CHAPTER-I

INTRODUCTION

1.1 Introduction:

The Karmala tahsil is one of in the drought prone zone tahsil in Maharashtra state. The Karmala tahsil has been declared as a drought prone region by fact finding committee in 1973. Due to very low rainfall recharge of wells is limited. Karmala tahsil has only 13.58 % NSA under irrigation. About 55.15% irrigated area is under well irrigation. Therefore the study of Ground water management has been undertaken.

It is observed in the report by various government and semi government organizations that more than seventy percent of agricultural area in the state of Maharashtra is dry farming. Several irrigation projects have been constructed but they may not be enough to meet the target of irrigated area to be 33 %. The sustainability of irrigated area has been threatened due to increasing cost of constructing dams, canals and lift irrigation schemes. The component of well irrigation is quite significant. It is about 64% of irrigated area in Maharashtra. The ground water resource is a vital resource, especially in a drought prone zone. Use of ground water resource for Agriculture may be improved by implementing watershed management programmes. Karmala thasil is one of the 92 tahsil observing drought prone conditions. The management of water resource for agriculture in the drought prone zone has been studied by several workers (Saptarshi, 1993), (Bhagat, 2004), (More, 2008), etc. The present study aims at investigating ground water potential in Karmala thasil and its cost effective use. Therefore the present study entitled, **"Ground Water Management for Sustainable Development of Agriculture in the Karmala Tahsil of Solapur District, Maharashtra"** has been undertaken. The study has adopted a micro level approach and hence the data for most of the parameters have been at village level. The ground water source of irrigation in Maharashtra is 12, 25,585 wells and in Solapur district about 62,830 and in Karmala tahsil about **13577** wells and **5478** bore wells. There are also 145 minor tanks and 228 Streams used for irrigation. The present study has attempted to design strategy for use of ground water for two to there cropping seasons on sustainable basis so that shocks of droughts would be reduced considerably.

There are many places in Maharashtra particularly in arid zones. Where the ground water is available but the management is questionable. The villages getting benefit of canal irrigation or any other sources of surface water have shown decling ground water levels. The purchasing power of the farmers in the irrigation zone has increased sufficiently and hence they can invest money for construction of bore wells. In this way phenomenal increase in density of wells has been observed in the tahsil. This has put pressure on ground water. Therefore, it is interesting study which may give base for agricultural planning.

1.2 Importance of the Study:

By and large the concept of conservation of environmental resources has been well accepted notionally. In the developing countries like ours it has posed many challenges to the planners and implementing agencies. The present study attempts to meet such challenges.

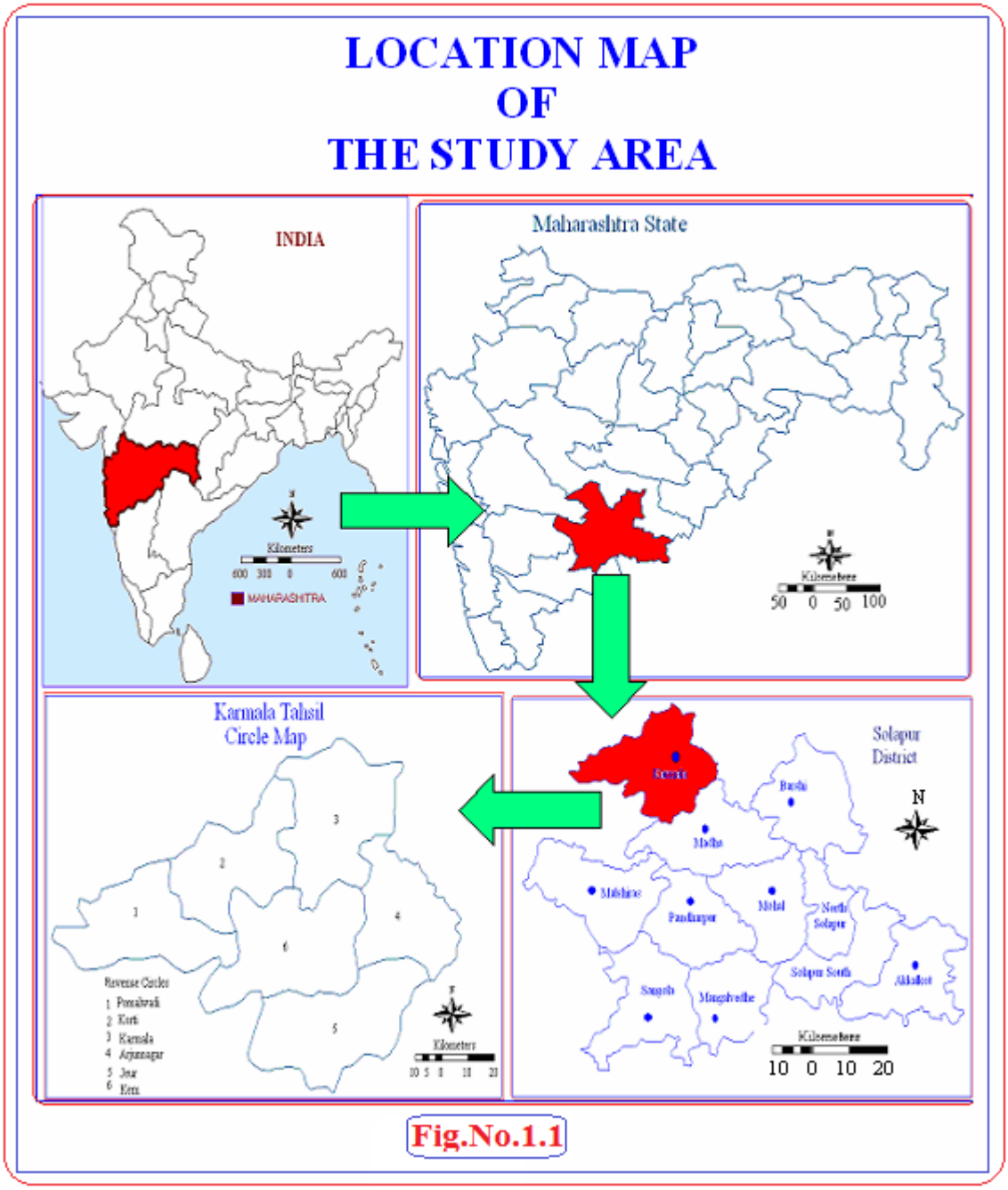
The 'action plan' suggested in the study would certainly aim at reducing such pressure on the surface and ground water. Thus, the significance of the study lies in both its academic values in the context of recent trends in environmental geography.

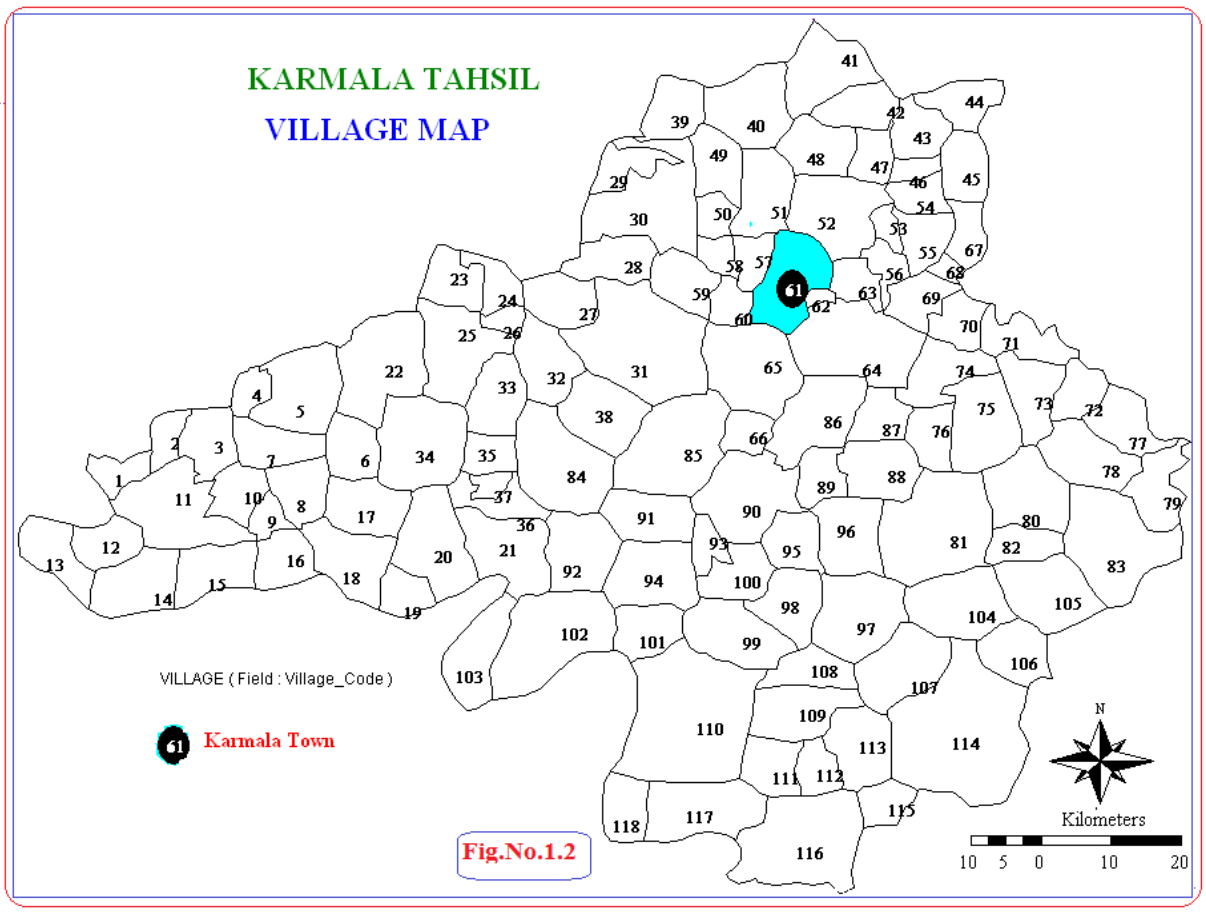
There are many places in Maharashtra, particularly in semi arid zones, where the ground water is available but the management is not efficient enough. Wherever surface water is used, it has been observed by the studies like Kadam (2004), More (2009), that the ground water levels have been depleted in the areas of canal irrigation. Such areas show technological inputs so that use of water is increasing. Secondly, such areas also show water pollution that may enter into the aquifers. Therefore efficient use of ground water has become a need of the hour. The present work aims at finding out solution for such issues related to use of well water on sustainable basis.

1.3 The Study Area:

The Karmala Tahsil of the Solapur district has been selected for the present work. The Tahsil comprises of 118 villages and only one urban center. The absolute location of the study area is 18 º 6 ' North to 18 º 32' North Latitude from 74 º 47' East to 75 º 24' East Longitude. (Fig.No.1.1) the Karmala tahsil lies in rain- shadow zone of the western ghat in the lower Bhima basin. The population of the tahsil is about 254489 with density 157.47 persons/sq km according to the Solapur census hand book 2011. In the present

study an attempt has been made to analyze various sources of ground water such as wells, tube wells, bore-wells. Further groundwater level has to be assessed by using various techniques. The tahsil has about 121921.63 hect, of total cultivable land out of about 161609.89 hectare of total geographical area of Karmala Tahsil and total net sown area (NSA) is 93534.5 hectare. The Tahsil has only 13.58 % NSA under irrigation. The major crops grown in the Tahsil are Jowar, Bajara, wheat, sunflower, Sugarcane vegetables, and etc.The very low area is under irrigation. This area is particularly selected because Agriculture is the main occupation and most of the agriculture depends on monsoon rain. The agriculture has become difficult in this area due to insufficient rainfall and irrigation facility there are 118 villages in the tahsil. (Fig.No.1.2) agriculture in the tahsil sustained only due to wells bore wells and tube wells which are directly depend on ground water which is the main source for irrigation. (Fig.No1.1and 1.2)


LOCATION MAP
OF
THE STUDY AREA
INDIA
MAHARASHTRA
Maharashtra State
Karmala Tahsil
Circle Map
Revenue Circles
1 Pomalwadi
2 Kurt
3 Karmala
4 Arjunnagar
5 Jeur
6 Kem
Solapur
District
Karmala
Barshi
Madha
Mohol
Pandharpur
North
Solapur
Solapur South
Akkalkot
Sangole
Mangalvedhe
N
Kilometers
Fig.No.1.1



1.4 The statement of Problem:

The tahsil faced following problems and hence unable to achieve economic stability inspite of various support schemes by government agencies.

- In-sufficient or lack of water for agricultural is the main problem.
- Lack of water in dry season for both drinking and agriculture.
- Ground water level is very deep in the study area.
- Migration for employment to the nearby cities like Pune, Pimpri-Chinchwad, Panvel, Thane and Mumbai etc.
- Irregular rainfall in the study area.
- Low irrigated area because of non availability of water sources.
- Degradation of land through soil erosion.

- The ground water level of wells and bore wells is very deep.
- Lack of green fodder for sheep, goats and other domestic animals.
- Runoff is high in the areas with thin soil cover.
- How to overcome such different? How the present populations negotiate with droughts? Can well irrigation provide water in dry spells and hence ensure productivity of agriculture? What is the significance of depletion of ground water? Can a strategy be developed to use well water in efficient manner so as to achieve sustainability in agriculture? The present investigation attempts to answer such questions.

1.5 Ground Water Management:

It is necessary that management of ground water for agriculture should be such that levels of the same should remain constant for longer period. for this following aspect have been taken in to account.

1) Geological study of aquifer.
2) Level of aquifer and its potential.
3) Rate at which water is drown from the well.
4) Cropping pattern under well irrigation. The production per unit consumption of water should also be considered possibility of any alternative cropping pattern may be tested.
5) The present study has attempted to design a strategy for efficient utilization of ground water in the tahsil.

1.6 Hypothesis:

The problem of agricultural development in the Karmala Tahsil is mainly associated with drought prone condition and limited development of irrigation.

Therefore it is necessary to develop a planning strategy to use the available water resources in sustainable manner. Thus, the study hypothesizes that **proper management of ground water, watershed management programmes and agriculture planning may mitigate the problem of scarcity of water and thereby improve sustainability of agriculture.**

1.7 Aims and objectives:

The main research question in the present work is how available ground water recourse can be used wisely and effectively for sustainable agriculture in the tahsil. The study focuses on following objectives.

Objectives:

1) Estimation of water recourse: The available water resources in the Karmala tahsil are rainfall, canal and ground water.
2) To study seasonal fluctuations of well water levels.
3) To understand present way of utilization of ground water resource for agriculture in the tahsil. For this, area under different crops under well irrigation has been studied.
4) To carry out cost benefit analysis of crops based on well irrigation in the study area and to find out productivity and employability of different crops.
5) To suggest strategy for efficient use of ground water for agriculture.
   i) Implementation of programmes for recharging.
   ii) Methods of efficient irrigation.
   iii) Optimization of cropping pattern.

1.8 Methodology:

For fulfillment of each objective, following methodology has been adopted:

Objective 1: For carrying out estimation of available water resource in the tahsil average rainfall has been taken in to account.

There are three main sources of water viz.Rainfall, well and canal. The present study has noted water balance studies as observed in various geographical investigations especially, those related to drought prone zone in the state. However present investigator reds that it is not necessary here as the study focuses mainly on well water resource. Therefore simple computational methods have been used to estimate water resource.

A) Rain water: The rain water received in a village has been quantified as the product of geographical area and average rainfall. By subtracting loss by way of runoff and percolation available rain water may be quantified as below.

Estimated volume of water from rain in mh = Rainfall in meter × TGA-Loss by percolation & evaporation.

$$Ri = \frac{0.4\ Pi \times Ti}{1000}$$

Ri = rain water available in ith village in mh. Ti = TGA of ith village. Pi =Average rainfall in mm.at ith village. (Based on isohytal map at micro level)

B) Estimation of ground water use for agriculture: It is assumed that the crops grown on the basis of well water use the same as per its requirement .Therefore may be proper to estimate water from well as the water required by different crops. The amount of water taken from the well can be equal to the product of area under the crops based on well irrigation and there water requirement by subtracting the average rainfall in the cropping season of such crops. For example, the hybrid jowar requires 550 mm. water as per expents in agriculral sciences. The season for the crop in the study area is from mid June to September. If the crop is dependent upon well irrigation the amount of water drawn from the well for same would be:

$$\text{Area under hybrid jowar} \times \frac{550\ \text{m- Rainfall from mid June to September}}{1000}$$

The figure gives ground water utilised for hybrid jowar thus, hectarage of irrigated crops in a village can be used to quantify well water available in that village as formulated below (Bhagat-2004).

This is carried out on the basis of area under different crops under well irrigation and it is assumed that the water is used as per crop requirement.

$$\text{Ground water used for Agriculture} = \sum_{i=1}^{n} Ai\ (Ri - ri)$$

Where, Ai = Area under ith crop in hectare based on ground water.

Ri = Requirement of water by ith crop.

ri = Effective rainfall in the cropping season of ith crop. More (2008)

C) Estimation of transported water:

This is based on the data procured from the irrigation department.

Objective 2: To estimate and quantify available ground water resource in the tahsil and to study seasonal fluctuations of well water levels.

The methodology adopted here may be outlined below:

A) **Estimation of Ground water:** The quantity of ground water at each village has been computed as stated earlier.

B) **Growth of well irrigation:** The data regarding number of wells and hectarage under well irrigation at tahsil level have been procured from socio economic revive from 1991 to 2011.The data have been used to understand the growth.

C) **Distribution of Ground water:** Village level data for available rain water and ground water in meter hectare (MH) have been shown using GIS so that distribution can be understood. A separate map showing village level information about ground water resource has been used for comparison. The census data would be used to map hectarege under well irrigation.

D) **Fluctuation of well water level:** This is studied for the randomly selected villages to understand availability of ground water in monsoon and post monsoon period.

Objective 3: To understand present way of utilization of ground water resource for agriculture in the tahsil. For this, area under different crops under well irrigation has been studied.

A) **Ground water utilization for Agri:** The village level data for crop wise hectarage under well irrigation are not available. Therefore a survey was conducted to understand the cropping pattern under well irrigation. The information has been used to understand the dynamics of well irrigation in the tahsil. A case study approach has been found to be sustainable. This has made it clear about consumption of well water for different crops.

Objective 4: To carry out cost benefit analysis of crops based on well irrigation in the study area and to find out productivity and employability of different crops.

To carry out cost benefit analysis of crops in the study area and to find out per unit consumption of water in agriculture. The technique of cost-benefit-analysis has been found quite useful to understand the share of cost for rural employment which may be useful to decision strategy.

Objective 5: To suggest strategy for efficient use of ground water for agriculture.

i) Implementation of programmes for recharging.

ii) Methods of efficient irrigation.

iii) Changing cropping pattern for optimization of water requirnent.

1.8.1 Techniques: The Case studies have been useful for the same.

1) **Selection of villages for case study:**
   Random selections of villages for case studies have been carried out with forced dispersion.
2) **Questionnaires:** questionnaires were designed to collect the information regarding input and output for the crops based on ground water resource.
3) **R R A & P R A:** Techniques have been used during the field study to understand the dynamics of water resource.
4) **GIS:** Techniques have been used for mapping.

1.8.2 Laboratory Work:

S.O.I. toposheets on the scale 1: 50 000 have been used for the preparation of the base map & relief analysis. The base map is used to prepare various thematic maps in G.I.S. environment. -The maps namely contour map, slope map, absolute relief map, relative relief map, dissection index map, drainage density map, drainage frequency map, geomorphic map have been prepared and analyzed.

1.9 Previous Literature:

1.9.1 Drought Prone area and characteristics:

Theoretically, drought may be considered as the sum effect of precipitation, temperature, wind, sunshine, soil texture, soil moisture etc. The resultant effect of interaction of these variables is the adverse balance between available soil moisture and evapo-transpiration.

Drought is a natural part of climate, although it may be erroneously considered as a rare and random event. Drought differs from aridity, which is restricted to low rainfall regions; it can occur in any climatic zone, but its characteristics vary significantly from one region to another. A drought is a deficiency of precipitation over an extended period of time, usually a season or more, which results in a water shortage for some activity,

group or environmental sectors. Droughts are classified as meteorological, agricultural, hydrological and socio-economic as suggested by Indian Meteorology Department.

Agricultural drought can be defined by the lack of availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time. Drought is primarily an agricultural phenomenon that refers to conditions where plants are responsive to certain levels of moisture stress that affect both the vegetative growth and yield of crops. As a consequence of usual hydro-meteorological variability, drought occurs in pre-monsoon season when the potential evapo-transpiration (PE) is higher than the available moisture due to uncertainty in rainfall while in post-monsoon season drought occurs due to prolonged dry periods without appreciable rainfall (Karim et al., 1990).

In both the seasons, due to sudden increase in temperature coupled with non-availability of rainfall causes a sharp rise in PE. One may relate to the occurrence of drought with certain physical observations:

- development of continually broken cracks on the dried up topsoil
- burnt-out yellowish foliage in the vegetation cover (top yellow syndrome), particularly observed in betel nut trees and bamboo groves, and
- Loosening of soil structure, ending up in the topsoil transforming into a dusty layer.

The failure of crops is the consequence of decrease in the soil moisture proportion below the wilting point. This means that drought prone areas are vulnerable to uncertainty in agricultural production. These regions generally exhibit backward economic conditions.

Definitions of droughts and famines have been put forth by many scholars. The "Drought" is a "spell of dry weather" (Tanhill, 1947). For this purpose, climatological studies based on Thornthwaite's classification have been carried out by Carter (1954, 1955), Sanderson (1954), Gilbert (1954) and others. Karmarkar (1981) (Saptarshi, 1993)
The Indian Metrological Department has given the definition of drought "as a situation occurring in any area when the annual rainfall is less than 75% of normal" (1971). In terms of typologies, droughts are classified as meteorological, agricultural, hydrological and socio-economic. (Indian Metrological Department)

Meteorological drought: is usually defined by a precipitation deficiency over a pre-determined period of time. The thresholds chosen such as 50 % of normal precipitation over a six-month time period will vary by location according to user needs.

Agricultural drought: is defined more commonly by the lack of availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time. It is observed that the study area has experienced this kind of drought frequently.

Hydrological drought: is normally defined by deficiencies in surface and subsurface water supplies relative to average conditions at various points in time through the seasons. Like agricultural drought, there is no direct relationship between precipitation amounts and the status of surface and subsurface water supplies in lakes, reservoirs, aquifers and streams because these hydrological system components are used for multiple and competing purposes such as irrigation, recreation, tourism, flood control, transportation, hydroelectric power production, domestic water supply, protection of endangered species and environmental and ecosystem management and preservation. There is also a considerable time lag between departures of precipitation and the point at which these deficiencies become evident in surface and subsurface components of the hydrological system.

Socio-economic drought: differs markedly from the other types of drought because it reflects the relationship between the supply and demand for some commodity or economic good (such as water, livestock forage, or hydroelectric power) that is dependent on precipitation. Supply varies annually as a function of precipitation or water availability.

1.9.2 Drought-prone zone in Maharashtra:

The fact finding committee (1973) has made clear distinction between “scarcity” and “droughts”. In the scarcity manual of the government of Maharashtra “scarcity” has been described as marked deterioration of agricultural season due to failure of rains or floods or damage to the crops from insects, resulting in severe unemployment and consequent distress among agricultural laborers and cultivators. Thus, the socio-economic effects of backwardness, scarcity conditions and drought- prone character are somewhat similar but causal analysis may help to identify the differences amongst such areas.

1.9.3 Criteria for identification of drought prone areas:

Numerous attempts have been made to study drought-prone zone of Maharashtra in the last few decades. Krishnan (1969) has carried out the study of agro-climatology of arid and semi arid zones of Maharashtra. Subramanian (1975) has presented a detailed account of the official policies to cope with droughts and famines in Maharashtra in 1970-73. More useful and practical approach has been presented in the reports of the official committees of the state government of Maharashtra. There are mainly-

1. Fact finding committee (FFC) (N. S. Pardasani), 1960
2. Second irrigation commission, 1972
3. Fact finding committee (FFC) (S.E. Sukhankar), 1973
4. Maharashtra State Irrigation Commission (S.G. Barve), 1962
5. Eight-monthly Use Water Committee (Deuskar et al), 1979
6. Konkan irrigation development Committee (Khatal), 1980
7. Konkan Master Plan committee (Swaminathan), 1981
8. Irrigation Management Authority Committee (Suresh Jain), 1981
9. Regional Backlog in the state Committee (Dandekar), 1984
10. Study group (Kasbekar), 1984
11. White Paper on drinking water supply programme, 1995

The criteria adopted by these committees for identification of drought-prone zone of Maharashtra are slightly different. The FFC-1960 has attempted to adopt three main criteria to identify chronically scarcity affected areas. These are:

a) Rainfall
b) *Annewari* and suspension of land revenue, and
c) Declaration of scarcity in the past

The committee has considered the coefficient of variation of rainfall of each of the important months or pairs of months as one as of the important tools for ascertaining the uncertainty of rainfall. *Annewari* has been taken as a fairly reliable and convenient index of the incidence of scarcity in the area. *Annewari* is a measure of success in productivity of agriculture in a year. This method of assessing the crop has been a regular feature in

the state, since the British times. The most successful agriculture season is denoted by 16 *annas*. If the *annewari* is four *annas*, this means that, by and large, there is 25% of success and 75% failure of crops in a village. However, the committee relied much on *annewari* for the identification of crop conditions in the absence of any other data. The committee has also remarked that it is necessary to probe deeper into main causative factors of droughts, namely rainfall, with reference to the annual rainfall, its variability and its weekly distribution in relation to soil and cropping pattern of the area, to identify the drought- prone areas with precision.

The committee has identified about 53 tahsils including the tahsil under as the drought-prone tahsils in the state. The second irrigation commission-1972 (SIC) was set by the central Government to go into the question of future irrigation development in the country in a more comprehensive manner. As per one of its terms of reference, the SIC has analysed the irrigation facilities available in the chronically drought affected and food deficit areas. It has set following criteria to identify chronically drought affected areas

a. Meteorological data
b. Revenue remissions
c. Frequency of famine or scarcity and
d. The availability of irrigation facilities.

The commission has dismissed *annewari* as the important criterion to identify drought prone areas in the country. The commission was of the opinion that the subjective element in the assessment of *annewari* by the village officers could not be considered as an objective basis to delineate drought-prone zone.

The commission adopted the definition of "drought" set out by the Indian Metrological Department (1971). The commission has made distinction between drought areas and chronically drought affected areas. The former is one which shows 20% probability of occurrence of annual rainfall being less than 75% of normal. The chronically drought affected areas are the areas where the probability of rainfall departure by >25% is 40% or more. The commission has assumed that the areas receiving rainfall less than 750 mm are liable to drought and areas receiving rainfall between 750 mm and 850 mm are vulnerable and the rainfall is doubtful. Adopting tahsils as a unit for identification of the drought zone, the commission has declared about 45 tahsils as a drought affected tahsils

in Maharashtra. The tahsils where 30% or more of the cropped area was under irrigation in 1971 were excluded from the drought zone. Thus the commission has eliminated 8 tahsils from the list of chronically scarcity affected tahsils prepared by FCC-1960.

The FFC-1973 has identified about 83 tahsils as the drought-prone tahsils in the state on the basis of the following criteria. (Saptrashi, 1993)

1. Criteria based on causes of drought:
    a) Normal precipitation
    b) Timeliness of rainfall with reference to cropping pattern
    c) Soils
2. Criteria based on the effects of drought:
    a) *Annewari* and suspension of land revenue.
    b) Declaration of scarcity in the past
    c) Out-turn
    d) Marketable surplus.
    e) Migration
    f) Fluctuation in the prices
    g) Food grain off take, and
    h) Density of high population.

The major differences between the criteria considered by this committee and those by the previously mentioned committees lie in giving greater importance to timeliness of rainfall with respect to the agricultural operations. According to the practice followed by Agricultural Metrology Division, agricultural drought is considered to be experienced when 4 such consecutive weeks occur in the period from middle of May to middle of October. The FFC-1973 has studied weekly distribution of rainfall for the stations located in the low rainfall zone i.e. below 750 mm, for identifying drought-prone character. It was observed that crop failures were generally witnessed when 11 weeks out of 22 week from June to October were drought week. While considering drought week, the committee has followed the definition put forth by Ramdas (FFC-1973). According to him, drought is an occurrence when the normal weekly rainfall is 5 mm or more.

Secondly, the committee has also considered the soil characteristics, so as to understand the requirement of rainfall for maintaining soil moisture. Deep soil having depth from 60

cm to 90 cm can withstand long dry spell of one month and the crops are normal. In case of medium deep soils normal yields are observed, if the dry spell does not exceed three weeks. While shallow soils show failure of normal yields if the dry spell exceeds two consecutive weeks. Thus, some areas in the transitional zone surrounding the drought prone zone with deep black soils have been declared as free from the effects of droughts.

The committee has adopted the following method for identification of drought- prone areas in the state. The broad zone has been delineated on the basis of isohyets map and soil map of Maharashtra. This zone includes the areas falling within the isohyets of 750 mm and the areas having shallow soils within the isohyets of 750 mm and 800 mm (Fig. No.1.2). this was followed by the study of the weekly rainfall distribution for 15 years, since 1958, within the broad zone. The drought prone characters of the tahsils in the zone have been verified on the basis of the frequency of occurrence of large number of deficit weeks in the monsoon period.

Finally, areas within the zone which are sufficiently resistant to droughts on account of moisture retentivity of soils and facility of canal irrigation have been eliminated. Though a tahsil is considered as the areal unit for identification, parts of a tahsils having high soil moisture retentivity and area under irrigation exceeding 10,000 hectares have been declared as free from adverse socio-economic effects of droughts. Therefore, some of the tahsils are partly included in the drought-prone zone of the Maharashtra.

The central position of the study area can be understood with the help of the maps showing the distribution of rainfall and the drought-prone areas in the state have been adopted for further analysis.

1.9.4 Drought Prone Zone:

The parameters like aridity index have been used to define drought condition by Subrahmaniam and Raju (1986). Irrigation is a lifeline of agriculture especially in the drought prone zone according to many scholars and planners like Singh (1992), Jadhav and Ajagekar (1993), Saptarshi (1993), Bhagat (2000), Kadam (2002) and More (2009). Some researchers have inferred that during the years of large scale droughts over India, the production of food grains had decreased by 15 % and on the other hand, the prices of food grains increased up to 25 % in the same period.

The problems of drought prone areas have been discussed by Misra (1984) and Maharashtra Water Resources Regulatory Authority (2008). Misra has given the techniques for measuring the water resource on the basis of rainfall data. For this, he has considered that the loss due to evaporation is roughly half of the rainfalls, if number of non-rainy days are 7330 and loss due to infiltration is one-tenth. Ramkrishnan (2000) has opined that 77 districts in India receive less than 75 cm of rainfall per year. These districts are classified as the droughts district and account for about 34 % of the Net Sown Area of the country. In addition to these, there are another 22 district in Maharashtra, Gujarat, M.P., Karnataka, Rajasthan, U. P. contributing about 9 % of the cultivated area of the country which receive rainfall between 75 cm and 82 cm per year (Gregory, 1989).

The Fact Finding Committee (FFC, 1973) has been noted in the government report that 'Water budgeting' is essential to have idea about ground water recharge and planning for water conservation. The committee has classified the present study area i.e. *Krmala* tahsil, as a drought prone region in the state of Maharashtra. FFC (1973) has made a clear distinction between 'scarcity' and 'droughts'. In the scarcity manual of the Government of Maharashtra 'scarcity' has been described as marked deterioration of agricultural season due to failure of rains of floods or damage to the crops from insects, resulting in severe unemployment and consequent distress among agricultural labours and cultivators.

1.9.5 Socio economic aspects of droughts:

The drought-prone areas in context with hydroclimatic setup and agro- economic and social problems have been studied for over a century. Due to high frequency of droughts in several parts of India, researchers have compelled to undertake studies pertaining to persistently drought-prone areas.

Some researchers have highlighted the problems due to droughts in Maharashtra. In the report on Techno-economic survey of Maharashtra (1963), it has been suggested that irrigation facilities should be extended to water deficit areas in the state as a long-term solution of droughts.

Banerjee. (1969), Chaterjee (1969), Hussain (1970), Namjoshi and Sathe (1978), Shirnivastva (1978) Brahme (1983), Saptarshi (1993), Memorial (1995), Singh (1996)

Viswakumar (1988),Sarang(1999) Kadam (2000), Nagsmita,Prithvish,Gupta, Sen.(2002). Bhagat (2003 Husain Majid(2004) Singh(2004) and More (2009) have attempted to study the relationship between agricultural and allied activities with the agro-climatlogical approach in different parts of India and Maharashtra. Subramaniam (1975) has outlined the problems of droughts in Maharashtra during 1971-73. The study records relief measures and official policies to cope with the droughts and famines in the state. Das (1983) has emphasized three facets of droughts namely strategy of agricultural development, production and price of food grains in India.

Sen. (1986) has urged that in the exhaustive market economy, exchange entitlement may worsen for reasons other than general decline of food supply. While discussing starvation and famines, he has stated, "famines imply starvation, but not vice versa". It is also stressed that the relative deprivation must be understood with the help of entitlement approach.

In addition to the above studies, many economists like Ghosal, (1988) Deshpande and Salunke (1988), Nadkarni (1991) has investigated the socio economic aspects of droughts in India and Maharashtra. In all these studies the economic problems, the plan outlays and the cost structures have been emphasized.

1.10 Water Resources:

The values of various water balance parameters are calculated according to the procedure put forth by Mather (1961). Thorne and Thrane (1961)

While suggesting the plan outlay for the agricultural development in the Bhima valley, in the areas under irrigation, it has been stated that the benefit-cost ratio is higher if proportion of area under perennials is kept low (Techno-economic survey of Maharashtra, Wilcox, (1948), 1963).Rnodes (1972) Ray and Arora (1973), Rao (1975), Kulkarni (1978), Mathuram; and Mathur. (1981),

Reddy & Reddy (1981) has explained the technique like protective irrigation, conjunctive use of groundwater & surface water, water harvesting, optimization of cropping pattern, improved methods of irrigation etc. Naganna and Barai (1982) have suggested a strategy for drought-prone area of Kolar district of Karnataka to utilise groundwater by sinking deep bores along the lineament which carries the water across the

Western Ghats from areas of surplus to an area of deficit. Godman (1984) "Principles of water Resources Planning" Arekari and Ray, (1988)

Robert (1991) has remarked that water is especially significant resource for agriculture in low latitude region with markedly seasonal climatic regime.

Many researchers have used water balance technique. Musande (1992) has worked out the frequency and time of irrigation on the basis of water balance study. Deosthali and Gadgil (1992) have noted that the term water balance is very important in agricultural climatology.

Many scholars have noted that the water table is lowering down due to high utilization of the water for mitigating expanded needs. It is also found that the state and the study area have been facing the problems like water scarcity and frequent crop failure Singh (1992), Allan (1995), Choudhari (1996), Jeet (1998) (Dwivedi, et al 2006).

Chaudhari and Shastri (1993) have suggested the need of contingent planning for the sustainable development in agriculture with the help of water balance technique. Dhoble (1993) has calculated the moisture use efficiency for agricultural planning. Saptarshi (1993) has estimated groundwater on the basis of cropping pattern. Srinivasatu and Nagabhusharam (1998) have calculated the groundwater on the basis of yield of well or bore well.

Sundaram (1998) and Chattopadhyay et al (1998) have explained the integrated approach of ecosystem at micro-level in the developmental process of village and farm. Chattopadhyay et al (1998) have explained the participatory approach in the plan formation for sustainable development programme at micro-level. Singe and Julya (1998), Sanchez (1998), Jana and Lahiri-data (1999), Kumar (2000), etc. have adopted social approach in the sustainable development.

Many researchers and planners have adopted the approach of water resources for agricultural development like Rao (1983), Basu (1991), Wohlmeyer (1993), Sauza, (1993), Donald and Cheryl (1996), Kanth and Khan (1996), Ramnaiah and Chandrayudu (1996), Mehta and Sodhi (1996), Hanley et al (1997),Khan(1997) Singh and Juyal (1998), Karvar (1998), Daniella Tilbury (1998), Roling et al (1998), Pretty (1998), Harikawa (1998), Penning et al (1998), Munton and Collins (1998), Misra (1998), Parameswaran (1998), Chattopadhya et al (1998), Sanchez (1998), Niyogi (1998),

Cariglia (1999), Thompson (1999), Toman (2000), Kumar (2000), Woo (2001). Ghosh. (2002) Todkar (2002), Undey and Turkunde (2008)

1.11 Ground Water:

Todd (1959)R.H. Brown (1972), Technical Publication (1985), Herman Bauwer (1978), Rushton (2003), Thangarajan (2004), Dhonkarikar (1992), Walton, Williamc (1970). Alvin S. Goodman (1984) "Principles of water Resources Planning" Handa (1984) Tiwari et al (1986) studied ground water management in the parts of Western Ghat in Maharashtra (Ratnagiri and Shindhudurg districts).

Sivanghanam and Kumarswamy et al (1988) studied the influence of the Management of Ground water on the agricultural activities in Vaippar basin in Tamil Nadu. From the survey of existing literature, it has been revealed that detailed study of ground water management within India is very limited (Sinha, 1971, Karanth, 1999). Freeze, and (1979 Ground Water Assessment Development and Management gave a Geo interpretation of ground water management from the basaltic aquifers.

Mathuraman and Matness (1981) carried out experimental work on the water and rock interaction of thermal waters of the springs located among the western ghat of Maharashtra. Ground Water Management and Studies within the state of Maharashtra is rather in adequate. Various agencies such as Geological survey of India (GSI), General Ground Water Board (GWB), National Environment Engineering Research Institute (NEERI), Maharashtra water commission and few Educational Institutions have carried out some studies towards ground water management. Dhokarikar (1992) studied ground water resource development in basaltic rock terrain of Maharashtra.

Handa (1983) studied hydro ground water zones of India and gave a broad picture of management of ground water in Deccan trap. Thigale and Pawar (1982) studied the Ground water management from Pune area of Maharashtra. Adyakar (1984) in his review on the ground water from region of India classifies *Bhima* and *Godavari* basin as class I type. In recent years, Pawar (1985) studied hydrology of Pune Metropolis.

Rushton (2003)Thangarjan(2004),Karlekar(2004) Ingale (2008), Bhagat (2008),Bhakar,Sharma,Shrivasthav,Jetan(2009)

1.12 Soil Resource:

Some researchers have worked on the soil fertility. The study of the chemical and physical properties of the soils has become necessary since the growing demand for agriculture products has led to the mechanization of soil cultivation and hence a lot of research work has been done on soils. Hillgard (1906), Gedroiz (1917), Agarwal and Gupta (1968), Rnodes (1972) Kovda (1973), Hongchum (1988), Arekari and Ray, (1988) Hendry and Buckland (1990), Sehgal and Abrol (1994), Gupta and Gupta (1997), Hurni (1981), Maji (1996), Maji et al (1996), Gupta and Gupta (1997), Salama et al (1998), Sankar (1998), Hopkin and Richardson (1999), Mehta et al (2000) etc. have studied the issues regarding water conservation, water logging, drainage etc. (cf More, 2009)

Acharya et al (1998) has carried out farmers' survey in central India. Cropping in Madhya Pradesh, Central India experiences an overall nutrient deficit. In addition to increasing supply of inorganic fertilizers, the balance between inputs and losses must also be met by indigenous organic sources such as farmyard manure. With the objectives of increasing manure production and soil nutrients used in cropping, he surveyed 100 farmers from 4 randomly selected villages in Madhya Pradesh to record perception attitudes towards farmyards manure use for crop production, estimate nutrient balances and test fields for concentrations of soil organic carbon, nitrogen, and available nutrients.

1.13 Resume:

The study aiming suggesting appropriate use of ground water has scope in the field good agricultural. The present chapter has given introduction to the selected topic and study region. Methodological discussion is followed by review of previous literature. The next chapter presents physiographic environment of the tahsil under study. This kind of basic geographical information may be used while designing planning in the last part of the thesis.