CHAPTER II

A REVIEW OF LITERATURE

There are numerous studies which are undertaken on various issues related to watershed development and management. Prominent among these relate to river valley project. The watershed characterisation in these however, highlights soil erosion control, controlling runoff and moderating floods. In semi-arid area, these are related to augment ground water storage. There is also extensive literature available on delineation of watersheds, appropriate use of land, water and soil resources and evaluation of watershed programmes at various levels. An attempt here is made to review the literature on the issues which are related to the present study in order to have an understanding of exhaustive research being carried out at watershed level.

India has the tradition of collecting, storing and preserving water for various uses. Historically, it dates back to Indus valley (3000 to 150 BC), and the archaeological evidence at Dholavira shows that Indus valley had several reservoirs to collect rainwater and suggest that irrigation and drinking water supply system was developed from a large number of wells with brick lining (Central Ground Water Board, 2007). In independent India, however, the watershed concept was introduced in the late 1950s as an approach for increasing the productivity of rainfed areas by the physical management of soil, water and forest in its natural context - from a ridge to a watercourse. The first large scale soil conservation work was launched in 1962-63, called as Soil Conservation Works in the Catchments of River Valley Projects (RVP). This was a purely technical intervention and was specifically introduced for checking siltation in reservoirs (Joshi et al., 2004). The first area development programme, DPAP, (Drought Prone Areas Development programme), which was later implemented exclusively on watershed basis, was launched in 1973-74 by Ministry of Rural Development in many parts of the country following the severe drought of 1972. This programme was specifically launched to tackle special problems faced by fragile areas which were constantly affected by drought conditions. During the same time, research projects were also taken up by institutes like Central Soil and Water Conservation Research and Training Institute (CSWCRTI) and Central Research Institute for Dryland Agriculture (CRIDA) to validate soil and water conservation technologies and demonstrate the benefits of watershed activities to farming community. In 1980s, Indian Council of Agricultural Research (ICAR) launched 47 model research watersheds on the same lines (Joshi et al., 2004).
In 1977-78, the Ministry of Rural Development started a special programme for hot desert areas of Rajasthan, Gujarat and Haryana and cold desert areas of Jammu and Kashmir and Himachal Pradesh (which were earlier under DPAP) called Desert Development Programme (DDP). The integrated watershed development program with participatory approach was emphasized during mid-1980s and in early 1990s. This approach had focused on raising crop productivity and livelihood improvement in watersheds along with soil and water conservation measures (Wani et al., 2006).

During the 1980s, several successful experiences of fully treated watersheds, such as Vilasrao Salunkhe (Pani Panchayat, Maharashtra) followed by Ralegan Siddhi (Maharashtra), Adgaon (Maharashtra) and Sukhomajri (Haryana), came to be reported. A scheme for propagation of water harvesting/conservation technology in rainfed areas in 19 identified locations was launch by Ministry of Agriculture in 1982-83. This approach was adopted in 22 other locations in rainfed areas. With experience gained from all these, the concept of integrated watershed development was first institutionalised with the launching of the National Watershed Development Programme of Rainfed Areas (NWDPRA) in 1990, covering 99 districts in 16 states. Indian watershed projects spread widely in the late 1980s and 1990s in an effort to develop semi-arid areas that the Green Revolution had bypassed (Turton et al., 1998 and Rao, 2000).

The Hanumantha Rao Committee however, studied the effectiveness of these projects and reported that “the programmes have been implemented in a fragmented manner by different departments through rigid guidelines without any well-designed plans prepared on watershed basis by involving the inhabitants. Except in a few places, in most of the programme areas the achievements have been dismal. Ecological degradation has been proceeding unabated in these areas with reduced forest cover, reducing water table and a shortage of drinking water, fuel and fodder” (Hanumantha Rao Committee, 1994). The major reasons mentioned by the report were lack of involvement of local people, lack of coordination between different departments and lack of guidelines and norms for implementation of these projects.

In 2000, the Ministry of Agriculture revised its guidelines for NWDPRA, making them “more participatory, sustainable and equitable”. The Common Guidelines were revised by Ministry of Rural Development in 2001 and then again modified and reissued as “Guidelines for Hariyali” in April 2003. As per the guidelines, the projects were implemented by Gram Panchayats at field level under guidance of Project Implementing Agencies (PIAs), which may be NGOs or Government department. The concept of Watershed Development
Team (WDT) was strengthened and was made of multi-disciplinary experts like (Civil Engineering, Animal Science, Agricultural Science etc.). District Rural Development Agencies (DRDA) were constituted at district level to approve the plan (Hariyali guidelines, 2003).

In 2006, series of evaluation studies were conducted by Indian Council of Agricultural Research (ICAR), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), National Remote Sensing Agency (NRSA). These concluded that though there were few sporadic success stories, the overall impact of the projects undertaken under Hariyali Guidelines was inadequate. These new guidelines bring in new institutions like Watershed Cell cum Data Centre (WCDC) at district level to bring professional technical and social support to project implementing agency (PIA) with specialists in agriculture/water management, social mobilization, management and accounts etc. Other institutions like National Level Support Organizations (NLSOs) and State Level Support Organizations (SLSOs) are also created for training and support of WCDCs and PIAs (Shah, 2001). A majority of watershed development projects in the country are being sponsored and implemented by the Government of India with the help of various state departments, non-governmental organizations (NGOs), self-help groups (SHGs), etc.

The literature suggests that the first generation watershed projects were mainly designed for soil conservation whereas the second generation watershed projects aimed at conserving degraded land area or more specifically soils (Ahluwalia, 2005 and Joshi et al., 2005) and third generation watershed projects were introduced emphasising on participatory approach. The new approach focuses on raising crop productivity and full livelihood improvement programs (Wani et. al., 2006). These newly developed approaches like livelihood improvement and productivity enhancement are superior to the earlier approaches.

Watershed management approach to conserve the natural resources has faced research results, lessons learned, failures and successes, periodic guidelines and evaluations. During the past four or five decade, the social and economic aspects of watershed management have been given high priority.

The literature on watershed development in India is growing rapidly, but most of it is confined to qualitative descriptions of success stories. The few quantitative studies available tend to be based on a small number of heavily supervised projects, with no information about long term impacts. Benefits after the first year or two were typically assumed and, not surprisingly, cost-benefit findings were almost always favorable. At the same time, the vast
majority of projects were never subject to evaluation and there were good reasons to suspect that most of them had little impact (Kerr and Sanghi, 1992).

There is plenty of literature available on watershed management programme covering wide range of issues. However, in this research work a review of selected literature has been attempted from the vast literature available in the context of understanding major issues. The literature pertaining to the study is reviewed under the following heads: Management of land resource, Enhance ground water storage, Prioritisation and characterisation of watershed, Studies on site suitability for crops and Socio-economic impact of watershed.

A number of studies have discussed (Shah, 1998; Farrington, et al., 1999; Deshpande and Thimmaiah, 1999; Vaidyanathan, 1999, 2006; Kerr et al., 2000; Biswas, 2003; Reddy and Dev, 2006 and Pascual et al., 2009) in watershed development programmes. They have covered policy related issues, institutional drawbacks, implementation issues, community and participation issues, etc. (Deshpande and Reddy, 1991; Rao, 2000; Joshi et al., 2004 and Wani et al., 2006).

II.1 Management of Land Resources:

Appropriate use of land resources is basically main activities in watershed management like land levelling, contour bunds, gully plugs, check dams and vegetative measures. This enhances the availability of water in the watershed and also increases the groundwater recharge and broadly aims at soil and water conservation, efficient cultivation, afforestation, agro-forestry and land shaping and levelling for achieving the desired goal.

Despite the long history of the watershed development programmes, there are no systematic and large-scale impact assessment studies on the performance of watershed programmes. Individual scholars, NGOs, and international agencies undertook some studies largely on a project basis. There is also lack of proper indicators and evaluation methods to assess the tangible and non-tangible economic, social and sustainability impacts of the programmes (Joshi et. al., 2004). Most studies reveal positive change in land use pattern and noticed an increase in net sown area in watersheds across all states. The programmes such as Desert Development Programme (DDP), Drought Prone Area Programme (DPAP), and Integrated Wasteland Development Programme (IWDP) have also shown positive trend with more irrigated lands covered under the watershed programmes. Majority of these studies are carried out in central and south Indian states namely in Madhya Pradesh, Maharashtra, Andhra Pradesh, Rajasthan, Gujarat, Karnataka and Tamil Nadu. Rao. (2000) noted encouraging results in terms of increased irrigation, cropping intensity, yield, and better availability of drinking water from states like Gujarat, Karnataka and Andhra Pradesh.
A review of literature reveals that SWAT model, Meta-analysis and benefit-cost ratio is widely used for assessment of land use measures by various researchers in all over India (Agnihotri et. al., 1989; Chopra et. al., 1990, 1998; Sharma 1995; Joshi et. al., 2005 and Baker and Miller 2013). These studies provide good description of the impact but they do not explain the reasons of differential impact.

A small scale study conducted in Banga village, reveals the impact of watershed programme implementation (Agnihotri et al., 1989). It shows that by providing 2 to 3 supplemental irrigation over 243 ha of agricultural land. As a result, yield of wheat increased from 8 to 37 quintals per ha. Increased availability of fodder has given a fillip to milk production in the village. Benefit-cost ratio for the increased agricultural production and dairy development sectors in the village worked out to 2.05 with the discount rate of 12 percent, assuming a project life of 30 years. Thus, results reiterated that investment in watershed management project all along the Shivalika foot hills for increasing agricultural production, development, rehabilitating denoted hilly catchment, etc. was economically feasible.

Watershed impact studies conducted by various scientists in different geographical settings have also been reviewed. Some of these are revived here. A study on Kandi watershed (Singh et al., 1989) reveals that in Punjab after implementation of harvesting structure and landuse measures there was significant shift in land use pattern i.e. from uncultivated to cultivable area and from unirrigated to irrigated due to the project. The cropping pattern analysis also indicated a slight shift in favour of commercial crops.

Another study in Lalitpur District of Bundelkhand Region of Uttar Pradesh conducted in six villages of two watersheds also reveal similar results (Singh, 1991). The study was based on primary data for two periods i.e., before (1989-90) and after (1990-91) the implementation of watershed development programme. Construction of water harvesting structures like check dam, percolation tank, and water bodies as per site requirement was taken up. The study showed that the gross cropped area increased by 4.31 percent in post implementation period over the base year. Net area sown also increased by 4.31 percent from 115.46 hectare to 116.57 hectare. Significant increase in cropping intensity and change in cropping pattern were attributed to the development of watershed with the introduction of watershed programme. The acreage under coarse grains declined by 35 percent and the cultivated area shifted in favour of paddy, soyabean and groundnut. During rabi season, wheat, gram, mustard and mixed crops were dominant before the programme was initiated but due to water development activities, there was increase in the area of wheat, pea and lentil. The study also revealed a shift in cropping pattern in favour of commercial crops.
Another study on Aravalli foot hills of watershed project of Haryana, suggest that after completion of soil and water conservation works, area under irrigation increased from 125 ha to 601 ha, consequently reducing rainfed area from 741 ha to 265 ha (Arya et al., 1994). Subsequently, there was an increase in crop yields from 20 to 44 percent, 55 to 89 percent and 41 to 67 percent in gram, guar and bajra, respectively. As a result of increased feed and fodder availability both from fields and forest, the farmers started keeping improved breeds of cows and buffaloes. Another study in the Aravalli foot hills regarding watershed project of Haryana, reveals that due to soil and water conservation, area under irrigation increased from 125 hectares to 601 hectares, consequently reducing rainfed area from 741 hectares to 265 hectares. Similarly, there was an increase in crop yields from 20 to 44, 55 to 89 and 41 to 67 percent respectively from 1983-84 to 1988-89 in the crops like gram, guar and Bajra. Whereas, the yields of irrigated crops like wheat, mustard and barely increased from 20, 11.3 and 17.4 quintals per hectare in 1983-84 to 43, 17.3 and 31 quintals per hectare in 1988-89, respectively. The increased feed and fodder availability enabled the farmers to maintain improved breeds of cows and buffaloes resulting in an increased milk production from 2626 litres per day during 1983-84 to 7146 litres per day during 1988-89 (Swarnalatha et al., 1994).

Different dimensions of watershed management have also been reviewed. These studies while addressing several issues have also focused the positive impact of watershed management on cropping, agricultural productivity, employment generation and increase in income amongst others due to implementation of landuse measures (Deshpande and Reddy, 1991; Shah, 2001 and Joshi et al., 2004). The analysis of the empirical study in Maharashtra and Andhra Pradesh villages compared pre and post-project conditions in the study villages (Kerr et al., 2000). Quantitative analysis at the village level addressed performance indicators such as changes in access to water for irrigation and drinking, soil erosion and conservation on uncultivated lands and drainage lines, and change in availability of various products from the common (government revenue) lands. At the plot level, performance indicators included changes in cropping intensity, change in yields, soil erosion on cultivated lands, farmers’ land improvement investments, and annual net returns to cultivation.

Besides these individual resources, the Government project reports reveal similar findings. One of these is by Government of Haryana, 2008. It shows that in participatory watershed management approach 19 earthfill dams were constructed in selected micro-watersheds of Panchkula and Yamunanagar districts since 2000-01, till 2006-07. These dams have a total catchment area of 1342 hectares and a combined water storage capacity of 328.63
hectare metres. It has been possible to provide the facility of irrigation to 1069 hectares
rainfed farmlands with gravity. In case of seven sites, 100 percent of run-off water was
harvested, at four sites 78 to 91 percent and at six sites, 58 to 70 percent was harvested.

Kumar and Kumar (2011) conducted a study on “Micro watershed characterization
and prioritization using Geomatics technology for natural resources management”. The
rainfed area of Sanjai river watershed is located in the central west part of the Subernarekha
basin under Kolhan Division of Jharkhand. For characterisation the watershed different
factors that were taken into consideration may be broadly grouped on the basis of their
interrelationship with one another. The natural resources which are taken into consideration
are slope, geomorphology, soil and landuse cover. For prioritization of watershed, Saaty's
analytic hierarchy process was used. The result shows that out of the total 123 micro-
watershed in the study area 7 micro-watersheds are of the highest priority whereas 106 are of
low priority.

Process of watershed delineation in plain areas was described in there study
“Automated Watershed Evaluation of Flat Terrain” Sameh et al., (2011). The present research
is focus on evaluating the possibility to delineate catchments from flat and arid areas by
means of DTM avoiding hard techniques like river burning or other manual hydrological
DTM corrections. Three GIS packages were used (Arc Hydrotools, TNTmips and
RiverTools) within two DEM: the 90 m and 30 m SRTM in addition to the ASTER 30 m, the
application sample presented by western Iraq desert-Ubaiydh wadi. A brief review is given
how the delineation algorithms have been developed since the 1980’s. Where result shows
that automated watershed analysis of flat terrains is cannot be done without manual evaluation
and correction either by using several seeding points or river burning technique.

The international watershed codification system for the Indian River basin proposed
by Pareta and Pareta (2014) for the better water resource management and monitoring, river
basin planning, innovative research in hydrology, and sustainable water resource
development. Based on natural system, the sub-continent largest trans-boundary to mini-
watershed boundaries have been delineated from SRTM, ASTER, and CARTOSAT DEM
data. The nine-digit watershed codification is proposed for the Indian River basins,
recognizing each hydrologic unit with unique international code that provides a single stand
to synergize all the development programs related to river basin planning, and natural/water
resource management, and avoiding doubling of interventions of various departments and
ministries.
II.2 Watershed Approach in Ground Water Storage Enhancement:

The ‘groundwater recharge movement’ in India has been promoting and reinvesting in rainwater harvesting (RWH) over the past three decades (Sakthivadivel, 2007). Over extraction of groundwater are increasingly serious issues with aquifer depletion, as groundwater tables are rapidly falling in a number of states in India (Shah, 2007). Research into feasible solutions to sustain groundwater stores is therefore, gaining considerable momentum and water management interventions for groundwater recharge is seen as one of the solutions to solve the groundwater problem. This is reflected in an increase in watershed development programs, in which water management interventions is an important structural component (Glendenning and Vervoort, 2010). Studies show that various watershed development programmes brought significant positive impact and helped in increase the water resource potential of a region through enhanced ground water resources coupled with soil and moisture conservation activities (Palanisami et al., 2009). However, there is a lack of systematic studies on the hydrological impact of water management interventions in a watershed. This despite the fact that the cumulative impact of water management interventions on stream flows could be significant (Calder et al., 2006).

The few studies that have quantified water management interventions in a watershed, impacts have generally done at local, small-scale catchments and have not considered larger catchment hydrological impacts (Badiger, et al., 2002). But there are several studies showed positive impacts of water management interventions at field and village scale (Rao et al., 1996; Agrawal, 1997; Farrington et al., 1999; Kerr et al., 2000; Wani et al., 2006; Reddy, 2004; Sreedevi et al., 2004; Palanisami and Kumar, 2009; Stiefel et al., 2009; Rockstrom et al., 2010 and Glendenning et al., 2012) while few studies indicated negative impacts at the watershed and catchment scale (Batchelor et al., 2003 and Kumar et al., 2008).

Studies reveal that the arguments against water management interventions have not yet been confirmed by any empirical studies. This is because the few empirical studies in India had focussed largely on local scale impacts and have not considered larger impact of ground water recharge (Badiger et al., 2002). Consequently, despite there are many researcher who have been attempted many studies on the impact of watershed management programme in enhance ground water.

Rao et al., (1996) described in their study on “Influence of conservation measures on groundwater regime in a semi-arid tract of south India”. The Chinnatekur watershed in Andhra Pradesh was treated with soil and water conservation measures such as diversion drains and staggered contour trenches in non-arable land, terraces of trapezoidal cross section...
with graded channel on the upstream side (graded bund), stone checks in arable land, rock-fill dams and nala bund across the gully. Geological survey was undertaken to determine the groundwater potential and to decide the strategies for enhancing groundwater recharge and topographic survey was undertaken to select appropriate measures for conservation of rain water and drainage. To assess the influence of conservation measures on groundwater recharge, water levels were monitored at weekly intervals in the existing 47 open wells in the watershed area along with water level in the wells located outside the watershed during 1984 (representing the pre-treatment period) and every year thereafter to determine the increase due to additional groundwater recharge. Groundwater recharge was computed with annual water balance equation. A report entitled ‘An Engineer’s Evaluation of Water Conservation’ is studied by Agrawal, (1997) and discussed the efforts of Tarun Bharat Sangh in 36 Villages of Alwar District. The reports, represents the most systematic effort to evaluate the impact of water harvesting on groundwater conditions. The Spearman’s rank-order coefficient of correlation was used to correlate changes in groundwater levels with the extent of water conservation efforts undertaken in sample villages. The study used data collected during 1995 to 96 from 36 villages in Alwar district where Tarun Bharat Sangh had been working under watershed management. Data input consisted of village rankings based on the storage capacity of recharge structures per hectare of cultivated area in the village and changes in groundwater levels based on levels reported by villagers before and after the construction of water harvesting structures (Johad). The resulting correlation was quite strong (0.77) and reported to be statistically significant.

Farrington et al., (1999) also provided an overview of the recorded impact of watershed development programme in India. Results indicate that successful projects have in fact reduced rainwater runoff and recharge groundwater and surface water aquifers, improved drinking water supply, increased the irrigated area, changed cropping patterns, crop intensity and agricultural productivity. Another study described before and after impact of watershed intervention in Huthur watershed, Kollegal taluk in the Southern dry zone of Karnataka (Shobha Rani S. 2001). The author addresses in her study, the role of watershed development program in augmenting groundwater recharge. The study covers ten micro watersheds implemented by Mysore Resettlement and Development Agency (MYRADA). The field data were collected from the population of 51 farmers who had irrigation wells in the watershed during 2000. The Gross irrigated area (GIA) increased by 28 percent (107 acres) from 18 percent (70 acres) after and before Watershed Development Project (WDP). In the watershed area, yield of dug wells increased from 410 gallons per hour to 704 gallons per hour. The
proportion of working wells increased from 80 to 85 percent due to WDP. The proportion of failed wells declined from 20 to 15. Construction of water harvesting structures through WDP enhanced the groundwater recharge in hydro-geological situation even in the presence of cumulative interference effect among irrigation wells.

Similar study was conducted by Badiger et al., (2002) for augment of ground water by traditional approach in Groundwater in Alwar District, Rajasthan. The study area comprises of four micro-watersheds, which lies in the Mewat region of Alwar district of Rajasthan. The farmers have practiced innovative methods of harvesting rainfall runoff for agricultural purposes by building earthen embankments called *paals*. These structures are built mostly on farmer owned lands across ephemeral rivulets to collect and infiltrate water from an area of approximately 10-12 hectares. In this study, 42 wells are being monitored which are spread in the study area, both, in areas influenced by artificial recharge due to *paals* and natural recharge areas. Water table fluctuations are being recorded weekly to keep track of the effect of pumping and recharge. The study noted that rise of the depth to water table was generally observed throughout the watersheds after revival of *paals*. A preliminary investigation of the topographic and hydrographic maps indicated that additional recharge in the study watersheds occurred mostly along the ephemeral rivulets in the submerged and surrounding areas around the *paal* structures. As far as recharge pattern is concerned, there is no perceptible difference up to a distance of 500 to 600 m. from the line of recharge. Moreover, the pattern is the same for both post monsoon and pre monsoon periods, indicating similarity in pumping pattern. A fact that emerges out, as far as recharge to ground water is concerned, there is not much difference whether you are very near to the recharge line or far away (500 to 600 m) from the recharge line. Also the pumping pattern seems to be the same near the recharge line as well as away from the recharge line. Same results found in the study conducted by Bisrat Alemu et al., (2002) in their study on “The Impact of Watershed Development Programme in Augmenting Groundwater Resource in Drought Situation”, revealed that the watershed development programme had proved its contribution towards reducing the effect of drought. The negative externality due to partial and complete failure of irrigation wells had been reduced due to watershed development programme. Construction of water harvesting structures through watershed development approach enhances the groundwater recharge in hydrogeological situations even if there was cumulative interference effect among irrigation wells. The watershed development programme contributed richly to physical and economic access to groundwater resource for irrigation. It had helped to reduce the gap between the
small and large farmers in respect of physical access to groundwater resource. The small farmer in fact was able to reap higher net returns per acre of gross irrigated area.

The Kothapally study by Sreedevi et al., (2004) has shown significant impact of watershed management on crop production, increase in ground water level, reduction in runoff water, increase in income, etc. Similarly, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has reported various benefits of the watershed development programmes in the country. In the study of Kattampatti-I and Kodangipalayam-II watersheds of Coimbatore District, Tamil Nadu and analysed the combination of “With” and “Without” approach and “before” and “after” approach to study the impact of watershed development activities (Palanisami and Kumar, 2009) The study indicated that construction of Watershed Intervention Technology (WIT) such as percolation ponds, check dams, farm ponds and renovation of tanks have enhanced the storage capacity in the watershed to store the excess runoff, which in turn had increased the groundwater recharge. The study revealed that the water levels in the wells have increased from 0.5 m to 4.4 m. The farmers in the watershed reported that the Watershed Intervention Technology were very useful in conserving rainwater and recharge the groundwater which reduced the water scarcity during most part of the year. Due to that, cropping intensity had increased from 100 percent to 134 percent and in many cases the productivity of major crops had increased from 31.7 percent for sorghum to 127.3 percent for maize. The water level in the open and dug wells had risen in the range of 2.5 to 3.5 m and 2 to 3 m.

A technical approach has been used by Stiefel et al., (2009) in their study on “Effects of rainwater harvesting induced artificial recharge on the groundwater of wells in Rajasthan, India” used the physical and geochemical investigation utilizing environmental tracers, groundwater level and groundwater quality measurements, and geological surveys was conducted to quantify the proportion of artificially recharged groundwater in wells located near rainwater harvesting structures. For quantify the proportion of artificially recharged groundwater, groundwater levels were monitored in 15 wells over the study period using a Solist depth-to-water meter. The depth to groundwater was then subtracted from the elevation recorded with a global positioning system (GPS) to quantify the water table in meters above mean sea level. The interpolated water table surface for each study site was derived from the average groundwater levels. Spatial interpolations were performed using the commonly utilized Kriging method. Average groundwater levels varied by 40 m at Jharapiplla village, ranging from 505 m. above sea level (m asl) in the most upstream well to 465 m asl in the most downstream well. Similarly, average groundwater levels varied by 15 m at Godawara
village, ranging from a high of 567 m asl at the upper region of the site to a low of 552 m asl in the downstream region. These data are useful to RWH efforts because they provide evidence of the general direction that water will likely travel if recharged from RWH structures, from a high water level to low water level.

In case of Rajasthan, Glendenning and Vervoort (2010) in their study reported the results of a 2 year field study in the 476 km² semi-arid Arvari river catchment, where over 366 Rainwater harvesting (RWH) structures have been built since 1985. Potential recharge estimates from seven RWH storages, across three different types and in six landscape positions, were calculated using the water balance method. These estimates were compared with recharge estimates from monitored water levels in 29 dug wells using the water table fluctuation method. They found that there was a huge gap in the potential recharge and the actual recharge values. Only around 7 percent of harvested rain water was recharged into the groundwater table with the rest probably being accounted for by soil storage and lateral flow into surrounding areas. They also found contrary to the claims, increasing the number of RWHs beyond a certain point will have no additional benefit in terms of groundwater recharge and will drastically reduce the runoff into downstream areas. At the optimal level, when the level of sustainability is highest, increase in irrigated area will actually reduce the level of resilience. However, there is no doubt that in times of drought RWHs somewhat acts as a sort of buffer against crop failures. In another study Glendenning et al., (2012) reviewed that rainwater harvesting (RWH) for groundwater recharge is seen as one of the solutions to solve the groundwater problem. This is reflected in an increase in watershed development programs, in which rain water harvesting is an important structural component.

A case study from eastern Rajasthan, India has been done by (Pathak et al., 2013) on “Multiple Impact of Integrated Watershed Management in Low Rainfall Semi-Arid Region. In the study area, an integrated watershed project was implemented using the holistic systems approach. A range of activities were undertaken including collection and analysis of baseline data; construction of water harvesting and groundwater recharging structures (check dams, percolation tanks, etc.); use of more efficient irrigation system; construction of drainage line treatments (gully plugs, loose boulder structures and gabions). During its first phase (1997-2001), the focus of the watershed program was on increasing water availability and controlling soil erosion mainly through water harvesting and groundwater recharging structures. The groundwater level in wells in treated areas of watershed was higher compared to that in untreated areas. This trend in groundwater level was observed during the entire period of the study (2002-2008). Even during low rainfall years (2003 and 2005),
groundwater levels in treated areas were higher than un-treated areas of the watershed. The study found in Gokulpura-Goverdhanpura watershed, increase of 52 percent in the wells functioning during 4-8 months in a year, and 114 percent increase was observed in perennially functioning of wells (8-12 months in a year). Before watershed program, 52 wells out of 227 wells were functional only for 1-4 months per year mainly during rainy season, whereas after the watershed pro- gram, all the 52 wells were functional for 4-8 or 8-12 months per year.

Singh et al., (2014) studied the impacts of integrated watershed development (IWD) interventions on water balance and different ecosystem services are analyzed in Garhkundar-Dabar (GKD) watershed of Bundelkhand region. In this study the authors implemented several in-situ and ex-situ interventions under the integrated watershed development program in GKD watershed. The most common in-situ interventions were field bunding, contour bunding and cultivating crop across the slope, which harvest surface runoff, allow more water to percolate and dispose excess runoff safely from the fields. Field bunding was done in 40 ha land area (15 percent of agricultural land) and contour cultivation was promoted in rest of the agricultural land in GKD watershed. This practice created an opportunity to accumulate surface runoff along the contour line, and also protected soils from erosion. Building check dams and low-cost gully control structures on the stream network (ex-situ practices) reduce peak discharge, reduce runoff velocity and harvest a substantial amount of runoff in watershed and increase groundwater recharge. Total nine check dams, including one in control watershed, having storage capacity between 1000 and 6500 m³; 150 low-cost gully control structures (called gabions locally) of 30-100 m³ capacity; and 15 drainage structures for safe disposal of excess water from agricultural fields were constructed, all together developed 35000 m³ of water storage capacity (40 m³/ha) in watershed. The water in the check dams could be used directly for irrigation and also served as sites for artificial groundwater recharge. Groundwater recharge enhanced from 7 percent to 11 percent of rainfall received in monsoon as compared to no intervention stage.

II.3 Studies on Site Suitability for Crops:

Land suitability analysis for different crop has been extensively researched in India. Through FAO extensive work on soil-site is available at all Indian soil types, yet scientists and researchers have assessed suitable site for crops across different geographical units using remote sensing data. Some of these are reviewed here. Among the earlier works, using GIS fuzzy model, crop land suitability is analysed for Kalyanakere watershed in Karnataka. In this
study the use of fuzzy (partial) membership classification is used to accommodate the above uncertainty in assigning the suitability classes to the pixel. The evaluation of the spatial variability of relevant terrain parameters is carried out in a geographic information system environment while assigning the land suitability for crops in the study area of Kalyanakere sub-watershed in Karnataka. Nine parameters (eight of soil and one of topography) are considered and suitability analysis is carried out by fuzzy membership classification with due weightage factors included to accommodate the relative importance of the soil parameters governing the crop productivity. According to the field information, the crop being grown in maximum area is finger millet. However, the crop-land evaluation results of the present study reveal that maximum area is potentially suitable for growing ground nut (Ahamed et al., 2000).

For Land suitability evaluation, the guidelines prepared by FAO (1976) and later version was applied in his Ph.D. thesis on “Land suitability evaluation using GIS for vegetable crops in Kathmandu valley/Nepal” Baniya N. (2008). Suitability evaluation was carried in two different phases, namely 1) Physical land suitability evaluation and 2) Socio-economic-infrastructure land evaluation. These two phases was incorporated into GIS technical tool. For this research identifies 15 challenging sub-criteria from three main criteria. For ranking and important judgment of the sub-criteria, pair-wise comparison using AHP process was carried out. Final result of the multi-criteria land suitability evaluation of Kathmandu valley show that more than 90 percent land area can hold good vegetable cultivation. Together they can meet little above 70 percent demand of the Kathmandu valley. So result of this study hast to communicate to farmers to make full use of land potential for the development of vegetable cultivation.

In his study Saaty T.L. (2008) described the Analytic Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales. It is these scales that measure intangibles in relative terms. The comparisons are made using a scale of absolute judgements that represents, how much more, one element dominates another with respect to a given attribute. The judgements may be inconsistent, and how to measure inconsistency and improve the judgements, when possible to obtain better consistency is a concern of the AHP. Land Suitability Analysis for Cereal Production is carried out by Bhagat et al., (2009) in Himachal Pradesh (India) using Geographical Information System”. In this study different parameters viz. climatic (precipitation and temperature), topographic (elevation), soil type and land cover and land use have been used in order to perform land suitability evaluation for cereals food grain crops in
Himachal Pradesh using Geographic Information System (GIS). The suitability analysis was performed by digital processing of georeferenced data (elevation, climate, soil and land cover) and calculating potential production areas by combining different types of geographical data through decision rules framed for each crop in ArcView spatial analyst. Suitable areas have been delineated for cereal crops in the form of land suitability maps. In comparison to the actual area under cereal crops, the possibility of further expansion under each cereal crop was determined. In another study Mustafa et al., (2011) presented Land Suitability Analysis for Different Crops using Multi Criteria Decision Making Approach. Land evaluation procedure given by FAO for soil site suitability for various land utilization types has been used to assess the land suitability for different crops and for generating cropping pattern for kharif and rabi seasons in Kheragarah tehsil of Agra. The database on soil, land use was generated from data derived from IRS-P6 remote sensing satellite and soil survey to perform an integrated analysis in the geographic information system environment. Agricultural and non-agricultural lands were delineated using the Decision Tree Classifier (DTC) and non-agricultural areas were masked for removal from future analysis. Different soil chemical parameters and physical parameters were evaluated for different crops. Subsequently all of them were integrated using a multi criteria decision making and GIS to generate the land suitability maps for various crops. Kharif and rabi season cropping patterns maps were developed by integrating crop suitability maps for the winter and summer seasons separately. Results indicated that about 55 percent is highly suitable (S1) for sugarcane and 60 percent, 54 percent and 48 percent of the area are moderately suitable (S2) for cultivation pearl millet, mustard and rice respectively. 50 percent of the area is found to be marginally suitable (S3) for growing maize.

Pareta and Jain (2012) made a study on “Land Suitability Analysis for Agricultural Crops using Multi-Criteria Decision Making and GIS Approach”. The study was carried out in Vattanam, and Kaliyanagari village, Tiruvadanai taluk in the north of Ramanathapuram district of Tamilnadu state. Relevant biophysical variables of landuse, soil, climatic, and topography were considered for suitability analysis. All data were stored in ArcGIS 9.3.1 environment and the factor maps were generated. For Multi-Criteria Evaluation (MCE), Pairwise Comparison Matrix known as Analytical Hierarchy Process (AHP) was applied and the suitable areas for crop land were identified. To generate present land use/cover map, QuickBird and IRS-P6, Resourcesat-1 LISS-IV satellite image was classified using ERDAS Imagine 9.3 by means of supervised classification. The present study identified that in the study area, 32.10 percent of total land being used was under highly suitable areas and 56.17 percent was under moderately suitable areas. The results showed that agricultural practiced,
which prevailed in the study area didn’t match with the potential suitability in the marginally suitable area. Thus, the average yield of the study area was substantially affected because of a significant proportion of crop land was under marginally suitable areas. This research provided information at local level that could be used by farmers to select crop land, cropping patterns and suitability. Another study from Turkey determined suitable lands for agricultural use Akinci et al., (2013). The Analytic Hierarchy Process (AHP) method was utilized in land use suitability analysis in this study. In application, the parameters of great soil group, land use capability class, land use capability sub-class, soil depth, slope, aspect, elevation, erosion degree and other soil properties were used. In determining the weights of the parameters, experts’ opinions were consulted, and the agricultural land suitability map generated was divided into 5 categories according to the land suitability classification of the United Nations Food and Agriculture Organization (FAO). After deducting the forests, pastures and reservoir areas from the reclassified suitability map, it was estimated that 0.08 percent of the study area (177.87 ha) is highly suitable for agricultural production, while 1.55 percent (3578.33 ha) is moderately suitable and 6.3 percent (14575.91 ha) is marginally suitable for agricultural production. Land suitability for rabi and kharif season was carried out by Halder J.C. (2013) and made a study on “Land Suitability Assessment for Crop Cultivation by Using Remote Sensing and GIS”. The present study is a qualitative evaluation of land to determine land suitability in Ghatal block, Paschim Medinipur district, West Bengal for rice and wheat cultivation based on four pedological variables, like Nitrogen-Phosphorus-Potassium (NPK) status, soil reaction (pH), Organic Carbon (OC) and soil texture that are mandatory input factors for crop cultivation. All these factors have been rated based upon the proposed method of Sys et al., (1993). The qualitative approach given by FAO (1976) has also been used to classify the land on the basis of their suitability ranked classes (i.e. S1, S2, S3, N1 and N2). This study proposes an integrated methodology for analyzing and mapping of land suitability using the Remote Sensing and GIS techniques. The result indicated that only 12.71 percent of agricultural land can be demarcated as highly suitable for rice cultivation whereas 7.78 percent of agricultural land as highly suitable for wheat cultivation in the study area.

Das and Sudhakar (2014) described land evaluation procedure given by FAO for soil site suitability for various land utilization types for rainfed agriculture has been used to assess the land suitability for khasi mandarin orange and pineapple in East Khasi Hills District of Meghalaya. The database on soil and land use/land cover was generated from IRS-P6 remote sensing satellite data, soil survey and laboratory analysis of soil samples to perform an integrated analysis in the Geographic Information System environment. Different soil
chemical parameters and physical parameters were considered to evaluate soil site suitability for orange and pineapple. Different thematic layers were derived from soil map by using ArcGIS software. Subsequently all of them were overlaid and integrated in GIS environment and suitability criteria was applied to the resulted composite map and generated land suitability map for orange and pineapple. The result indicated that the soil sites of the study area are highly to marginally suitable for mandarin orange whereas it is marginally suitable for pineapple. The study reveals that highly suitable areas for orange are found in the Cherapunjee and Mawsynram area that covers 34.5 km² areas. Moderately suitable (37 percent of the total geographical area) and marginally suitable (24 percent of TGA) areas are found only because of slope constraint (8-30 percent slope). The hills with deep gorges and ravines on the southern portion of the district is found not suitable for orange plantation because of steep slopes (>30 percent) and stoniness.

II.4 Watershed Programmes and its Socio-economic Impact:

Since 1970s, India has invested significantly in watershed development as an agent of rural development. The focus of watershed development got modified over the last 20 years, from soil conservation to water conservation to a more participatory planning approach. The evaluation studies however, showed magnitude of socio-economic impacts from watershed development which are often unclear or disputed (Pangare and Gondhalekar, 1998; Reddy 2000; Kerr et al., 2002 and World Bank, 2004). Socio-economic benefits mainly associated with watershed development include improved agricultural yields and farmer returns, increased access to domestic water and new employment opportunities. However, these benefits will vary for different resource user groups located across most watersheds.

Two methods drawn from the impact evaluation literature are reviewed by Jalan and Ravallion, (1999). First, reflexive comparisons collect baseline data on probable participants before a project is implemented, say in the next raft of watersheds for treatment. These data are compared to the same individuals after project implementation. This method is followed in many watershed programs across India though a review by Kerr et al. (2002) in Andhra Pradesh and Maharashtra found significant data problems or lack of data records. Second, in cases where it is unfeasible or unethical to set up a pre-intervention sample, such as in food aid or educational programs, a control group can be set up by matching project participants to non-participants from a wider survey, such as a national census. Many researchers are used the benefit-cost analysis in economic evaluation of the project (Joshi et al., 2008 and Gray and Srinidhi 2013).
Studies by Deshpande and Thimmaiah, (1999), Kshirsagar et al., (2003) and many others have acknowledged that the watershed development programmes are potential to augment income and reduce poverty among the watershed communities. These studies have focused that there is positive change in crop yielding and productivity, cropping intensity and optimum use of farm implements despite some odds. Deshpande and Thimmaiah (1999) have observed several positive impact of National Watershed Development Programme for Rainfed Areas (NWDPRA, implemented in 1990) across the four states in the Western and Central Rainfed zones of India viz. Gujarat, Rajasthan, Madhya Pradesh and Maharashtra. However, they have noticed that the changes are varying across states.

Three major projects have been assessed the impact (Makkowal, Katour-Manhota and Atwarapur Dam) on the basis of productivity and income of the beneficiaries, cost benefit was analysed of the projects Sidhu et al., (1991). This study indicated that out of the three only two projects were economically viable and significantly helped enhancing the productivity and income of the beneficiaries. The cropping intensity increased and more fallow land is brought under cultivation. But the third project miserably failed because of inappropriate location of the project and heavy cost incurred in low catchment area and seasonal nature of the rivulet feeding the dam. Another study from Bunga Watershed Project in Bunga in Ambala District of Haryana, reveals that the impact of the programmes carried out in the area on crop productivity and socio-economic status of village as well as to examine the benefit-cost ratio of investment Singh and Gupta (1991). They indicate that increased availability of assured water supply for irrigation and introduction of new high value crops in the area improved the socio-economic status of the people in the area. This is clearly reflected by improvement in social amenities. Positive benefit cost ratio suggested that the project was economically viable.

Same results found in the study conducted by Singh and Thapaliyal (1991) in their study attempted to assess the impact of national watershed development project (NWDP) on rainfed agriculture in Jhansi district of Uttar Pradesh. This study Two watersheds out of seven were selected purposively. Five villages from each were selected randomly. The beneficiaries were listed and categorised into four size-groups. They indicated that the watershed approach helped in increasing the cropped area and the cropping intensity. They shifted in the cropping pattern from cereals and oilseeds to pulses in rabi season. Input levels increased, expect pigeonpea and barley. They also showed that the average productivity of all kharif and rabi crops, except arhar and barley, was increased after the implementation of NWDP. During the kharif season, the yield of paddy, jowar and bajra increased tremendously. Average
productivity increased in higher level was noted in the case of gram, wheat, lentil and potato. From Haryana’s experience with four selected watershed development projects i.e. Sukomajri, Bunga, Chowki and Tibbi has been analysed by Arya et al., (1994). The study tried to identify the determinants of people’s participation in them and drawing lessons useful for securing people’s involvement in watershed development and management programmes. The study revealed that farmers were not interested in long-terms gains from any project and were not willing to sacrifice especially if they were living on the margin of subsistence. Only with increased productivity of crops and increased milk yields resulting from supplemental irrigation made possible by the reservoir water the villagers would be ready to invest in the soil and watershed intervention technology and to participate in the programme.

Rao, (2000) discussed the overall impact of watershed projects under the Drought Prone Areas Programme has been positive and significant. There has been a marked improvement in the access to drinking water in the project areas. Crop yields have risen and there has been a substantial increase in area under cultivation in the rabi season, leading to rise in employment and reduction in migration of labour. Availability of fodder has also improved leading to a rise in the yield of milk. The impact of watershed development is carried out by Shah, (2000). The study compares drought in a village in each district with the benefit of watershed programme for the last four to five years, utilising at least 70 percent of the total budget allocated under the programme, with adjoining village without the benefit of watershed development programme. The study investigates the position regarding access to drinking water, area under crops in kharif and rabi seasons, yields of main crops, fodder and animal husbandry, milk yield, local employment and migration and food security. The findings are revealing in that they show the incidence of drought to be much less severe in watershed villages when compared to the adjoining non watershed or ‘control’ villages. The study comes to the conclusion that the overall impact is not only positive but also impressive.

The study was also conducted in hard rock are of Raichur District, Karnataka. Erappa, et al., (2002) made a study on “Sustainable Development of NWDPRA Watershed: Case Study of Raichur District, Karnataka”. The NWDPRA project was assessed among four major sectors viz; (i) the production sector, (ii) the technology sector, (iii) the environment sector, and (iv) the participation sector. Among these, the impact on the production sector was effective. Although the incremental yield, as well as increased area under the crop had not been very significant, the changes were noticeable and had long term prospects. It was noted that the process of implementation had two important short comings viz; the savings in the allocations for primary activities were not fully utilized, and there was hardly any local level
flexibility given to the implements for the effective implementation of the programmes. There was only fragmentary evidence of a watershed development team constituted in the region. These teams were not functioning as effective bodies to sustain the interventions. As regards the quality of life and employment sector, there was enough evidence to indicate increased employment and a visible improvement in the quality of life. This was accompanied by increased consumption and market participation. However, the quantum of increment was not as much as could be seen in irrigated agriculture. Therefore, it was obvious that the adoption of watershed treatment and their sustenance would take a back seat for some time. The environment impact of the treatment was quite visible especially in terms of increased moisture availability, bio-mass, fodder, fuel and fruits, water for irrigation and finally, increased food availability. Another study from south India evaluated the relative success of watershed development projects in raising agricultural productivity, improving natural resource management, and reducing poverty Kerr et al., (2002). This study, based on a survey of 86 villages in Andhra Pradesh and Maharashtra, India. Both quantitative and qualitative analyses were used in looking at the question of what approaches enable a project to succeed. The study finds that projects involving the villagers in planning and decision-making performed better than their technocratic, top-down counterparts, but projects that combined participation with sound technical input performed best of all. All projects faced difficulties in ensuring that poor people shared the benefits of watershed development.

A comparative study has been conducted by Shiyani et al., (2002) entitled “Socio-economic impact of watershed development in South Saurashtra Region of Gujarat”. Data were collected from a sample of 120 watershed beneficiaries and 120 non-beneficiaries. It was revealed that the watershed development played an important role in increasing cropping intensity, productivity of various crops, profitability, and employment generation. The watershed development also reduced the income disparity among the beneficiaries. Reduction in yield gap and in unit cost of production were added advantages of watershed development. However, relatively higher utilization of female labour per hectare of farm by the beneficiaries of watershed development proved the hypothesis that the female population have been more adversely affected. Same study conducted by Reddy and Soussan (2004) and examined the impact of Watershed Development Programme on sustainable rural livelihoods during the period 1995-2000. For the purpose of assessing the impact of WDP on rural livelihood they selected four watersheds in three districts of Anantapur, Kurnool and Mahabubnagar. The measured impact was based on information collected from 30 samples of households from beneficiary households and 10 sample households from non-beneficiary.
households in each village. Impact indicators were grouped under natural, financial, physical, human and social capital. These indicators impact was measured in term of changes in livelihood activities, land use pattern, income, employment, consumption pattern, migration, availability of drinking water, health and education etc. This study showed that overall livelihood position in the sample indicated that Mallapuram is more favorably placed followed by S. Rangapuram, Mamidimada and Tipraspalle. Mallapuram has ranked “H” (high) in 8 out of 14 indicators without any “L” (Low). S. Rangapuram had 4 “H” and 2 “L” while Tipraspalle and Mamidimada have 3 “H” and 2 “L”. Improvements in the total household income and employment were statically significant in all the villages. In the case of natural capital: fodder availability improved significantly in Mallapuram only, which fuel wood and water have not recorded any significant improvement. Both the human capital indicators have improved significantly in most of the cases and social capital has not changed significantly.

Long-term impact was evaluated by Singh N. and Jain, K.K. (2004) in Kandi watershed area which were executed during 1980-88 and1990-98 respectively to redress the degrading natural environment of Kandi Area in Punjab. The 158 farmers from KWADP project and 198 IWDP projects were surveyed. The growth rates of various production effects and employment generated by project-II worked out to be better than project-I. There was significant improvement in the technical parameters such as run-off, siltation loads, ground water recharge and run-off producing rainfall. The per hectare income from crops and dairy registered a growth rate of about 4 percent per annum. The long-term improvements in the environment including availability of fuel wood, fodder, timber, drinking water, quality of life, etc; by the afforestation done during the project period, if incorporated, would further improve the rates of returns to such investments.

Budumuru and Gebremedian (2006) in their report on “Participatory Watershed Management for Sustainable Rural Livelihoods in India”, pointed that participatory watershed management projects have been raising income, agricultural productivity, generating employment and conserving soil and water resources. The study suggested that watershed development brought several positive trends including diversification of the rural economy, development of new institutions, increasing cropping intensity, improved fodder production, increased availability of drinking water with rising ground water table, capacity development of the community etc. Based on the evidence found, it had been suggested that participatory watershed management could be a viable strategy of rural development for achieving sustainable rural livelihoods in India.
Hope R.A. (2007) evaluated social impacts of Dudhi and Bewas micro-watersheds of Madhya Pradesh in India. This study uses a propensity score matching method to estimate social impacts on gross agricultural returns and domestic water collection times from treatment and control watershed data in the state of Madhya Pradesh, India. Three outcome indicators are derived from the available data: (a) gross returns to kharif agriculture (monsoon crop); (b) gross returns to rabi agriculture (post-monsoon crop); and, (c) domestic water collection time in the dry season. Findings indicate that the majority of farmers planting kharif crops are no better off after the project in income terms with no significant variation amongst social, income or land stratified groups. The smaller group of rabi farmers fare even worse, on average, but significant variation is found across social groups and land ownership. Studies shows a positive social impact is estimated by a significant reduction in domestic water collection times for households with the highest collection times.

The impact of organisational instruments on livestock activities of watershed developments in Andhra Pradesh was analysed in his study Jain, A.K. (2008). The study revealed that livestock population had increased varying from 68 to 83 percent in cows, 57.5 to 73 percent in buffalos and 63 to 149 percent in sheep and goats across the watersheds. The milk yield improved by 84.5, 62.7 and 73.2 percent on number of milking days increased by 20,10 and 20 in NGO, government organisation and research organization managed watershed respectively. Across the watersheds, landless have improved their incomes through milk sales by 155 to 168 percent. Similarly, small and marginal farmers have improved their incomes through milk sales making dairying as a viable alternative for improving their economy.

Joshi et al., (2008) described in their report on “Impact of Watershed Program and Conditions for Success: A Meta-Analysis Approach.” In this study ordinary least square (OLS) approach was employed to estimate the regression equation with benefit cost ratio (BCR) of watershed programme as dependent variable and geographical location of watershed (L), size of watershed (S), focus of watershed (F), rainfall in the watershed area (R), implementing agency of the watershed (I), people’s participation (P), time gap between project implementation and evaluation (T), various activities performed in the watershed area (A) and the type of soil (L) in the watershed area as explanatory variables. These results reconfirmed that watershed projects are able to meet their initial costs and generate substantial economic benefits and justify the investment in watershed program as income levels were raised within the target domains. The coefficient of multiple determination (R2) shown that the variables included in the model were able to explain more than 56 percent variation in the
BCR. Under the Comprehensive Assessment of watersheds in India, macro-level evaluation of 636 micro watersheds was done through meta-analysis. The results of meta-analysis revealed that watershed programme is providing multiple benefits in terms of augmenting income, generating rural employment, increasing crop yields, increasing cropping intensity, reducing run-off and soil loss, augmenting groundwater, building social capital and reducing poverty. In terms of economic efficiency, watersheds generated an average benefit-cost ratio of 2 and 0.6 percent of watersheds failed to commensurate with the investment (<1 B:C ratio).

Narkhede et al., (2008) in their article on “Impact of Watershed Project on Socio-Economic status and Agricultural Development in Maharashtra”, stated that higher percent of the respondents indicate change in cropping pattern and cropping intensity in case of the beneficiaries was found more than the non-beneficiaries. That was due to the availability of water for irrigation which encourages the farmers to change their cropping pattern, thereby cropping intensity. In a case study on “Impacts of Watershed Development Programmes: Experiences and evidences from Tamil Nadu”, reported that watershed development programmes had become the main intervention for natural resources management. The study found that watershed development was a key to sustainable production of food, fodder, fuel wood and meaningfully addressed the social, economic and cultural status of the rural community (Palanisami and Kumar, 2009).

Major benefit gap between land holder and landless farmer has been assessed by Kurian M. and Dietz T. (2014) and drawn on evidence from a post project evaluation of a Ford Foundation supported watershed management project in northern India to argue that participatory watershed management projects need not necessarily safeguard the interests of poorer rural households. The study demonstrate that given a particular institutional contract as in Haryana, irrigation service provision by contractors proved to be more effective than provision by a community organization in ensuring that water allocation. The study however, shows that wealthier land holding households benefited more than poorer households. Cropping intensity, farm productivity, acreage under dam assisted irrigation and farm incomes tended to favour wealthier households. Landless households were facing increasing competition for non-farm jobs from marginal land owning households. Women, another traditionally marginalized group in the region were suffering from an increased workload since improved access to irrigation led to doubling of agricultural yields.