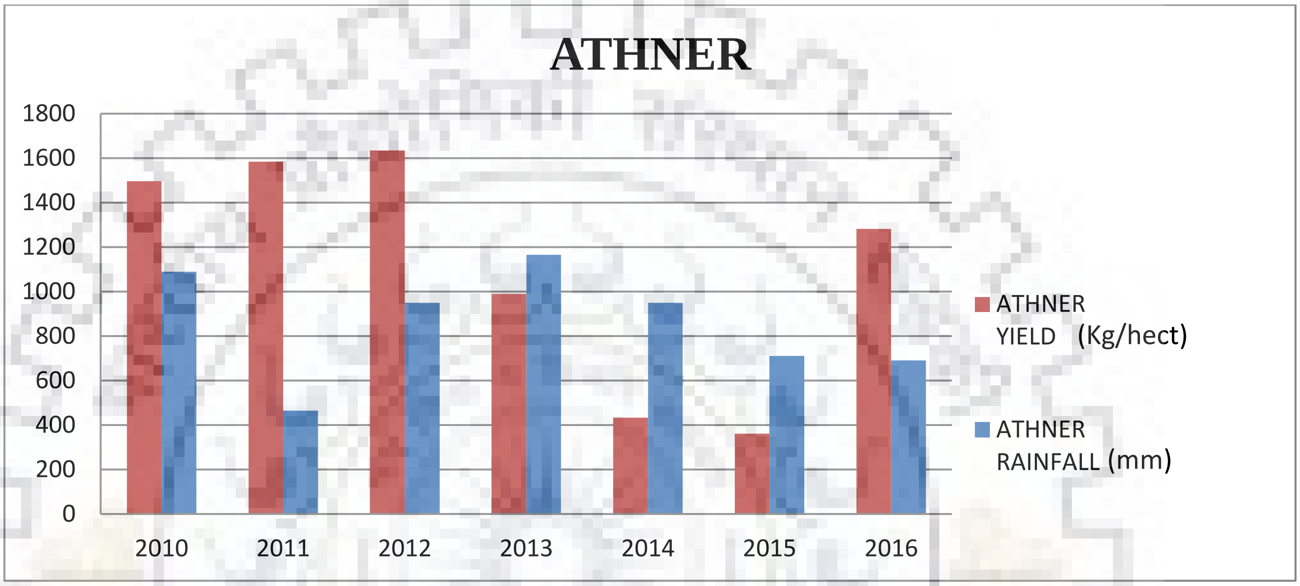


Figure 5.9 Athner soyabean yield (kg/hect) and Athner rainfall (mm)

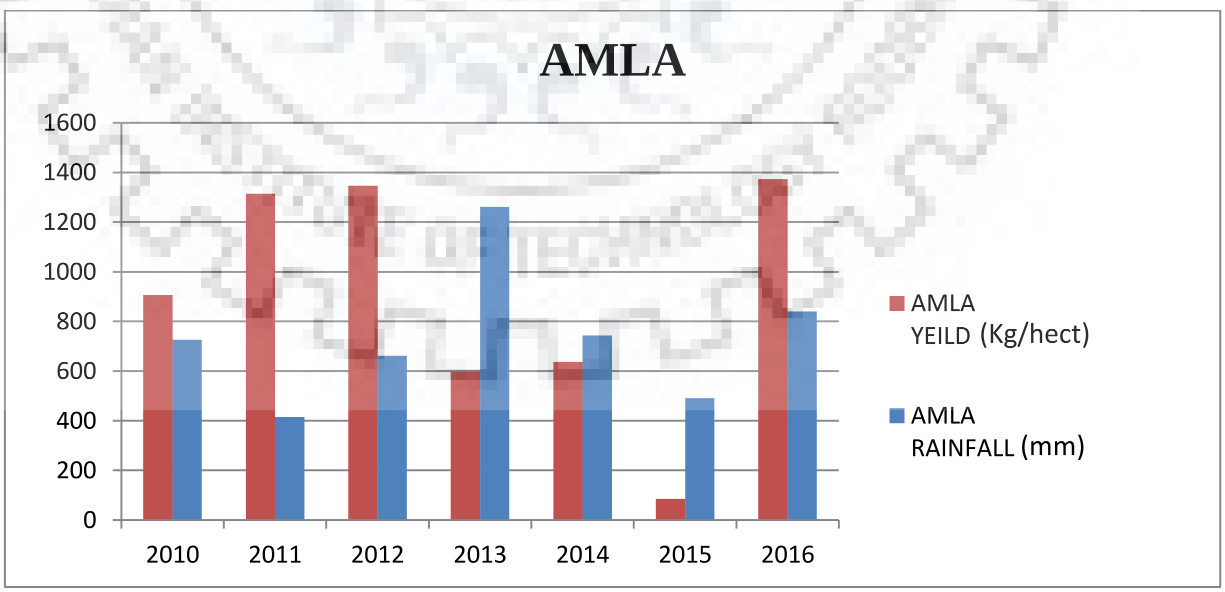


Figure 5.10 Amla soyabean yield (kg/hect) and Amla rainfall (mm)

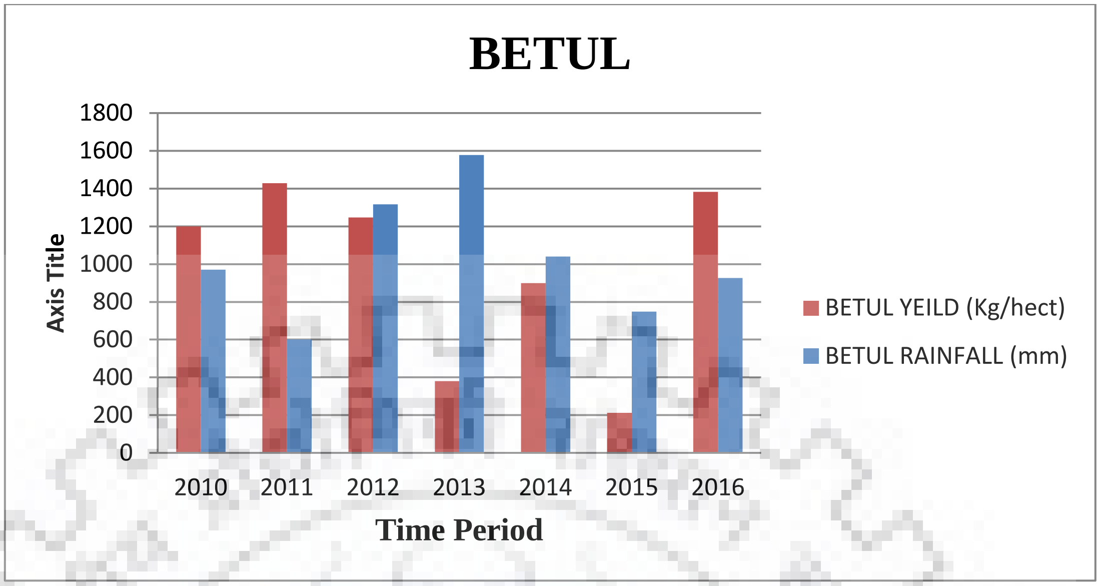


Figure 5.11 Betul soyabean yield (kg/hect) and Betul rainfall (mm)

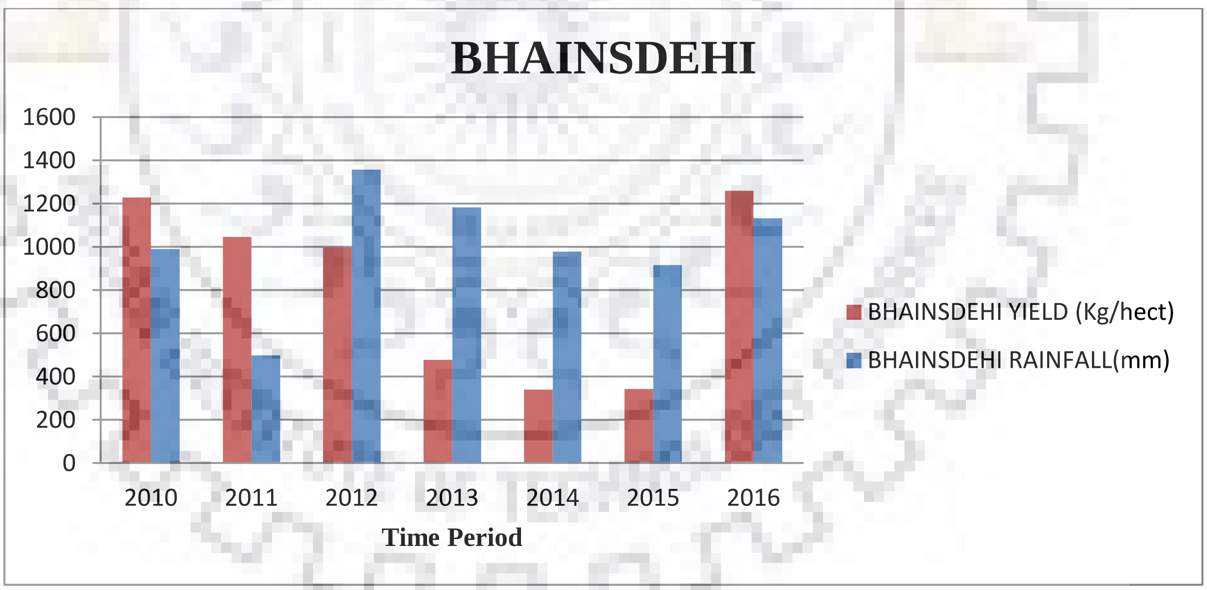


Figure 5.12 Bhainsdehi soyabean yield (kg/hect) and Bhainsdehi rainfall (mm)

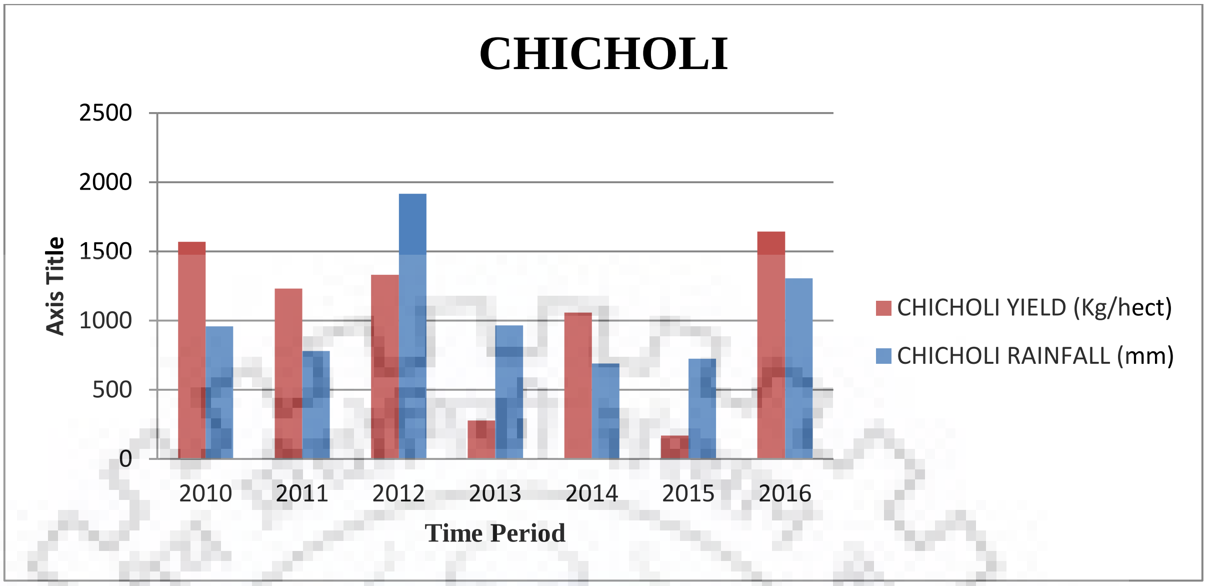


Figure 5.13 Chicholi soyabean yield (kg/hect) and Chicholi rainfall (mm)

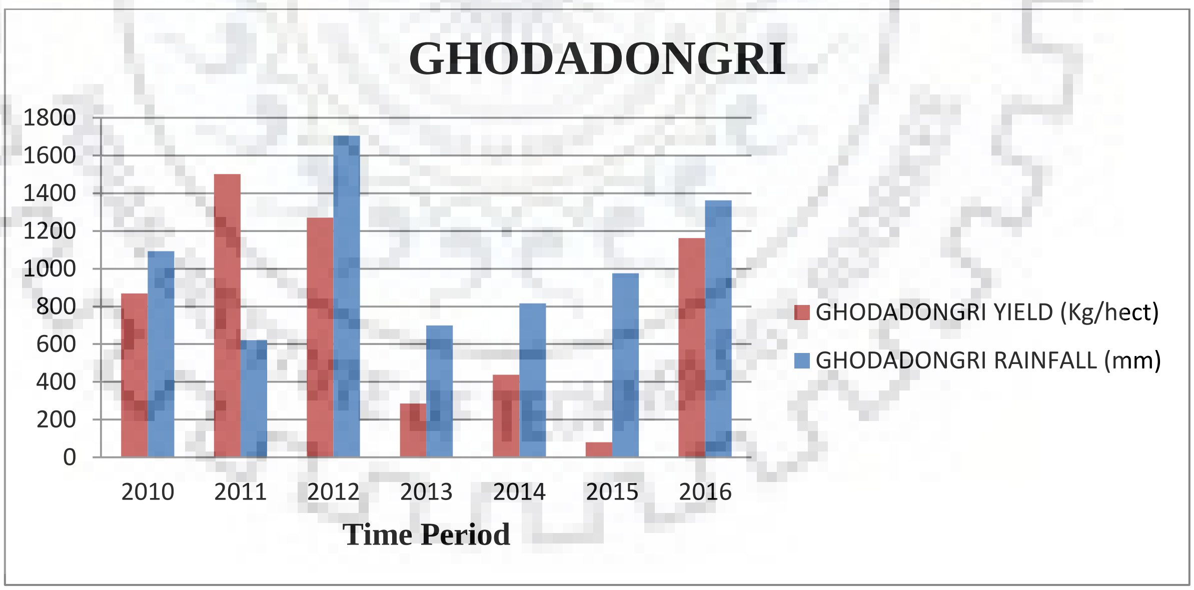


Figure 5.14 Ghodadongri soyabean yield (kg/hect) and Ghodadongri rainfall (mm)

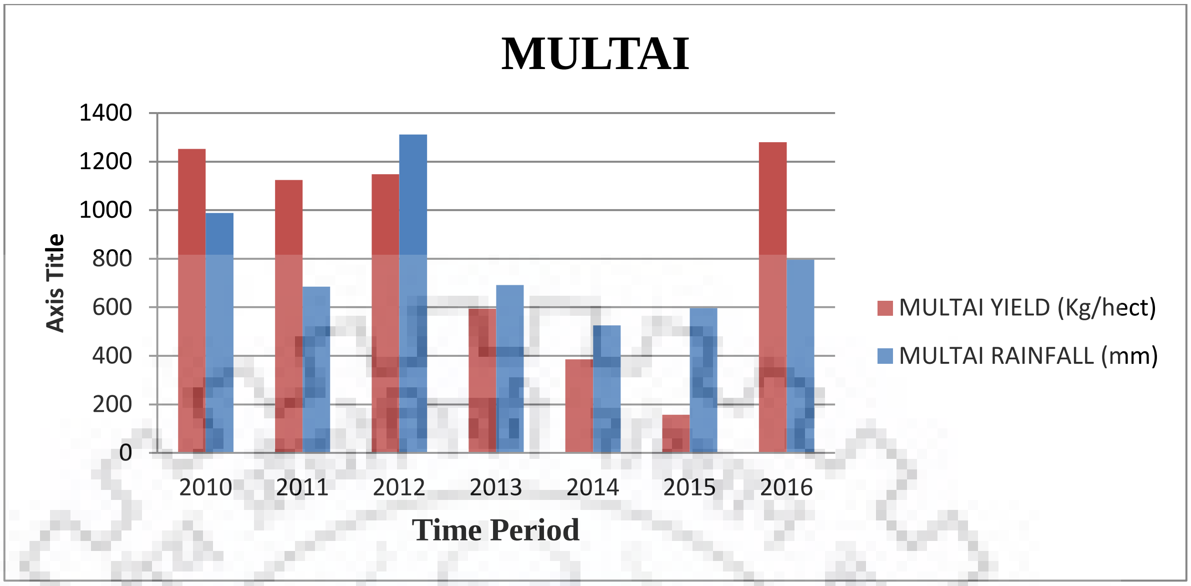


Figure 5.15 Multai soyabean yield (kg/hect) and Multai rainfall (mm)

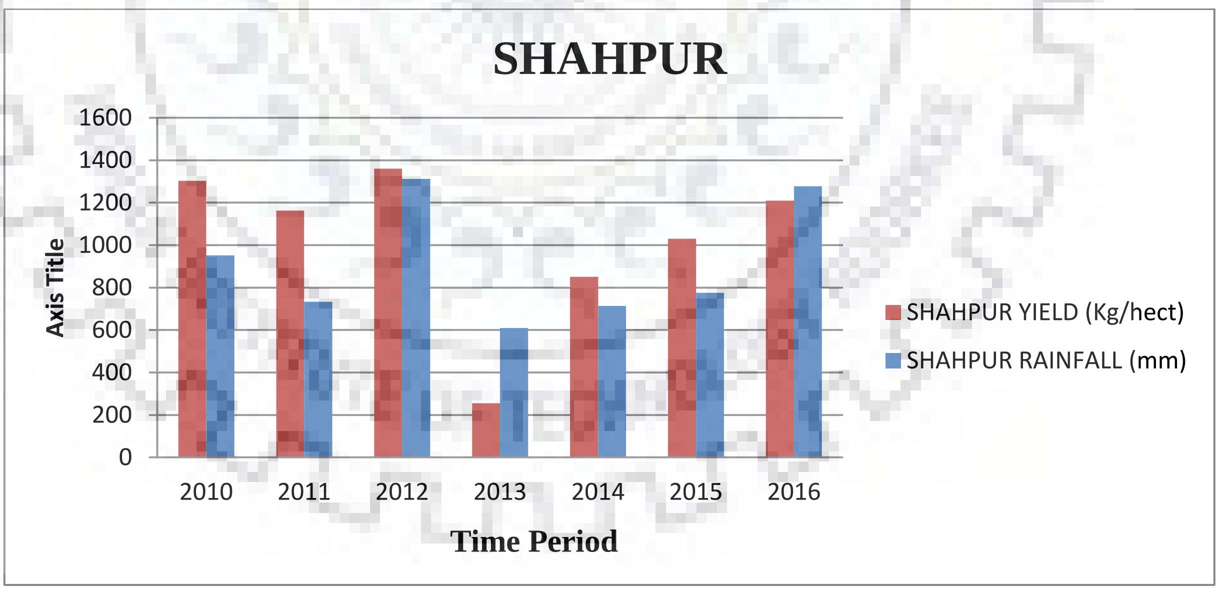


Figure 5.16 Shahpur soyabean yield (kg/hect) and Shahpur rainfall (mm)

5.3.8 Water use Efficiency of Soyabean

Water use efficiency of soyabeen (Kg/hect/mm) is minimum in year 2015 and maximum in 2011.water use efficiency of soyabeen of different year shows in Figure 5.17.

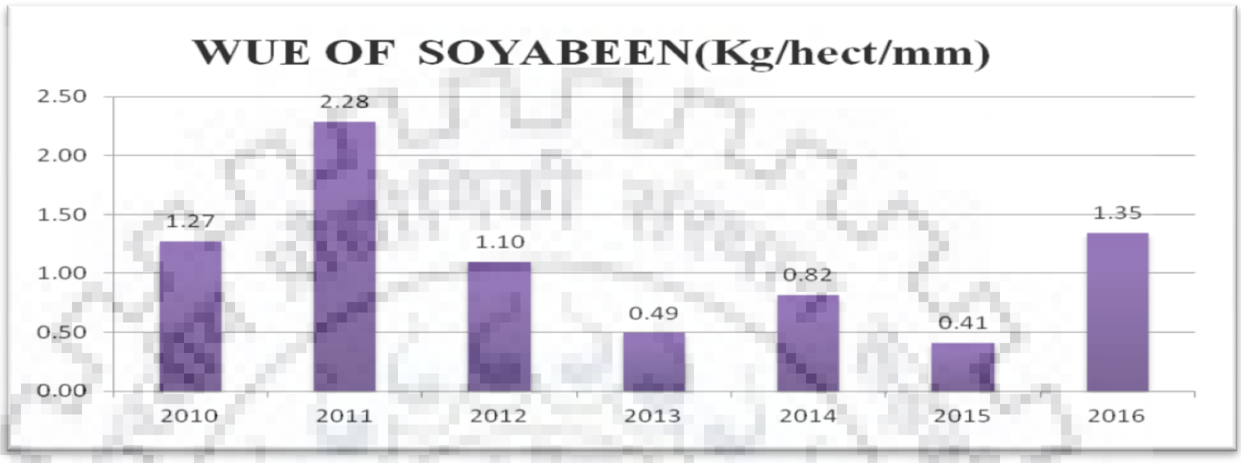


Figure 5.17 Water Productivity of soyabean (kg/hect/mm)

5.3.9 Soyabean Yield Trend

Trend of yield of soyabean (Kg/hect) represent a great fluctuation in yield of soyabean presented in Figure 5.18 .Trend show maximum yield in 2016 which is 1324 Kg/hect and minimum in 2015 which is 304 Kg/hect.

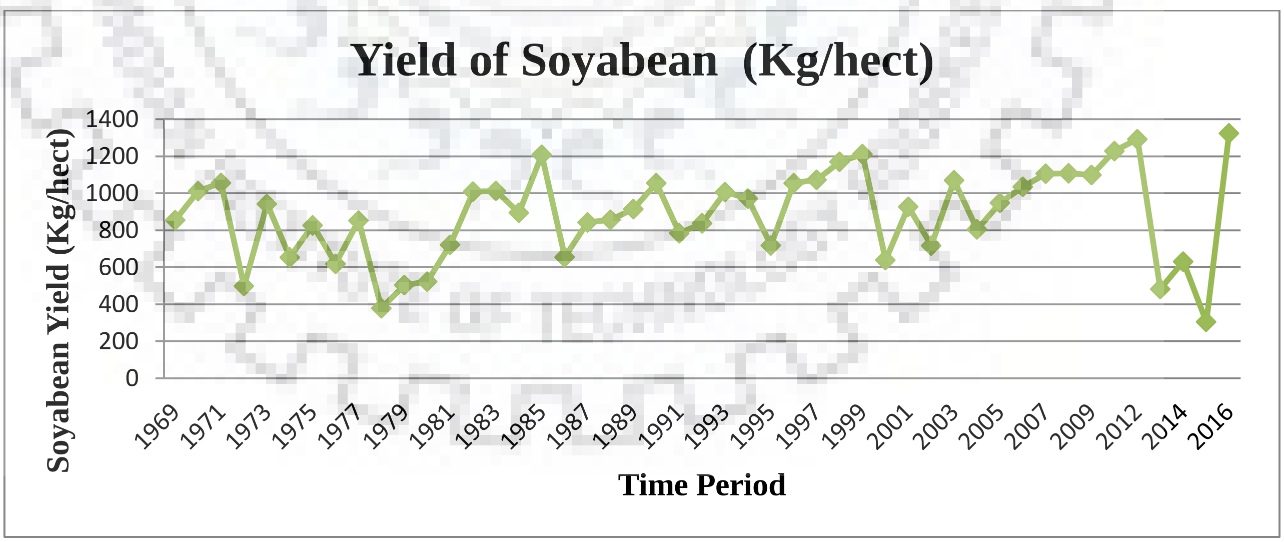


Figure 5.18 Trend of yield of soyabean (kg/hect)

5.4 Ground Water Depletion In Rabi Season And Wheat Yield

5.4.1 Wheat Yield of Different Block

Wheat yield (kg/hect) of development blocks gives as idea about region where the wheat should be cultivated where water productivity is more it also in providing crop loan in case crop failure. This statistics help in estimating the production in district, state and country and help in analyzing food security. Block wise yield for wheat crop is presented in Figure5.19.The average wheat yield for Betul district is shown in Figure5.20

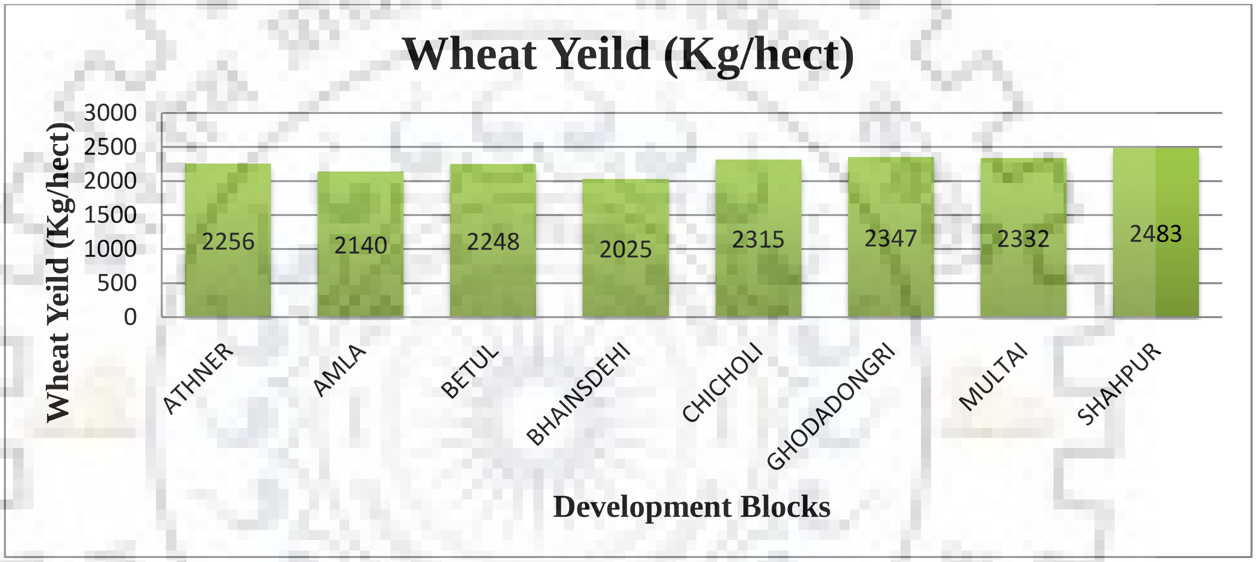


Figure 5.19 Five year average yield (kg/hect) of wheat

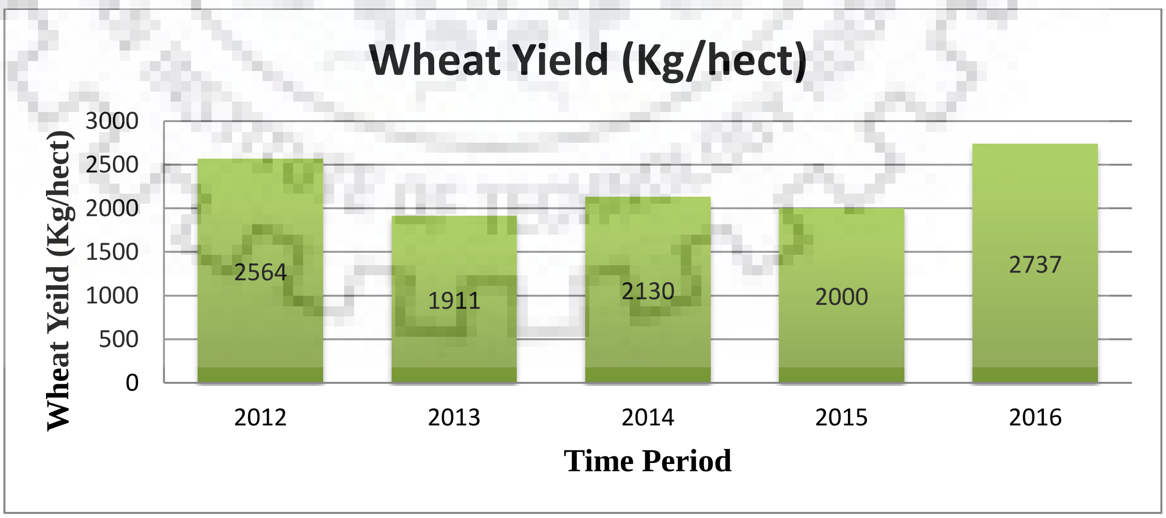


Figure 5.20 Betul District yield (kg/hect) in different year

5.4.2 Average Ground Water Depletion during a Rabi Season

Water depletion in rabi season is essential component for water security because it is non monsoon season so ground water is only source for irrigation .the ground water level depletion is presented in Figure 5.21.

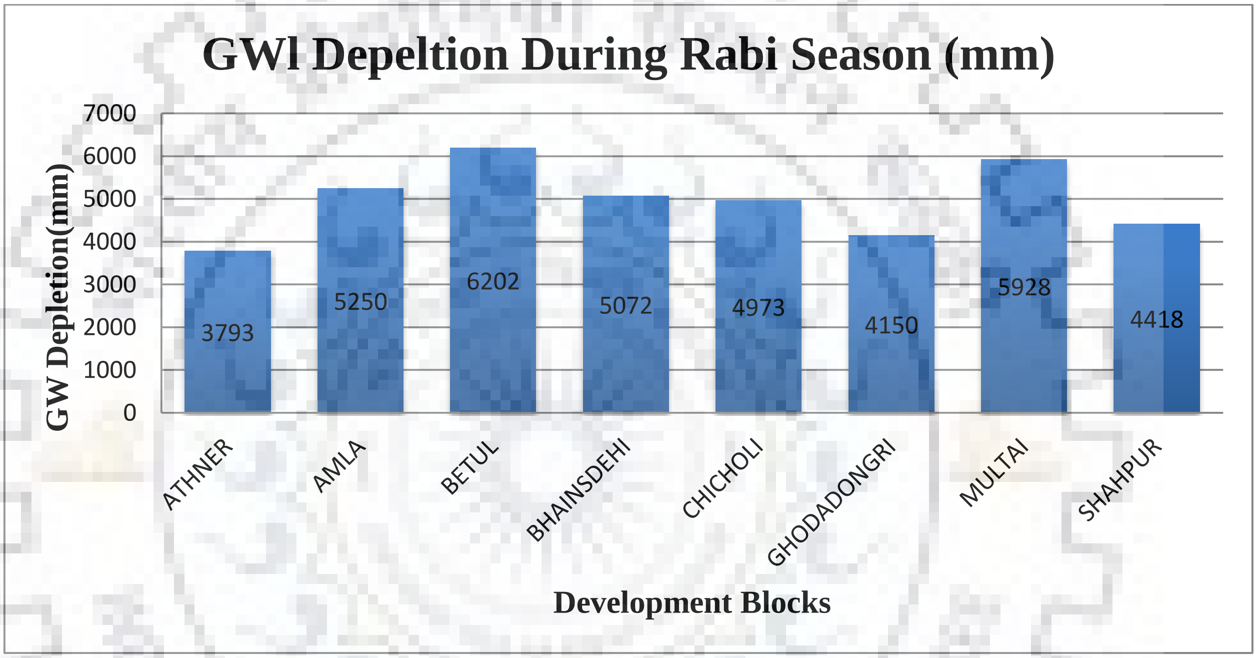


Figure 5.21 Five year average ground water depletion during a rabi season

5.4.3 Relation Between Grund Water Depltion And Wheat Yield

Development block wise representation gives idea about which area water management is required in this way we can really know what measures should be taken to avoid the water deficiency. Figure 5.22 to Figure 5.29 presents water use in rabi season in (mm) and wheat yield (kg/hect) in different development block (Athner, Amla, Betul, Bhainsedehi, Chicholi, Ghodadongri, Multai, Shahpur) of district Betul (Study Area).

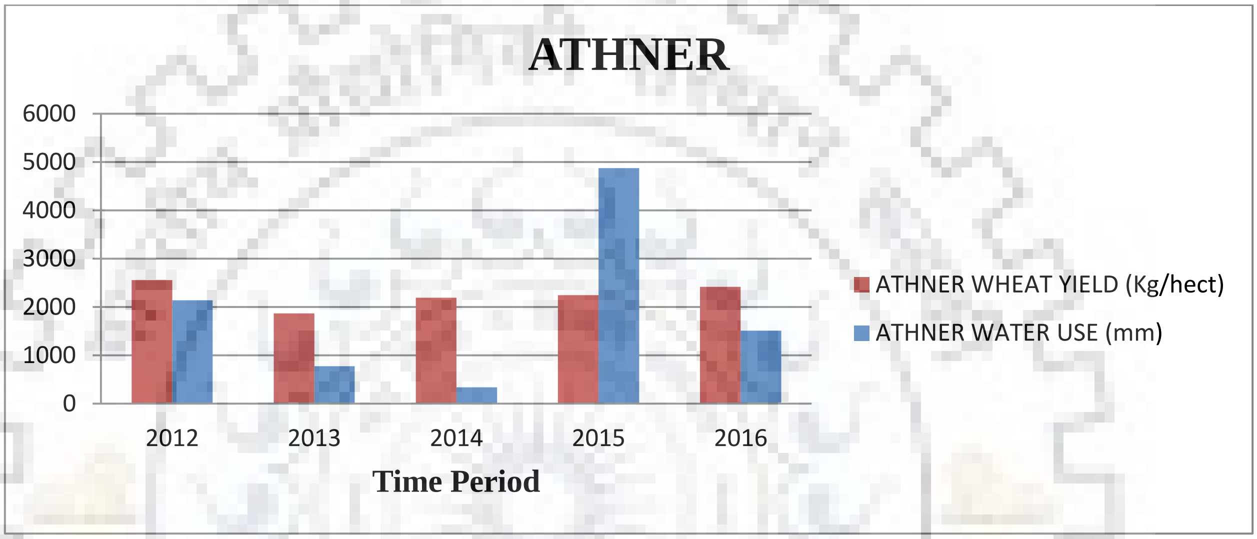


Figure 5.22 Athner wheat yield (kg/hect) and water used in rabi season (mm)

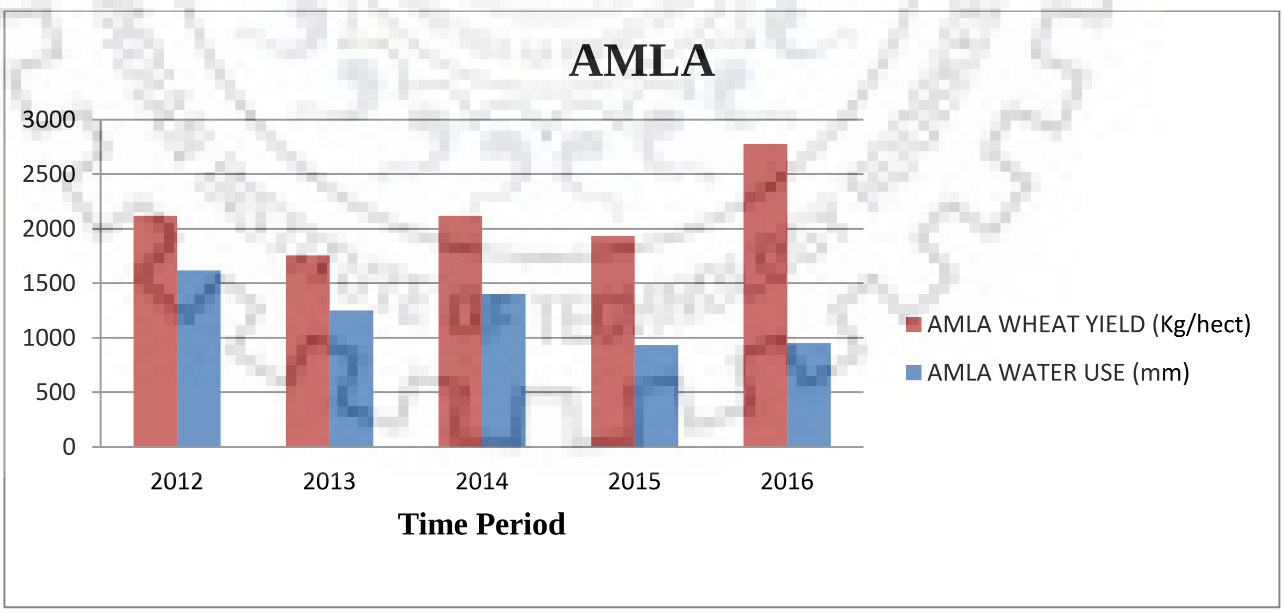


Figure 5.23 Amla wheat yield (kg/hect) and water used in rabi season (mm)

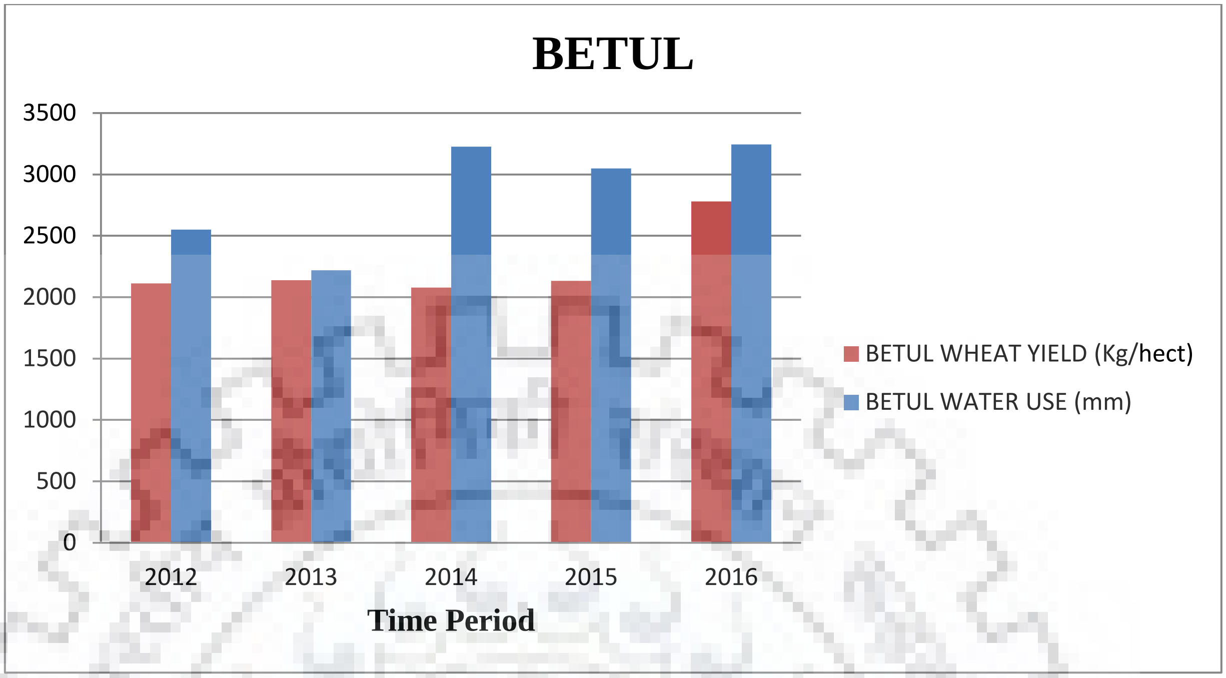


Figure 5.24 Betul wheat yield (kg/hect) and water used in rabi season (mm)

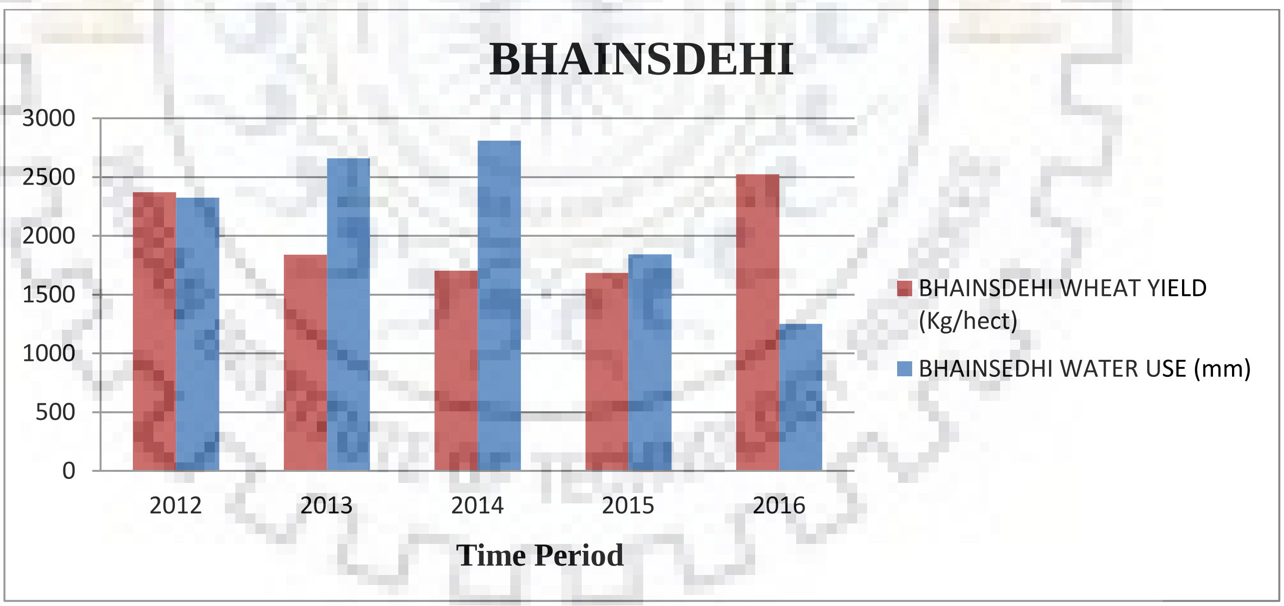


Figure 5.25 Bhainsdehi wheat yield (kg/hect) and water used in rabi season (mm)

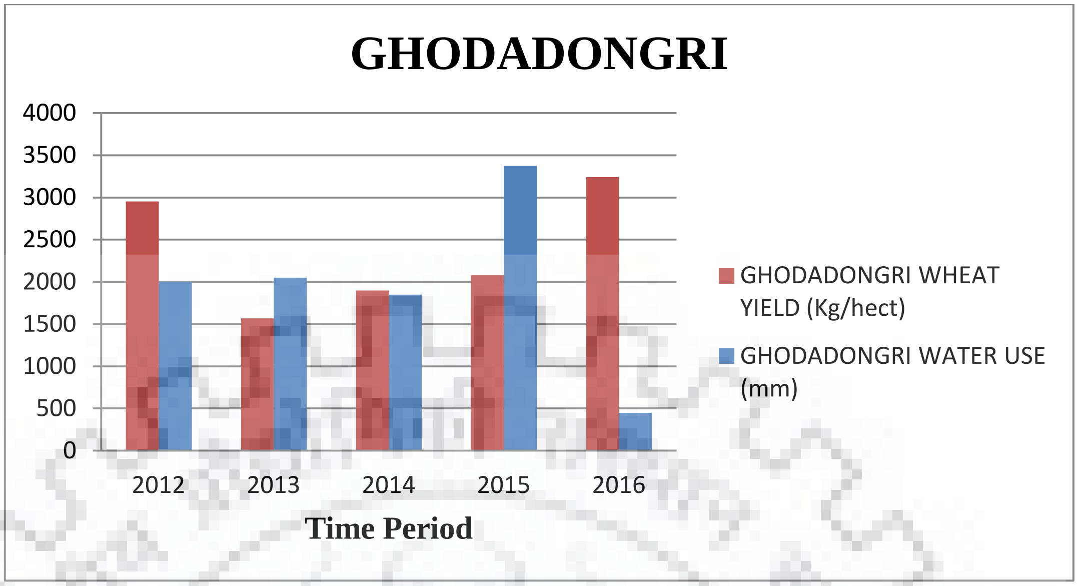


Figure 5.26 Ghodadongri wheat yield (kg/hect) and water used in rabi season (mm)

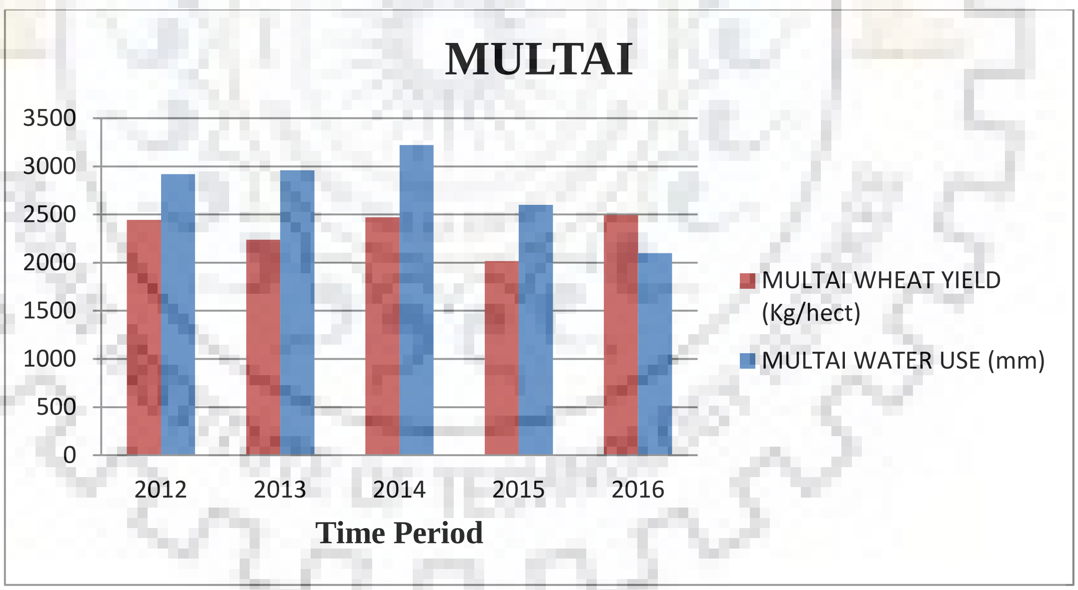


Figure 5.27 Multai wheat yield (kg/hect) and water used in rabi season (mm)

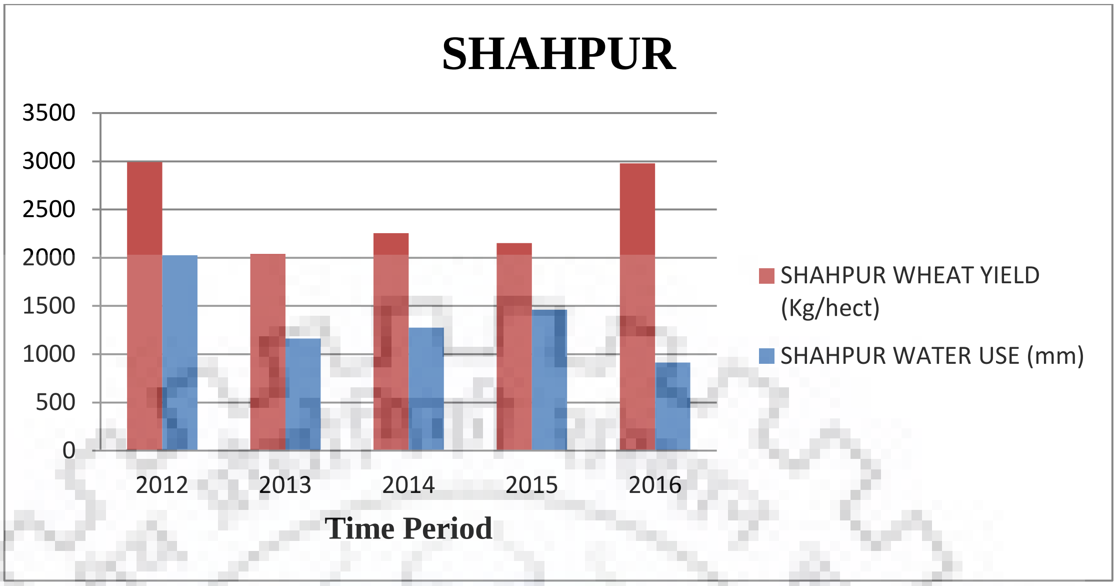


Figure 5.28 Shahpur wheat yield (kg/hect) and water used in rabi season (mm)

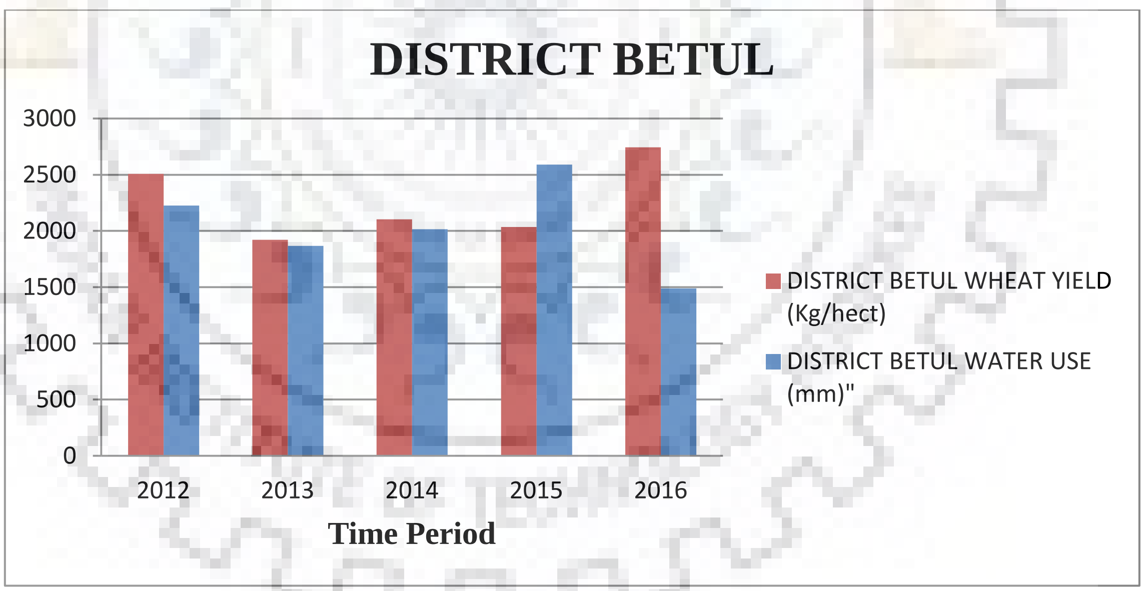


Figure 5.29 District Betul wheat yield (kg/hect) and water used in rabi season (mm)

5.5 Ground Water Recharge Using Observation Well

5.5.1 Elevation of Observation Well

Reduce level observation well is used to find reduce level of water surface in post-monsoon and pre-monsoon. The location and elevation of observation wells is given in Table 5.7.The elevation of a well like any other structure is measured from the mean sea level. A height of measuring point is assigned to each well. When height of measuring point is added to the mean sea level and after deducting the water level from the height of measuring point you get the existing water level. This process is performed pre monsoon and post monsoon and the water level recuperated can be assessed. The majority of the wells lie in the range of 571.62m to 768.67m. (Figure5.30)

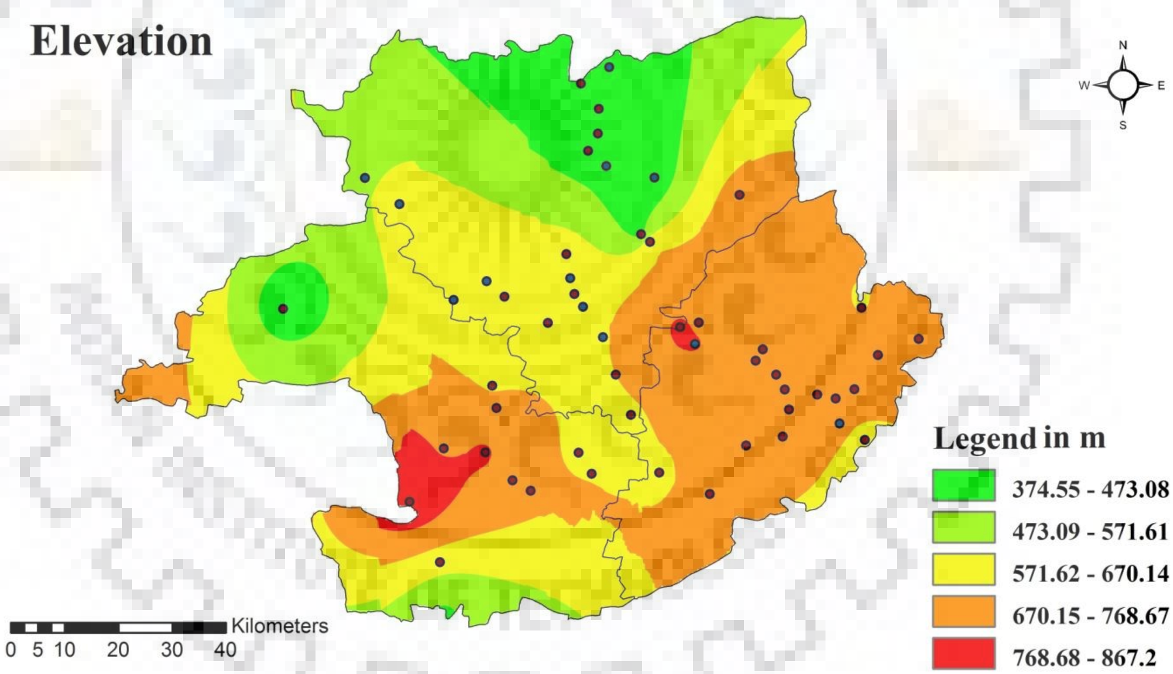


Figure 5.30 Reduce level of observation well in meter

Table 5.7 Locations and Reduce Level in (m)

Latitude	Longitude	Observation Well	Elevation of Ground Level
21.46667	77.65	SBTL-005-OW	613.5
21.72917	77.74167	SBTL-009-OW	712.65
21.59167	77.80833	SBTL-015-OW	702.7
22.27917	77.875	SBTL-017-OW	374.3
22.19583	77.90833	SBTL-018-OW	385.58
21.875	77.82917	SBTL-022-OW	637.16
21.62361	77.91667	SBTL-029-OW	667.08
21.62917	78.0375	SBTL-031-OW	663.63
21.59583	78.12917	SBTL-036-OW	683.41
22.10028	78.16667	SBTL-037-OW	736.5
21.82222	78.20417	SBTL-038-OW	753.15
21.67917	78.19167	SBTL-040-OW	687.16
21.775	78.25833	SBTL-042-OW	757.36
21.69583	78.25694	SBTL-043-OW	723.42
21.69444	78.40417	SBTL-048-OW	630.14
21.8375	78.42361	SBTL-049-OW	753.91
21.86667	78.49583	SBTL-050-OW	724.35
22.2375	77.90833	SBTL-052-OW	377.83
22.16667	77.89167	SBTL-054-OW	418.31
21.99167	77.85833	SBTL-056-OW	637

21.925	77.875	SBTL-057-OW	656.5
22.02917	77.99167	SBTL-059-OW	443.81
22.01667	78.00833	SBTL-060-OW	643.83
21.91667	77.75	SBTL-062-OW	623.65
21.88333	77.35278	SBTL-069-OW	398.2
21.76667	77.73333	SBTL-070-OW	654.97
21.65417	77.725	SBTL-072-OW	779.6
21.60833	77.775	SBTL-073-OW	724.42
21.65833	77.65	SBTL-074-OW	755.77
21.56667	77.59167	SBTL-075-OW	870.2
21.79167	77.95417	SBTL-077-OW	670.33
21.725	77.98333	SBTL-078-OW	655.14
21.65833	77.89167	SBTL-079-OW	652.95
21.88333	78.1	SBTL-083-OW	750.03
21.875	78.06667	SBTL-084-OW	785.58
21.7625	78.35	SBTL-089-OW	694.75
21.91667	78.39167	SBTL-090-OW	663.78
21.8	78.24167	SBTL-092-OW	758.19
21.84167	78.21667	SBTL-093-OW	744.42
21.74167	78.26667	SBTL-094-OW	736.21
21.77917	78.38333	SBTL-098-OW	733.46
21.76833	78.31667	SBTL-100-OW	741.8

5.5.2 District Map of Ground Water Recharge

Assessment of groundwater recharge is necessary to find the groundwater availability as it helps in

Recharge = Post monsoon water Elevation(Nov-Dec)–Pre monsoon water Elevation(May)

formulating the irrigation management policies, which helps to ensure crop and food security.

Recharge is found out by deducting the pre-monsoon water surface elevation from the post-monsoon water surface elevation.Figures 5.31 to 5.34 show the trend of recharge for a period of 33 years starting from 1984 till 2016. ArcGIS 10.2 environment has been used to map the recharge. Recharge maps have been developed for a period of 5 year interval namely 1984, 1990, 1995, 2000, 2005, 2010, 2015 and 2016. Different colour codes are assigned for regions with respect to amount of recharge. One significant remark which can be made from the recharge maps is that there is no specific trend or location of groundwater recharge, but the central region is always having recharge.

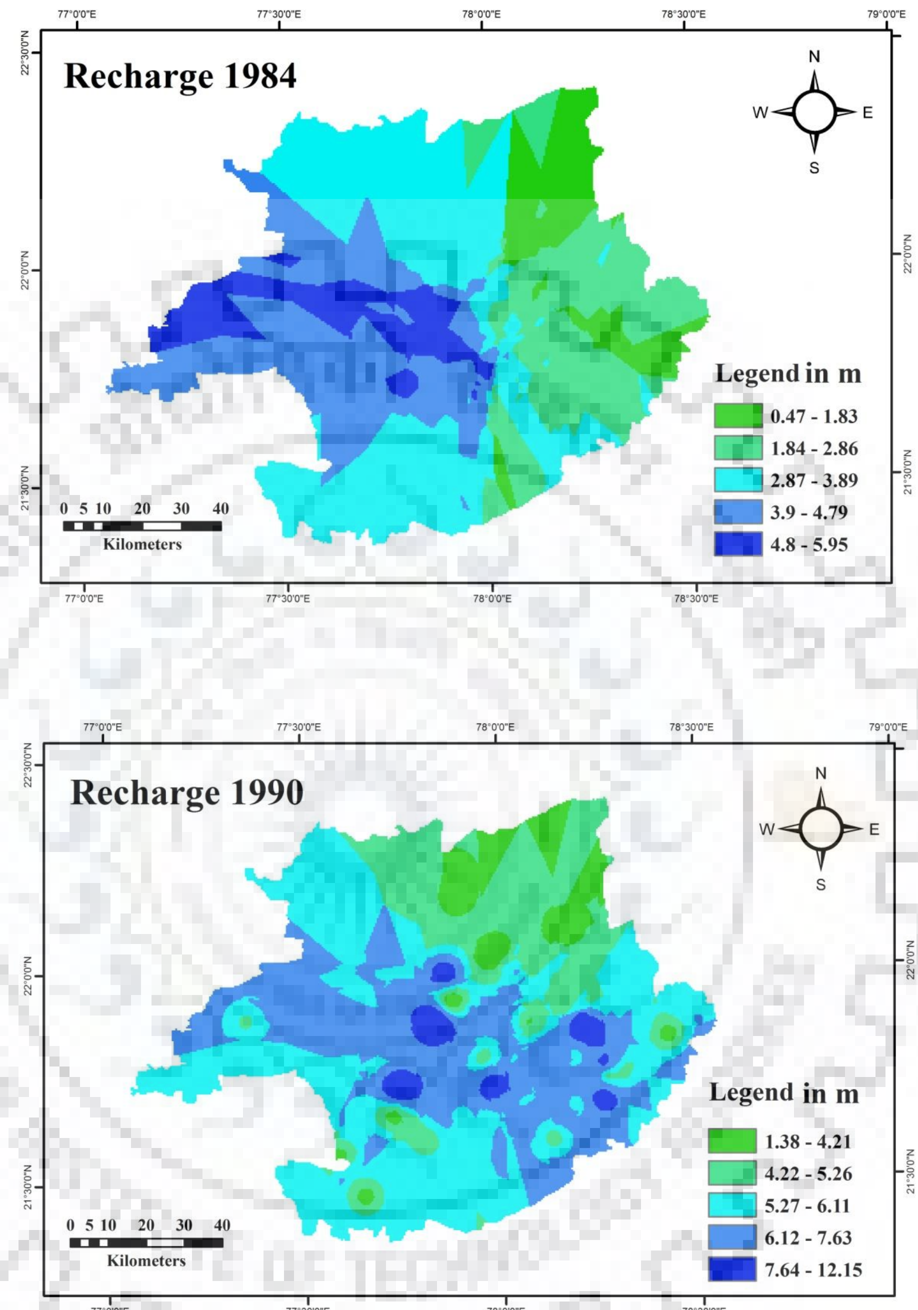


Figure 5.31 District Map showing ground water recharge in year 1984 and1990

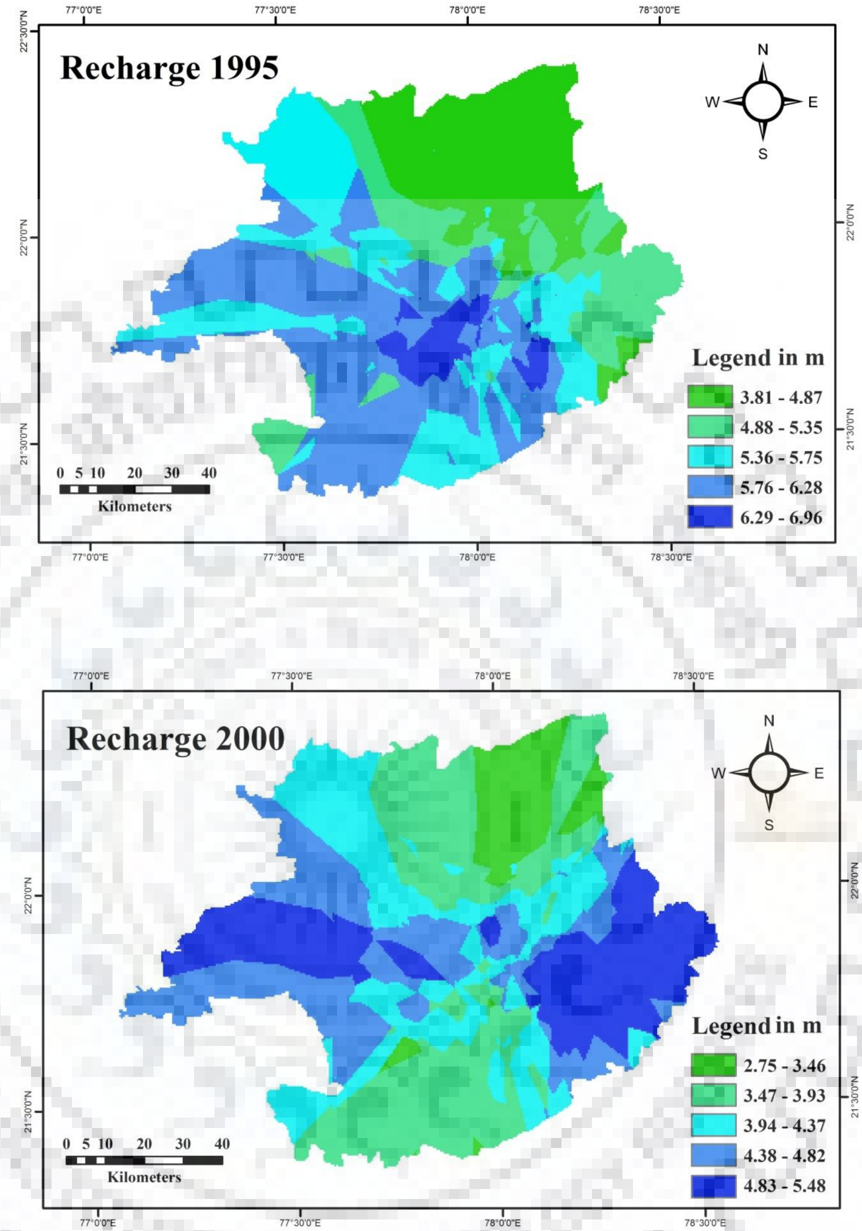


Figure 5.32 District Map showing ground water recharge in year 1995 and 2000

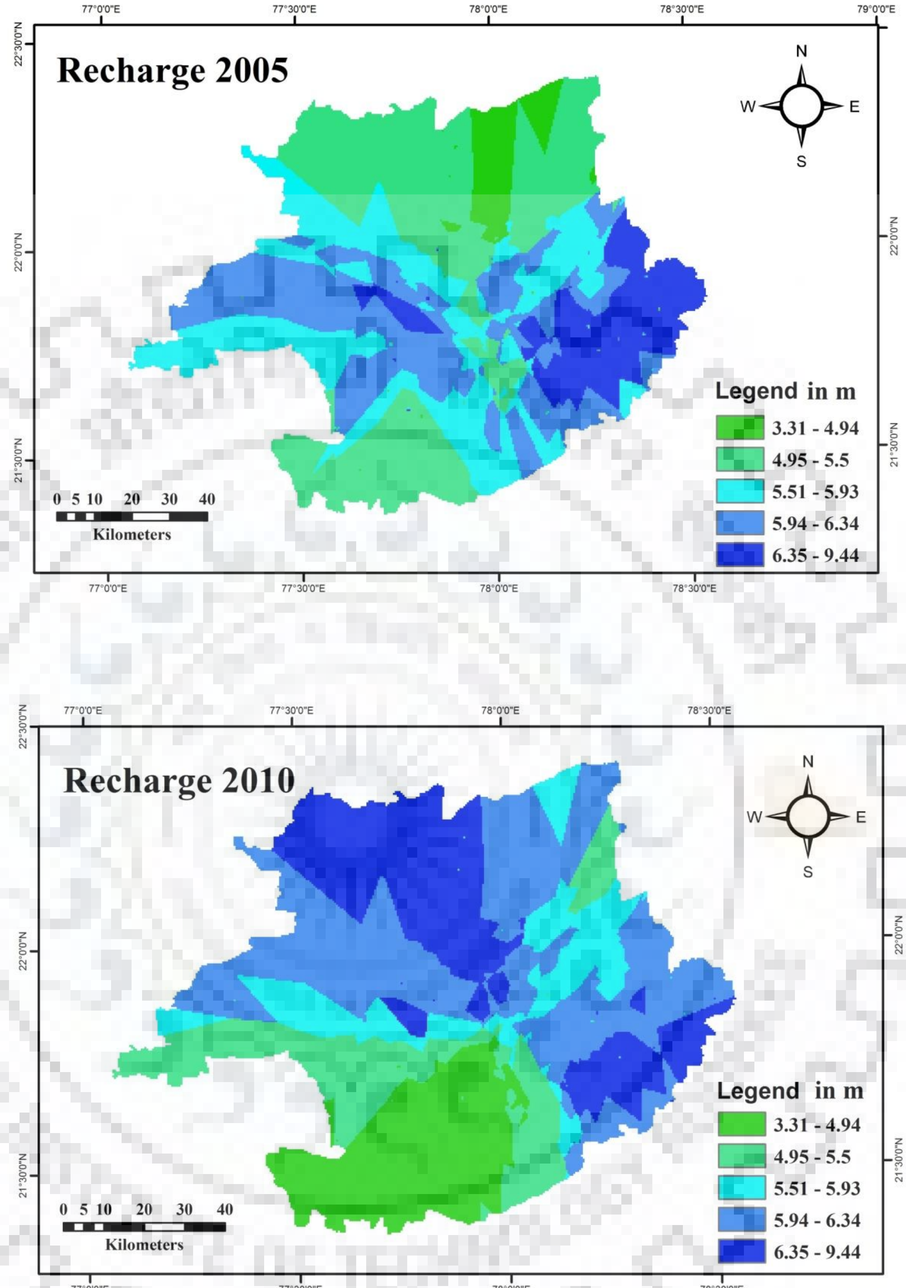


Figure 5.33 District Map showing ground water recharge in year 2005 and 2010

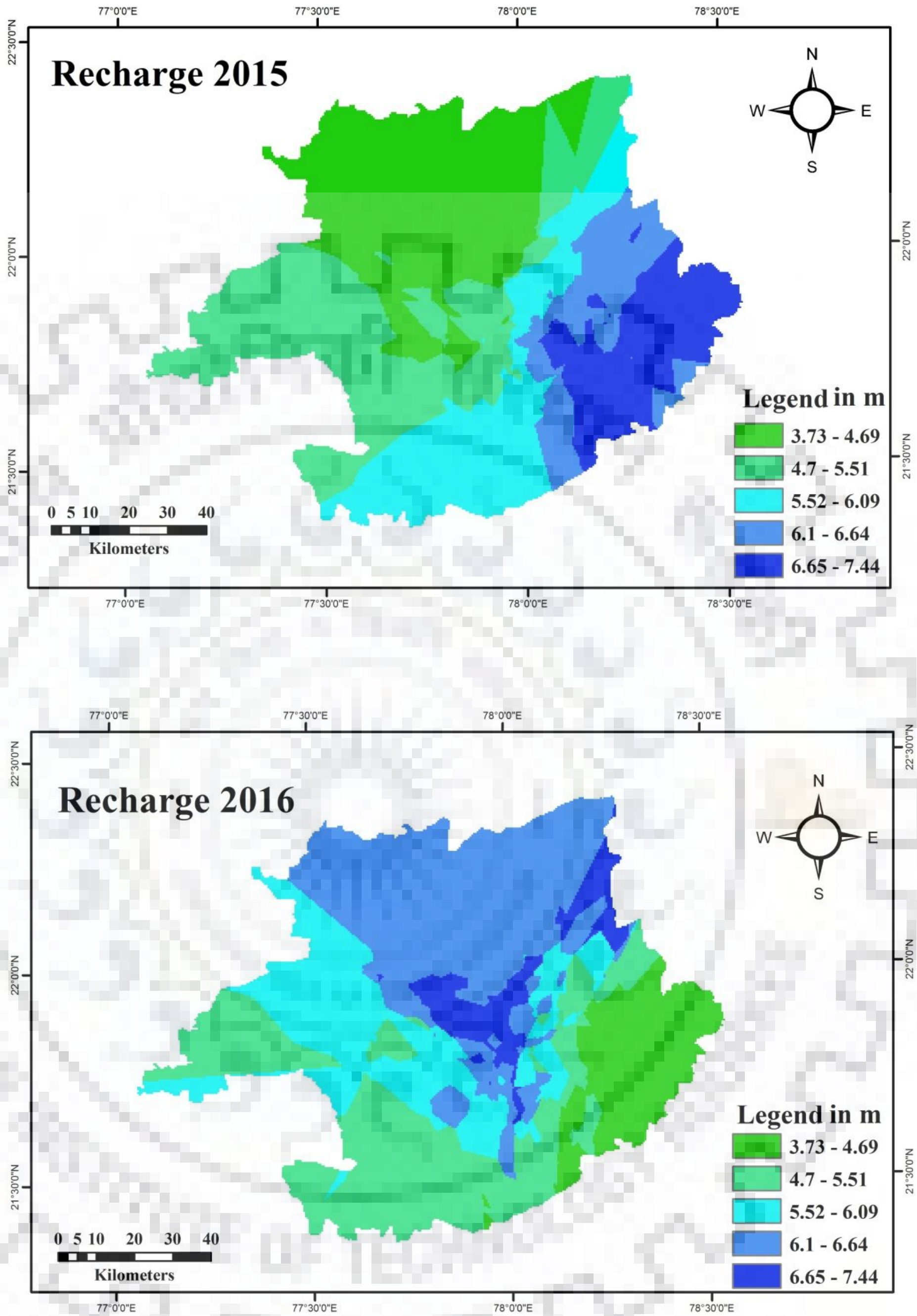


Figure 5.34 District Map showing ground water recharge in year 2015 and 2016

5.6 Ground Water Depletion in Rabi Season

Collecting data from observation well from different location in district with elevation of water surface ground water depletion during rabi season is represented using ARC GIS 2.0 by using green colour light green show less water used or depleted dark green show more amount of water used during rabi season. Water depletion in rabi season is generally depends upon water consumption for rabi crop in the season .the main issue is water defiance in end of the rabi season with affect the yield of the rabi crop if there is lack planning and or wrong interpretation in water availability then yield produce would be less than expected.

Water Depletion in rabi season= Water surface elevation (Nov) –Water surface elevation (Feb-Mar)

Figure 5.35 to 5.39 shows the variation in the water consumption by wheat in Rabi season for a period 34 years starting from 1985 till 2016. For mapping the yield of wheat ArcGIS 10.2 environment has been used. Dark green colour represents higher water consumption and light green represents lower consumption of water. It further gives us the information about the yield of wheat, as it is proportional to water consumption. From the maps of the year 1990, 1995, 2005 and 2016 it can be inferred that less water was consumed by wheat resulting in lesser yield of wheat.

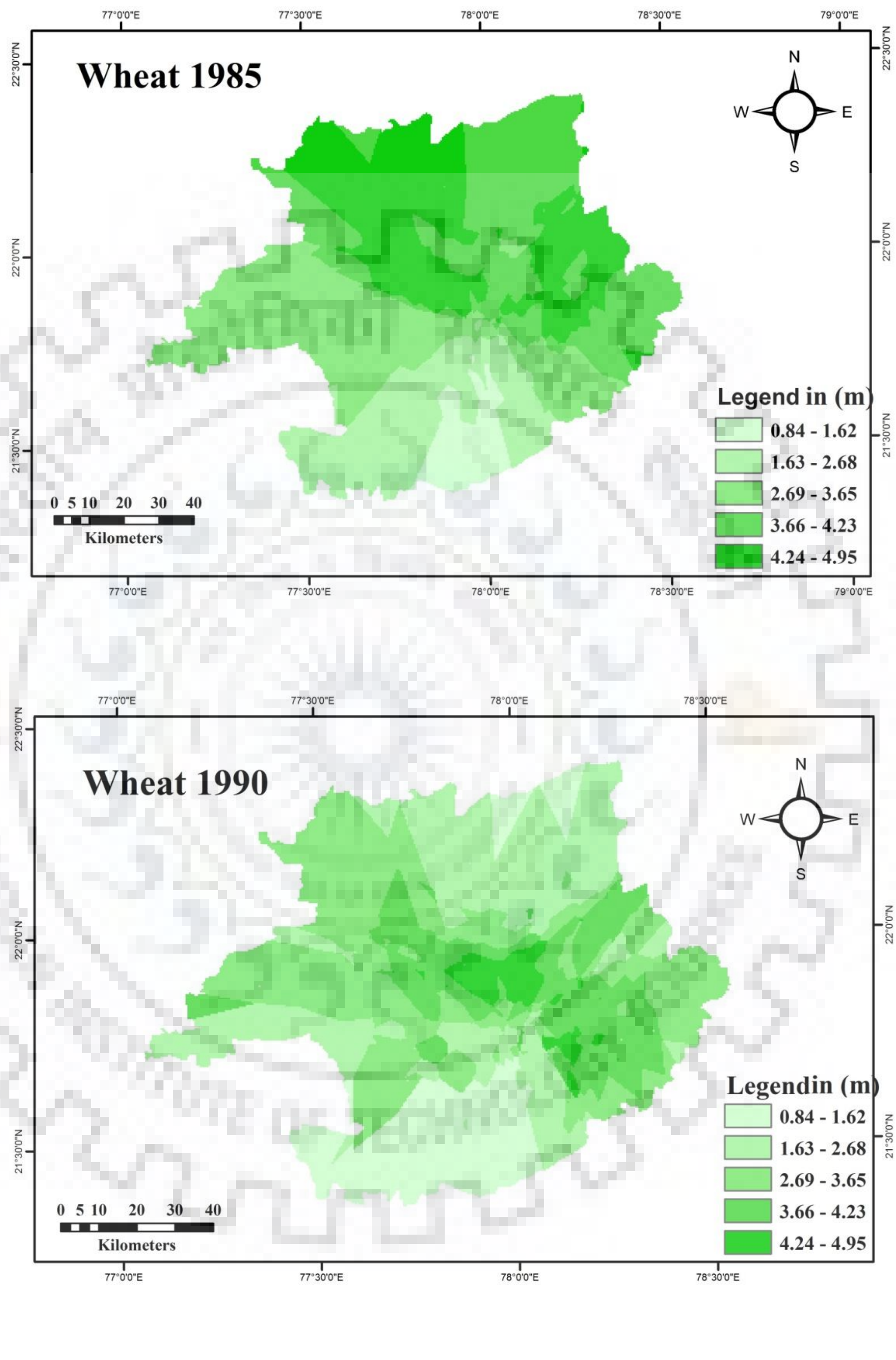
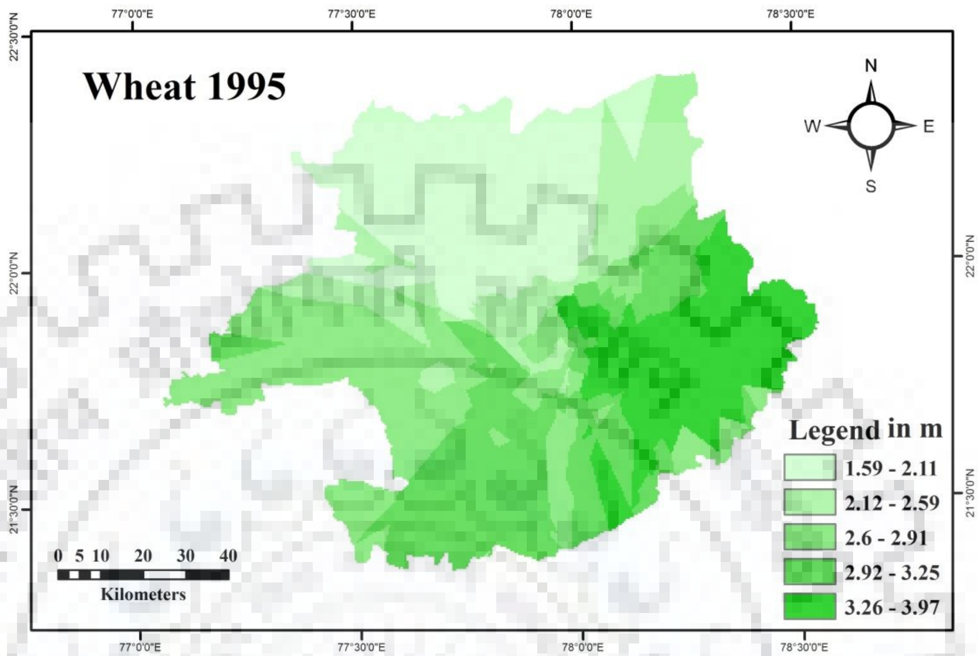


Figure 5.35 District Map for water consumption by wheat for the year 1984 and1990



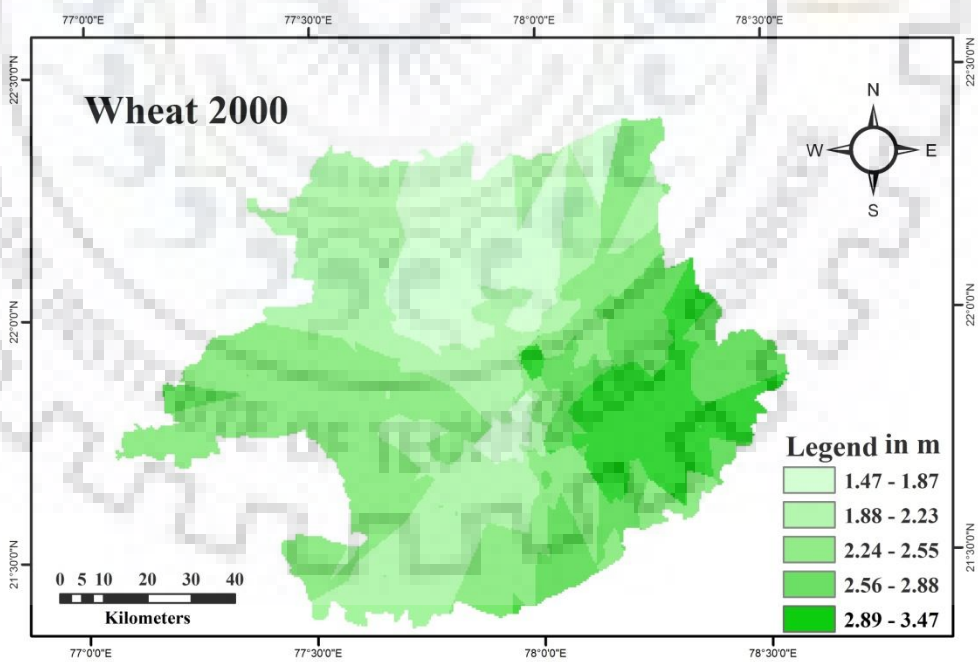


Figure 5.36 District Map for water consumption by wheat for the year 1995 and 2000

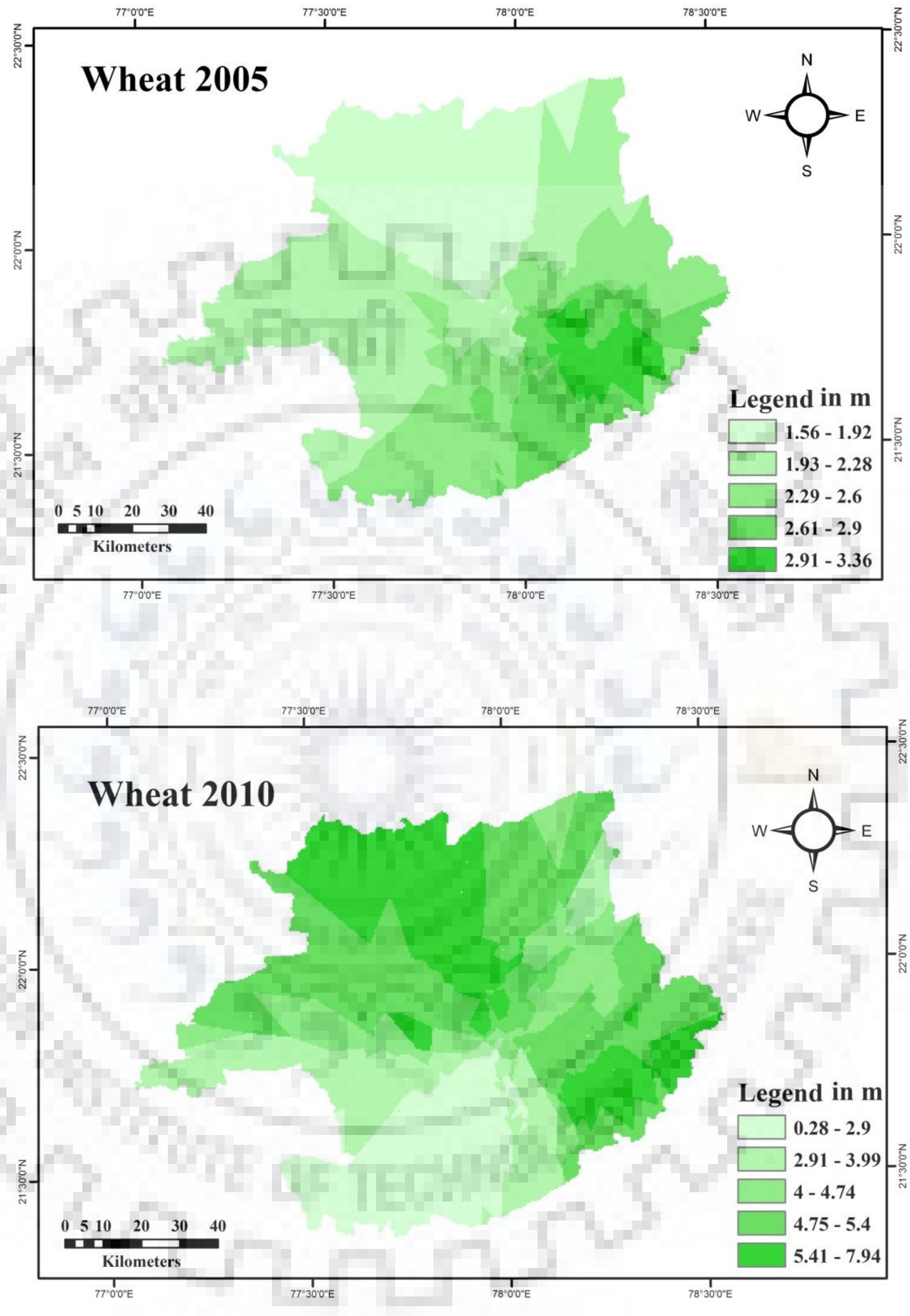


Figure 5.37 District Map for water consumption by wheat for the year 2005 and 2010

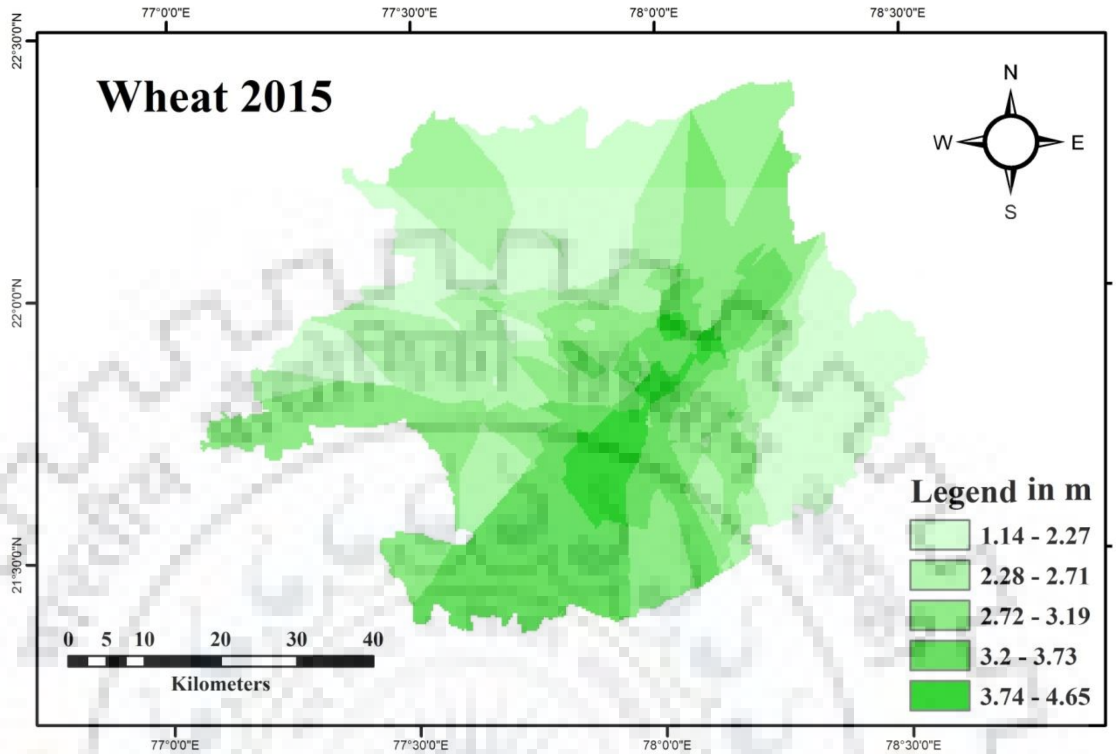


Figure 5.38 District Map for water consumption by wheat for the year 2015

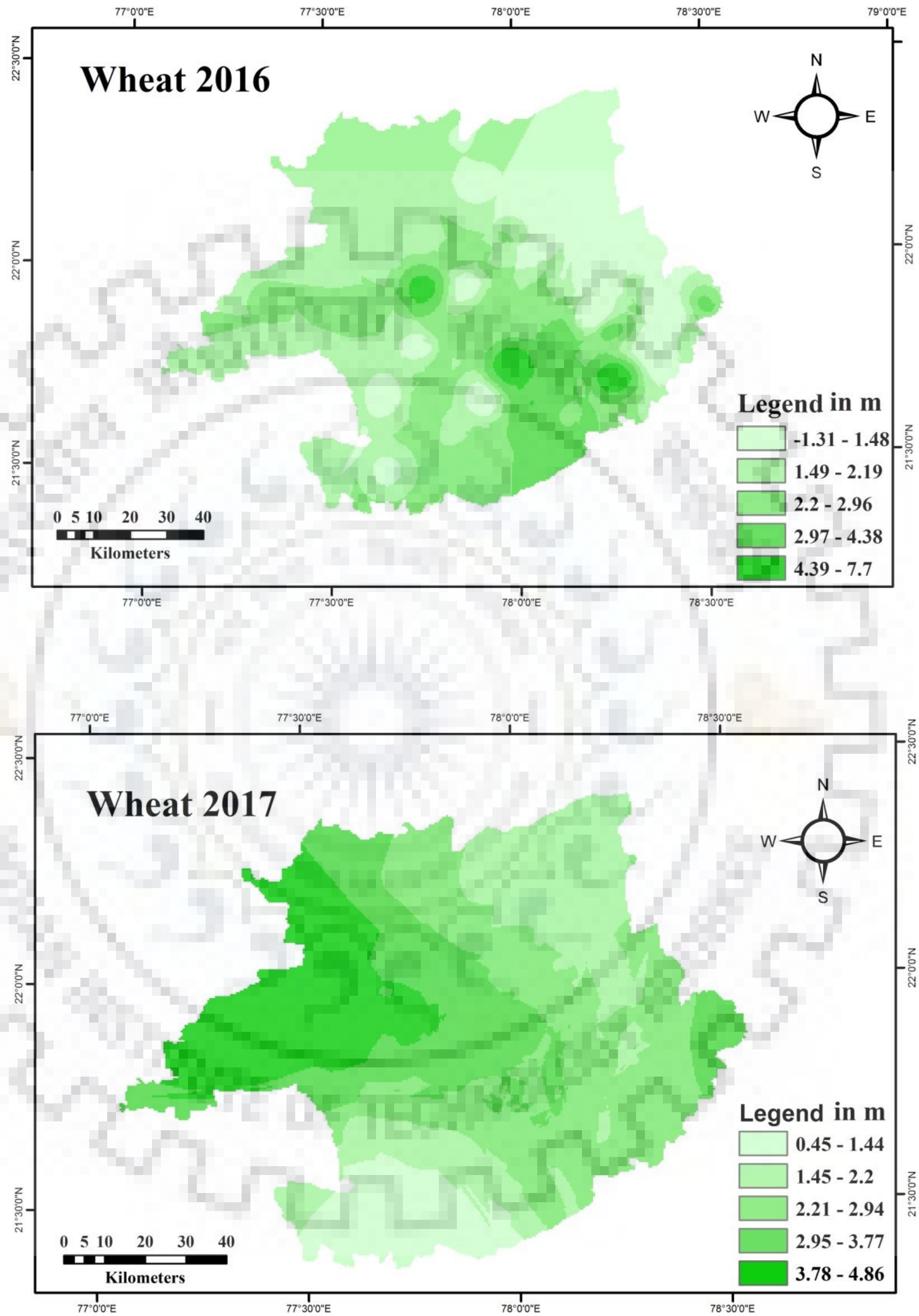


Figure 5.39 District Map for water consumption by wheat for the year 2016 and 2017

5.7 Farmer Survey

Extensive field survey was conducted, and after discussing with the cultivators the field data was compiled. It has been found that in Rabi season wheat is the most preferred crop reason being its price does not fluctuate that much as compared to other cash crops. Moreover government gives Minimum Support Price (MSP), hence it is considered safe and provides food grains for the livelihood of the farmers also. Recently there has been a shift in the cropping pattern; well established farmers having mature water availability are cultivating Dollar Gram as it is giving good profit. One of the typical problems with Rabi season is that the farmers are not able to supply the required number of watering as the water level in the tube well falls down, which lowers the yield. In Kharif season the most preferred crop is soybean as it is basically a rainfed crop and it doesn't even require much field preparation, whereas cotton may require artificial water supply. Soybean also has minimum support price so it is preferred, but one of the drawbacks of soybean is that if there is less rain or excess rain, the entire yield is reduced.

Problems of farmers were also discussed and are explained. Because of hailstorm, the yield of wheat reduced to half. Surface water irrigation is not available, so the farmers have to be dependent on rainfall and tube wells. A peculiar behaviour has been observed, location where the canal has been constructed, the chill production has reduced drastically due to pest attack. The farmer survey details are summarized in Table 5.8 and Table 5.9.

Table 5.8 Production of different crop in Farmer Survey

Name	Village	District	Maize Production (Quintile/ Acre)	Soya been Production (Quintile/Acre)	chilly Production (Quintile/Acre)	Cotton Production (Quintile/Acre)	Wheat Production (Quintile /Acre)	Gram Production (Quintile/ Acre)
kishan lal	selgaon	Betul	20	2	No	No	10	3
Shri Ram	Devgaon	Betul	No	7	No	No	12	6
Nirbah	kajli	Betul	17	4	No	No	12	5.5
Mira Bai	pagra	Betul	10.85	3.5	No	No	10.85	No
Gopichand	Choki	Betul	12	3	No	No	10	No
Devi singh	Devgaon	Betul	25	3.5	No	No	18	3.5
Shiv	mahadgon	Betul	17.5	3	No	No	16	No
Premlal	mahadgon	Betul	15	2	No	No	1.2	No
Sunil	mahadgon	Betul	5	2.5	No	No	9	4.5
Yograj	gona	Betul	15	4.5	No	No	18	2
Ramesh	kajli	Betul	10	6	No	No	16	5.5
Sanjay	piprya	Betul	21	6.5	No	No	10	6.5
Abhishek	juwadi	Betul	15	6	No	No	10	8
Rupesh	Choki	Betul	25	7	No	No	12	6
Chander	Devgaon	Betul	18	8	No	No	5	7
Suresh	Devgaon	Betul	No	6	No	No	5	No
Hansraj	surgaon	Betul	12	1	No	No	18	No
Rakesh	hivarkhedi	Betul	15	10	No	No	20	10
kelash	Devgaon	Betul	No	4	No	No	2	8.5
Ram	Surgaon	Betul	No	3	No	No	8	No
Deepak	Paregaon	Betul	No	3.5	No	3.5	13	7
kamchand	Kharsali	Betul	No	No	12	5.5	8	7
Akhilesh	Deori	Betul	No	5	10	4	15	4.5
Skaram	Paregaon	Betul	No	No	10	4	20	7.5
Bupendra	Karpa	Betul	No	No	9	11	15.5	4.5
Rajaram	Badegaon	Betul	No	2	No	11	12	No

Table 5.9 Response of farmers during Field Survey

Name	Village	Method Of Irrigation	Climate Change Knowledge	Remarks
Kishan Lal Sahu	Selgaon	Farrow Form Nala &Well	Hail Storm	Climate Change Issue ,Crop Loan Problem
Shri Ram	Devgaon	GWI 300ft & Drip Irrigation	Hail Storm	Water Security Should be There
Nirbah Yadav	Kajli	GWI Farrow &Sprinkler	Hail Storm	Climate Change Leads to Less Production
Mira Bai	Pagra	Farrow Form Well	Hail Storm	
Gopichand	Choki	GWI Sprinkler	Hail Storm	Excessive Water Lead to Rotten The Root
Devi Singh	Devgaon	GWI Sprinkler	Hail Storm	Excessive Water Lead to Rotten Root
Shiv Dhayal Singh	Mahadgon	GWI & Drip Irrigation & Sprinkler	Hail Storm	No
Premlal	Mahadgon	GWI Sprinkler	Hail Storm	No
Sunil Pawar	Mahadgon	GWI &Sprinkler& Small River	Hail Storm	Less Soya Been Price Investment
Yograj	Gona	GWI 900 Ft Farrow & Drip	Hail Storm	Due Hail Storm 60% Of Crop Damage
Ramesh	Kajli	GWI & Canal	Hail Storm	Due Hail Storm Less Yield
Sanjay	Piprya	GWI	Hail Storm	Due Hail Storm Less Yield
Abhishek	Juwadi	GWI Farrow	Hail Storm	Water Not Sufficient Throughout Crop Period ,Improper Schedule
Rupesh	Choki	GWI &Small River	Hail Storm	No
Chander	Devgaon	GWI 250ft &Drip Irrigation	Hail Storm	Water Scarcity, Hail Storm
Suresh Yadev	Devgaon	GWI Farrow	Hail Storm	No
Hansraj	Surgaon	GWI Farrow	Hail Storm	Due to Electricity Problem Wheat Crop Welted

Rakesh Yadav	Hivarkhedi	GWI & Drip Irrigation	Hail Storm	Due Hail Storm Less Yield
Kelash Singh	Devgaon	GWI Sprinkler	Hail Storm	No
Ramchandra	Surgaon	GWI Sprinkler	No	No
Deepak	Paregaon	Canal With Farrow Irrigation	No	Due Canal Command Temperature Decrease
Kamchand	Kharsali	Canal With Farrow Irrigation	No	Cultivation of Chili Decreases
Akhilesh	Deori	Canal With Farrow Irrigation	No	Cultivation of Chili Decreases
Skaram Dhogya	Paregaon	Canal With Farrow Irrigation	No	Due Canal Command Temperature Decrease
Bupendra	Karpa	Canal With Farrow Irrigation	No	Cultivation of Chili Decreases
Rajaram	Badegaon	Canal With Farrow Irrigation	No	Cultivation of Chili Decreases

CHAPTER 6

CONCLUSIONS

6.1 General

Ground water resource is having its own constraints like availability quantity and quality for used in irrigation purposes is still major irrigation source in study area, where surface water irrigation is not available. Hence there is need of proper ground water management for crop planning the consumptive use is water sufficient for plant to grow healthy. The minimum water needs for crops in the study area are solely dependent on ground water.

6.2 Conclusions

Based on present study following conclusion can be drawn;

1. On the basis of analysis of data set such as rainfall ground water depletion, temperature, soyabean and wheat yield there is great fluctuation in rainfall result in major fluctuation in yield. Farmers are depend on rainfall for irrigation is vulnerable for their crop production, fertilizer used, sowing and harvesting, due to uncertainty of rainfall and no surface water availability.
2. Trend of “Yield of Soyabean (Kg/hect)” represent a great fluctuation in yield of soyabean in recent past in 2014, 2015, 2016 its was average in 2014(631 Kg/hect) and extremely low in 2015(305 Kg/hect) and above average in 2016 (1324 Kg/hect).
3. Yield of soyabean (Kg/hect) is a standard y= mx+c equation whose slope gives us the water productivity (kg/hect/mm). Data from 1984 to 2016 pertaining to soybean yield and rainfall has been used to develop this equation. .

$$\mathbf{y = 0.3066x + 622.52}$$

4. Due to climate change, insufficient rainfall and other factors soyabeen yield in year, 2015 was found minimum in recent years.
5. Farmer survey reveals that because of hailstorm, the yield of wheat reduced to half and many such incident in notice in past few years.

6. Rainfed and ground water dependent agriculture practices are vulnerable to climate change crisis. Therefore, special attention needs to be given to the development of groundwater resources in the land there. Large-scale artificial recharge measures will be adopted.
7. Due to less water availability in rabi season farmer sifting to more efficient irrigation techniques like sprinkle and drip irrigation hence amount of water withdrawn from ground water resource.

6.3 Future Scope of Work

There are several factors other than irrigation which considerably effect the yield of an crop these study consider irrigation as an parameter which effect the yield and socio economic condition of the farmer.

Experimental plots can be used for analysing the different parameter and their effect on yield. Consumptive use can be determined by use experimental plots method which can give closer result to actual use.

Water productivity can be determined using yield data and water used in experimental plot for growing the crop.

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