CHAPTER – 1

INTRODUCTION
Food security and environmental security are the principal global issues of 21st century. Despite the phenomenal advances made in agricultural technology, there are several regions of the world where food production has either not kept pace with the increase in population or has barely kept pace with the increase in population. Although stagnation and decline in agricultural production can be due to political and social reasons, degradation of soil and water resources and lack of appropriate technology to address the basic issue of resource mobilization and management may be the primary factors responsible for low agricultural productivity. Water scarcity and poor water quality are major concerns in numerous countries, which mainly depend on agriculture for livelihood of the people. Fresh water availability is already a major factor in sustainable use of resources. The water scarcity is further accentuated by ground and surface water pollution. UNDP warns that world soils and land resources have an important impact on the potential risk of enhanced green house effect. So it is impertinent to note that watershed management plays a pivotal role in food security and environmental security in the present era, characterized by increasing conflicts over water resources. Watershed is a basic hydrologic unit, and hydrologic and ecologic processes govern the quality of soil and water resources within the watershed. Recently, watershed management has emerged as an appropriate strategy to manage natural resources and to provide sustainable livelihood to the rural poor.

WATERSHED : CONCEPT and IMPLICATIONS

Section One

A watershed can be defined as the drainage basin or catchment area (natural drainage) of a particular stream or river simply put, it refers to the area of
land from where water flows to a particular drainage system / body of water like a river or stream, comes from.

A watershed can be ideally defined as an interconnected area of land draining from surrounding ridge tops to a common point such as a lake or stream confluence with a neighboring watershed. It is separated from other systems by high points in the area such as hills and slopes. It includes not only the waterway itself but also the entire land area that drains to it. For example, the watershed of a lake would include not only the streams entering the lake, but also the land area that drains into those streams and eventually the lake. Watershed is thus the land and water area, which contributes runoff to a common point. In other words, watershed is a topographically delineated area draining into a single channel.

Viewed in another angle watershed is a natural unit of land, which collects water and drains through a common point by a system of drains. Hence, it comprises a catchment area (Recharge Zone), a Command area (Transition Zone) and a Delta area (Discharge Zone). Therefore, watershed is the area encompassing the catchment, command and delta area of a stream. The topmost portion of the watershed is known as the "ridge" and a line joining the ridge portions along the boundary of the watershed is called a "ridgeline". A watershed is thus a logical unit for planning optimal development of its soil, water and biomass resources.

Further, a watershed is an area having common drainage, the rain water falling in the area coming within the ridge line can be harvested and made to flow out of the area through a common drainage point. Thus the water shed area encompasses both arable and non-arable land.

Use of land and water resources optimally would require identification of spatial units viz., watersheds, delineated on the basis of lay of land, rainfall quantity and distribution, and natural course of irrigation flows. The concept of watershed therefore covers not only the nature of endowment of land and water resources but also their use.
From hydrological perspective, a watershed is a useful unit of operation and analysis because it facilitates a systems approach to land and water use in interconnected upstream and downstream areas. In dry land areas such as the Indian semi-arid tropics, watershed projects aim to maximise the quantity of water available for crops, livestock and human consumption through on-site soil and moisture conservation, infiltration into aquifers, and safe run off into surface ponds. In catchment areas of hydroelectric dams, watershed projects typically focus on minimizing soil erosion that deposits sediment into reservoirs and to the maintenance of base flow.

Depending upon the area, the watershed vary from a large river basin to a very small stream basin. Therefore, the watershed have no particular size.

Watersheds can be classified into different categories based on their size, drainage, shape and mode of land use. The universally accepted classifications of watershed, which is used for managing the resources, are:

1. Mini watershed with an area of less than 100 hectares;
2. Micro watershed with an area between 100 and 1000 hectares;
3. Milli watershed with an area of 1000 to 10,000 hectares;
4. Sub watershed with an area between 10,000 to 50,000 hectares; and
5. Macro watershed with an area above 50,000 hectares.

It is suggested that an area of about 3 to 25 hectares is sufficient for micro-watershed. On the other hand an area upto 500 hectares is the limit prescribed for a micro-watershed by studies of Srivastava (1995). A small area is generally preferred so as to enable the farmers within the area to improve their soil, water and crops as complained by Kshirsagar and Ghodake (1991).

Depending on the land use pattern, watershed could again be classified as highland watersheds, tribal settlements and watersheds in areas of settled cultivation.
WATERSHED MANAGEMENT

Watershed Management refers to the conservation, regeneration and the judicious use of all the resources – natural (land, water, plants, and animals) and human – within a particular watershed. It tries to bring about the best possible balance in the environment between natural resources on the one side, and human and other living beings on the other.

It is an integrated technological approach with in the natural boundaries of a drainage area of optimum development of land, water and plant resources to meet the basic minimum needs of the people in a sustained manner. According to social conservation society of India, resources management means harmonious development of land and water watershed so as to promote or produce, on sustainable basis, abundance of plants and animals and their products, and still deliver clean and controlled flow of water to down stream. Food and Agriculture (FAO) (1987) defines watershed management is a process of formulating and carrying out a course of action involving the manipulation of resources in a watershed to provide goods and services without adverisive affecting the soil and water base.

Components of watershed management include community development, soil and land management, water management, crop management, afforestation, fodder development, livestock management, rural energy management and other farm and non-farm activities. Thus watershed management is the art and technique of managing watershed resources in such a way that maximum benefit may be derived from them. Alternately, it also deals with the techniques and tools that are used to mitigate the adverse impacts of various natural processes and human activities on watershed. Natural resource management and control of resource degradation is now a dire necessity for all countries of the world.

In the watershed approach, a watershed is made as a unit for planning and management of land, water and other resources and all interrelated factors such as...
physical, biological, technological, economic, socio-cultural, managerial, etc., are considered together in a systems framework.

Integrated nature of watersheds provides a strong rationale for using them as the basis for managing, restoring, and the rehabilitating ecological systems. Watershed management is based on the premise that many environmental problems (e.g., non-point source pollution (NPS), habitat loss and degradation, etc.) are best addressed at the watershed level because the context specific nature of the problems often requires complex policy solutions that require the expertise and authority of multiple agencies located at different levels of government.10

In his report on Watershed Management in India, C.H. Hanumantha Rao defined watershed management as "the strategy for protecting the livelihood of the people inhabiting the fragile ecosystems experiencing soil erosion and moisture stress. The aim has been to ensure availability of drinking water, fuel wood and fodder and raise the income and employment of farmers and landless labourers through improvement in agriculture production and productivity"11. There is no doubt about the fact that watershed management requires an integration of all scientific knowledge from many disciplines and a combination of technologies, strategies, and techniques with the development and use of available but appropriate tools. In other words, it should be conceived as multi-discipline, or interdisciplinary development effort, within the natural boundaries of an established, but identified drainage area so that the land or water and plant resources can be identified, conserved and developed in such a manner that both the immediate and long term needs of the people continue to be met in some what regulated but strained manner. Thus an ideal watershed management programme should aim at the total development and optimal utilization of the available natural and human resources.

Watershed management is a part of the broader concept of natural resource management. Natural resource management is a discipline in the management of natural resources such as land, water, soil, plants and animals, with a particular focus on how management affects the quality of life for both present and future
generations. Thus watershed management is one of the chief approaches towards sustainable natural resource management.

**Objectives of Watershed Management**

As mentioned above, watershed management aims to provide a holistic approach towards natural resource management including soil conservation, crop management, fodder development, forestry conservation etc., Since purpose and objective of watershed management varies according to place, region, country and demands of the people, it is difficult to identify certain common objectives of watershed management. However, generally speaking, watershed management projects aims to achieve the following objectives:

1. Conservation of moisture in rain-fed areas for optimal production;
2. To reduce soil erosion and ensure soil and water conservation;
3. To control the problems of salinity, drainage and alkalinity;
4. To prevent floods and siltation in reservoirs;
5. Collection of surplus runoff in farm ponds and its recycling;
6. To recharge ground water and increase water tables in wells;
7. To meet drinking water demands from human population and cattle;
8. To improve on farm irrigation systems for increased productivity;
9. To balance non agricultural uses on land and water; and
10. Generation of income and employment in harmony with land and the agro climatic conditions.

The objectives generally depend on the size of the watershed, its location and the population, which depends on the watershed.

**Components of Watershed Management**

The studies conducted so far on Micro-watershed mostly concentrated on the economic and eco-regeneration aspects. To improve the economy of rural areas especially in the agriculture sector, proper and optimum utilization of natural resources of land and water is essential. Most of the experiments and strategies on
Watershed Management invariably recognized land and water as the essential components. In using land and water for the purpose of production of food grains, fodder, fiber, timber and other raw materials, one should not ignore the role played by human resource. Murthy (1987) considered people at individual participation and groups and the institutions of the people as the important components of watershed development. Subsequently, Jaiswal, A.K. (1995) came to the opinion that besides individuals the organizations of the people are to be tackled effectively for the success of watershed approach. Srivatsava, D.N. and Purandar, A.P. (1996) considered technology as an essential feature of the watershed programme. Technology is used here in the context of its transfer and use in land, water and crop management. Bharad et al., (1991) considered the social melee physical climate, vegetation as the other components of watershed approach to cover wider sectors of watershed development programme to cover different categories in the watershed area in terms benefits to them.

The above discussion enable us to identify land, water, biomass technology, people and the community based institutions as the essential components in watershed development.

**Land Management:** Land Management involves sustainable management of land resources with a view to increase productivity and income without affecting the eco system characteristics. Land management may vary in accordance with its natural properties like terrain, moisture, texture etc., There are different types of land management including, structural measures, vegetative measures, production measures, protection measures. Structural measure include interventions like contour bunds, stone bunds, earthen bunds, graded bunds, compartmental bunds, contour terrace walls, contour trenches, bench terracing, broad based terraces, centripetal terraces, field bunds, channel walls, stream bank stabilization, check dams etc., Watersheds may contain natural ecosystems like grasslands, wetlands, mangroves, marshes, and water bodies. All these ecosystems have a specific role in nature. Vegetative measures include vegetative cover, plant covered, mulching, vegetative hedges, grass land management, fencing, agro-forestry, etc., Production measures include interventions aimed increasing the productivity of land, like
mixed cropping, strip cropping, cover cropping, crop rotations, cultivation of shrubs and herbs, contour cultivation conservation tillage, land leveling, use of improved variety of seeds, horticulture, etc., Protective measures like landslide control, gully plugging, runoff collection, etc., can also be adopted. Implementation of these interventions mentioned above should be done in tune with the uniqueness of the land under watershed management.

Water Management: Water Management involves storage of rainwater, surface water and groundwater and using the same for the benefit of land, people and cattle. Under water management, different methods are used for conservation and usage of water including rainwater harvesting, ground water recycling, preservation of water balance, checking pollution and above all sustainable use of water without affecting the environmental balance.

Biomass Management: Biomass Management involves areas of intervention like eco-preservation, biomass regeneration, forest management & conservation, plant protection & social forestry, increased productivity of animals, income & employment generation, activities, coordination of health & sanitation programmes, better living standards for people, eco-friendly life style of people, and formation of a learning community.

PEOPLE'S PARTICIPATION

Effective involvement and participation of beneficiaries from the planning stage till the full implementation in watershed development programme is essential.

Bhathkal. B. et. al., (1991:28) studied on people's participation in watershed management programme. Each team member involved in the development of the programme should be aware of overall objectives, sectors, components, implementation strategies, role of community and understand the need of these linkages to achieve the objectives with other sectors and beneficiaries that the successful implementation of the programme objectives and work schedule is mainly depends on the people's participation.
Further in the opinion of Srivatsava D.N. (1995:8) the long term and sustainable development is possible through active participation of people and the beneficiaries. Many watershed projects have failed due to lack of people's participation. On the other hand he noted that the watersheds undertaken by Non-Governmental Agency have active people's participation despite financial limitations 16.

Participation of the people depends largely on the creation of people's organizations created for that purpose. People's organization has been the area of the study of R.P. Singh (1995). The study identified that N.G.Os played an effective role in promoting organizations of the people in watershed programmes. Local leadership in these organizations were helpful in promoting new technology. The success of the organizations of the people depended on homogeneity of the group, their perceptions on the programme, capacity to raise funds and the level of participation. In the initial stage of watershed development programme implementation there was no people's participation and involvement of N.G.Os only Government institutions like agricultural department was given this task by creating soil conservation wing for this purpose where local people were engaged as wage earners on work basis. At later stage it was realized the importance of people's participation17.

TECHNOLOGY

The guidelines formed form time to time on watershed development envisaged human resource development through promotion of local technology as well as by introducing new technology.

Availability of a viable, acceptable and appropriate local technology, favourable disposition of the people to apply this technology, means of learning about new technology and the role of extension agencies are some of the factors that determine the adoption of technology by the people in a watershed area.

Trends towards Integrated Watershed Management
On the whole, watershed management is an art and technique of managing the resources in such a way that maximum benefit may be derived from them. Watershed approach is one of the best available strategies to address degradation of natural resources and secure sustainable livelihoods for the people. Hence for the last 40 years, concerned governments, development agencies and NGOs have been employing watershed management principles across the world. However, during the initial years of watershed management, technocrats and engineers gave more emphasis to biophysical aspects of the watershed. Social and economic aspects of watershed management have been given high priority only after the 80s. In addition, people's participation has been recognized as being one of the key factors to successful management of natural resources. Thus, of late, an integrated concept of watershed management was evolved which gives focus on community needs and problems as part of the holistic watershed management. The recent debate on watershed management involves the following issues:

- The role and importance of indigenous technology in soil and water conservation;
- The effectiveness of policy and legislation with regard to conservation of natural resources;
- The capacity of rural dwellers, communities, civil society and government institutions to adequately design and implement sustainable watershed intervention programmes;
- The effectiveness of watershed management technologies to produce to desire results; and
- The replicability and sustainability of watershed management interventions.

Realizing the potential of watershed based approach in rural development, Government of India also adopted a paradigm shift towards integrated watershed management, especially in semi-arid and arid regions of the country. The country has made massive investments so far in this direction. The following section
analyze in detail the growth and development of watershed management programmes in India.

WATERSHED DEVELOPMENT PROGRAMMES IN INDIA

Need for the watershed development Programme:

Indian agriculture has made remarkable strides during the green revolution phase of its growth but experience during the post-green revolution phase has cast doubts about its capacity to feed the growing population. Besides, green revolution has been largely crop and region specific and the benefits have largely accrued to the irrigated wheat growing areas, leaving vast areas of the country outside the development process. Further, recent policies failed to address the problems of irrigated agriculture through improving the allocative efficiency of crucial inputs like water., as a result concerted efforts are being made towards improving the conditions of the dry/rainfed farming.

This has led to development duality. Dry land areas in the country account for about 70 percent of the total cropped area and about half of these dry land will continue to depend on erratic rainfall for production even after realizing the full irrigation potential. These areas contribute more than half of the country's food grains production and the country will have to depend for most of (60 percent to 80 percent) its requirements of coarse cereals, pulses, oil seeds and cotton upon this land. Agriculture growth in these dry land areas has been quite low and stagnation of production and productivity has been observed in all the major food crops of dry land agriculture. More than 50 percent of the area had less than 2 percent of agriculture growth during 1956-57 to 1978-79 (Jodha, 1987). The main source of instability in the overall agriculture production in India is due to instability in dry land agriculture. It is estimated that in order to food grains requirements productivity of dry lands has to be increased by at least 72 percent (Higde, 1989). The main reasons for this phenomenon are that large land areas of these dry lands are under rain shadow zones, suffers drought and was a long
history of droughts. Further, dry land farming suffers from heavy incidence risks of all kinds and around 40 percent of the population is subjected to sustained poverty.

Moreover, over the years, the increase in human and livestock population in drought prone and desert areas has placed the natural resources of the regions under great stress. The major problems are continuous depletion of vegetative cover, increase in soil erosion and fall in groundwater table. Besides, these regions are increasingly being confronted with environmental problems such as wind and soil erosion. In fact, it is feared that the intensity of resource degradation is reaching irreversible levels in some of these regions. In fact, about 15 percent of India’s 329 million hectares of geographical area is already degraded (Reddy, 2000). All these facts account for diminishing productivity of land and loss of natural resources. Inherently, dry land agricultural areas are backward in resources base in rural infrastructure, amenities and supporting services needed for agriculture growth. Moreover, development of these regions, enhancing the crop yields, holds the key for future food security. Promotion of appropriate technologies and development strategies in these regions would result in multiple benefits, such as (i) ensuring food security, (ii) enhancing the viability of farming, and (iii) restoring the ecological balance. Hence, there is a need for shift in the development priorities in favour of dry land agriculture. In other words, there is a need for integrated development and management of land and water resources which provide life support for rural communities and the prospects for agriculture in the dry land areas (conservation of as much rainwater as possible in situ harvesting and storage of excess run-off).

**Genesis and Growth**

Realizing the importance of raising agricultural productivity and improving the livelihood of rural population, India initiated watershed development programmes since 1970s. However, the programmes were initially known as Drought Prone Area Development Programme [DPAP] and Desert Development Programmes with a focus on arid and semi arid regions of the
country, especially Rajasthan. The main objective of this strategy was watershed based soil conservation measures. Despite repeated and special government efforts including the setting up of a separate office for the soil conservation measures in each district, the system could not achieve any tangible or intangible results in productivity. The main reasons behind this low performance were lack of trained personnel to implement the schemes and lack of proper agricultural extension services. Above all, these area development programmes limited the scope of watershed management into soil conservation and land management efforts without giving adequate attention to livelihood security of the inhabitants and related aspects. The failure of these Area Development Programmes necessitated the need for a comprehensive and integrated watershed management programmes in the country. An integrated approach to the programme as a strategy was initiated.

The village level micro watershed experiments were started in 1974 at four places and later expanded to 47 model watersheds in 1982-83—a set of diverse and isolated experiments in Sukumar Ji, Relegaon Sidhi and the operations research projects of the Indian council for Agricultural research (ICAR). In mid-80s, World Bank funded dry land watershed projects were initiated in four states Andhra Pradesh, Karnataka, Madhya Pradesh and Maharashtra.

In 1986 Government of India selected 99 districts in 16 states under watershed management programme. During the 8th Five Year Plan, extensive changes were introduced in the programme for the development of rain-fed agriculture during 1990-91. It was decided that the Central Assistance for the implementation of the programme was liberalized where 75 percent of the amount is to be given as grants and 25 percent as loans to states. The programme envisaged that a micro watershed would be taken up for development in every block having assured irrigation less than 30 percent.

On the basis of these initiatives and the presence of International agencies, watershed concept was widely implemented at various locations in India. The most important step in this regard is setting up of National Watershed
Development Project for Rain-fed Areas (NWDPRA), under Ministry of Agriculture. The NWDPRA was launched in 1990-91 in 25 States and two Union Territories and continues to be implemented during IX plan. During the IX Plan it is proposed to treat an area of 2.25 million hectares at an estimated cost of Rs. 1030.00 crores. At present WDPs of the MORD and the Ministry of Agriculture (MOA) are run separately and are allotted different funds from different programmes – DDP, DPAP, IWOP or MORD and NWDPRA and River Basin Programme (RBP) for MOA. Council for advancement of people’s Action and Rural Technology (CAPART) also funds its own watershed development programmes. In addition, the programmes are allotted funds from employment oriented schemes like the Jawahar Rozgar Yojana (JRY), Employment Assurance Scheme (EAS) and Swarna Jayanti Swayamrozar Yojana (SJSY).

On the whole in India, watershed rehabilitation was not originally conceived as a vehicle for rural development. The original concept of watershed management or rehabilitation was to focus on the management of these resources in medium and large river valleys, to prevent rapid run-off of water (and resultant soil erosion), and slow down the rates of siltation of reservoirs and minimize the incidence of potentially damaging flash floods. The WDP, conceived purely as a soil and water conservation program, has in the last decade been restructured as a comprehensive program for rural development. Among its foremost objectives are increasing agricultural productivity in dry land areas, employment generation and reduction of migration, improvement of common property resources and resource conditions of the socially and economically disadvantaged.

In recognition of the socio-economic and environmental benefits, India is one of the largest micro-watershed development (WSP) programmes. The country has made significant investments in this approach. It is estimated that since the mid 1990’s a total of Rs.17000 crores have been spent till march 2005 on watershed development in the country (table.1.1). These allocations/investments are expected to be doubled during 11 five year plan period with enhanced per hectare investment. In the next 20 -25 years Government of India has target of treating 63 million hectares with an estimated target of 76,000 crores.
Though these investment figures are relatively small compared to the ongoing and proposed investments in major irrigation projects, the key concern is that the benefits realized from watershed development may be far below its potential.

**REVIEW OF STUDIES**

Given the magnitude and spread of the watershed development programmes in India, several research studies were undertaken to examine the ecological and economic impact of these programmes across the country. The studies reviewed in the present study have been classified into two categories viz., general and specific. General studies are those studies which have assessed the impact of the programmes in general and descriptive manner. On the other hand the specific studies are those studies which have assessed the impact in Quantitative terms and in analytical manner.

**GENERAL STUDIES**

Gupta and Rames Babu (1977) has carried out studies on efficiency of contour farming, channel terracing and graded furrows to control erosion in the watersheds\(^19\). Patnaik et. al, (1982) has carried out studies on water harvesting structures in farm ponds in deep black soil plains\(^20\).

According to Sarin R and Ryab J.G. (1983) 'study on watershed' they noted that total rainfall in 1980 was only 400 mm, which was below 43 percent. Though the onset of the monsoon was early, the rains receded early and crops suffered due to late season and drought. An economic analysis revealed that though profitability is comparatively low rainfall year compared to good profitability could still be achieved using the improved technology compared to traditional technology. The average net profit form the improved watershed plots were more than triple than those from traditional fields. The improved system was more superior to the traditional system in terms of yields and profits\(^21\).

Krishna Swamy (1987) has suggested the methods of soil survey and land use planning for watershed management and studied the soil characteristics and
land use planning of micro watershed in Kundani lower Bhavani river valley project 22.

"Kishirsagar, K.G. and Ghodake, R.D. (1991)" in their study on performance of watershed technology at Internaitonal Crops Research Institute for Semi-Arid Tropics (ICRISAT) centre for right agricultural years, they noted that improved cropping systems yield increased to 3.9-4.4 tones per hectare against 0.5-0.7 tones with traditional Cropping systems. On an average, the watershed technology gave about 3 tones per hectare of cereal output and 1.2 tones of pulses. The average gross returns of the improved options were 4 to 5.4 times higher than those of the traditional systems. The additional gross benefits generated by the watershed based technology were in the range of Rs.3,300 to Rs.5,400 per hectare. This amounts to marginal rates of returns of 160 to 300 percent. In this study it was found that the watershed technology promises to reduce risk as compared to the existing cropping system of a single past-rainy season crop 23.

Mysore Rehabilitation and Development Agency (MYRADA) (1993) has described the experiences in the emergence and growth of people's institutions for sustained and equitable management in micro watersheds.

Asit. K. Biswas in his research work (1993) on "water for sustainable development in twenty-first century: a Global perspective" examined water crisis in arid and semi-arid countries. Further he also analyzed issues of water conservation and efficient use of water. In addition, he paid attention to social and environmental considerations of water resource development and management 24.

Detey K.R., Gore V.N., and Joy K.J. (1994) in their study "A holistic approach to soil and water conservation" viewed that the success of watershed development depends upon the perspective for an integrated development of land and water resources and it should go beyond subsistence, so that biomass surplus over subsistence would provide the inputs for a dispersed energy and industrial production system. The emerging biomass processing techniques have the potential to generate non-farm income and meet the needs of accelerated
infrastructure development not only of rural area but small towns and urban as well. The local groups should be informed of the prospects for raising productivity and creating opportunities for livelihood.

K.P. Singh opined that dry land agriculture is risky because of low rainfall and these areas are constrained by limiting soil moisture capacity and heavy erosion of topsoil, so he suggested that, watershed programme is more suitable for the dry land forming.

The study of T.K. Sarma (1996) on watershed a strategy of development stressed for community participation with flexibility in project design reveals that flexibility has to be used to take care of all the persons living within watershed are benefited, especially the land less labourers, and groups such as cattle herders, etc. It needs innovation and lot of skills to organize communities on desired lines. Mahajan (1996) has described the needs analysis and communication of Jhabha watershed.

Rajasekara, N. (1997) in his paper analyses the need for and significance of sustainable development programmes of India’s dry regions and the role of participation in sustaining the development process. The data shows how to reduce the farm income inequalities and improved environments have resulted in such areas. Discussions emphasize the point that socially acceptable living can only be attained by resorting to watershed development programmes. The empirical results indicate that training contact farmers from both genders can lead to the formation of groups, possibly headed by charismatic leaders, to achieve wholesome participation. Local resource users should be involved in the formulation, implementation, maintenance and evaluation strategies. As the benefits of the programme are not tangible in the short run participation can only be ensured through decentralization of decision-making and raising levels of consciousness.

Shah, Amita (1997) have carried out study on Moisture-yield interaction and farmers’ perceptions: lessons from watershed projects in Gujarat. Recent
watershed projects in India have promoted vegetative barriers, which through technologically more sound and environmentally conducive, might bring only limited economic gains. The paper examines the yield impact of vegetative bundings and farmers’ perceptions about moisture yield interactions in Gujarat. The analysis is based on responses from a sample of 197 farmers from two watersheds, Vatrak and Narmada, comprising both those who had, and those who had not adopted the vegetative barriers. The analysis suggests that; (1) traditional bundings are not only widely prevalent but also considered very important for higher yields under ‘normal rainfall conditions; (2) given the indigenous practice of soil-moisture conservation, fertilizer is the most important factor for obtaining higher yields; and (3) a strategy to provide stability in yield would require large scale investments in the form of water harvesting structures and irrigation. What is needed is to improve net returns, hence farmers’ paying capacity rather than large-scale subsidies spread over a large number of watershed projects in the dry land regions.

In this work “watershed development-planning and strategy”, Das.S.N. (1998) describes that optimal use of soil and land resources to provide the needs of ever-growing population is a fundamental issue for the international community is finite and menace of land degradation due to water wind erosion is real. In order to ensure sustainability in crop production, the afforsted causatives would need to overcome through a scientific data based development on watershed basis. The paper described the modalities of generating a soil and land information system for the entire country.

Fernandez, A.P. (1998) in his study Self-help groups in watershed management examines Mysore Rehabilitation and Development Agencies (MYRADA’s) involvement with watershed management in Gulbarga, India, and the associated PIDOW-MYRADA project, which was a partnership between Government, the Swiss Development Cooperation and Mysore Rehabilitation and Development Agency (MYRADA). Its objective was to enable the users involved to emerge as a fourth partner and progressively control watershed resources. Mysore Rehabilitation and development Agencies (MYRADA’s) role was to
ensure that process of planning and implementation would help people to acquire the skills, confidence and organizational expertise to manage the resources within their watershed. Initiative in Gulbarga spread rapidly to other Mysore Rehabilitation and Development Agency (MYRADA) watered projects. The paper discusses what has been learned about the role of Self-Help Credit Management Groups.

Pande, V.C. et al., (1998) in his study on watershed management in Semi-Arid Tropics of Gujarat points out that Integrated Watershed Management programme not only strengthens the resource base but also brings equity in distribution, sustaining the growth process. The vicious circle of underdevelopment, which revolves around poor resource base, in the Semi-Arid Tropics (SAT) can be broken through an integrated watershed development approach.

Datta S.K.; Virgo, K.J. (1998) Towards sustainable watershed development through people’s participation: Lessons from the lesser Himalaya, Uttar Pradesh, India. The paper reviews experiences of the Doon Valley Integrated Watershed Management Project in Uttar Pradesh, India, with emphasis on the evolution of a participatory ‘process orientated’ approach aimed at developing community capabilities to sustain the increased natural resource production systems introduced by Project activities. The focus is on promoting convergent planning and strengthening the skills and institutional capacities of the rural communities, as well as of the government agency responsible for implementation. Conclusions are that human resource development should precede external technical watershed management activities and under the participatory approach, external implementers need to be encouraged to merge their technical skills with the indigenous skills of villagers in order to achieve a convergent approach. The initial focus of watershed management project should be on communities and the adjacent areas under their influence, rather than on the physical aspects of watersheds. Women proved to be most receptive and capable of forming cohesive group to manage natural resources. The project produced initial improvements in living conditions and in local involvement by people in
managing natural resources. This was supplemented by physical soil and water conservation measures and community-managed grass and fodder tree plantations. Reduction in pressure in intervening forest areas is expected to favour natural eco regeneration. Increased environmental awareness and involvement of the villagers is expected to facilitate protection of afforestation programme beyond the village limits.

According to P.L. Sanjeeva Reddy and K. Prasada Rao (1999), watershed development programme are being implemented in India for over two decades. An integrated approach to the programme as a strategy was initiated during the period 1975 and 1973. Over this last two decades of experience in implementation of this programme several areas of successes and shortcomings have been identified. However, for sustainable development of agriculture, the authors believe that unifying the multiplicity of watershed programmes within the framework of an overreaching national initiative is desirable in national interest.

O.N. Srivastave (1999) “Study on Participatory Planning and Management of Watershed Projects—Some Considerations”, in India because of the irrigational use and over exploitation all types of lands (175 million hectares) in general and agriculture (62 million hectares) and forest (23 million hectares) lands in particular are suffering degradation. The Government from time to time has introduced special schemes to conserve and check further degradation of these lands as well as for restoration of environment and ecology. The individuals and other agencies including foreign donors has also joined development in sustained basis is mostly watershed and the strategy adopted in people’s participation. The dichotomy in working, decision making and financial pattern not only confuse the beneficiaries on several occasions but also creates embarrassing situations to the filed workers and other officials. It was also observed that in the government approach, the emphasis was lain on the technical aspects while the element of sustainability and people’s participation was neglected. Besides, the people are of the impression that the government as in past will come again and again to help rural people in conservation and development of natural resources and improvement of socio-economic conditions. In the case of other organizations and
institutions the effective people's participation was observed with less emphasis on technical aspects. The large number of experiments with varying financial and institutional arrangements came to a common conclusion that there is a need for active people's participation for successful implementation of watershed project on sustained basis.

Hinchcliffe, Fiona et. al., eds. (1999) Fertile Ground; the impacts of Participatory Watershed Management. Presents the findings of in-depth research into the impacts of participatory watershed management in a range of agro-ecological and socio-economic settings in Africa, Asia, Australia and Latin America. The twenty-three case studies in this publication present a picture of the problems, achievements and challenges faced by conservation professionals and farmers around the world. They provide evidence of the importance of local people's involvement in natural resource planning and management. The collection provides and analysis of the biophysical, socio-economic and institutional impacts of development and management practices and points to practical and realistic ways forward for both governments and external support agencies.

In this paper on “Watershed Management in India” S.L. Seth (2000) stated that watershed management would remove hunger and poverty from poor areas and watershed management would restore ecological balance, provide green cover over denuded areas, bring in more rains and improve environment. If watershed management has to become a people’s movement, technologies would have to be simple, low cost and should be based on vegetative measures which are self regenerative.

Y.V.R. Reddy G. Sartry, B. Hemalatha, Om Prakash and Y.S. Ramakrishna (2004) have conducted survey on 37 watershed locations under different agro-eco regions in India during 2001. Data were collected from primary stakeholders pertaining to physical (ground water, soil erosion, runoff reduction, etc.), biological (afforesatation, cropping intensity, productivity levels of dry land crops) and socio-economic parameters (additional benefit-cost ration, additional
annuity values, etc., and additional employment and reduction in out-migration of labour, participation of farmers in watershed programmes) in watershed programme areas compared to non-watershed areas. The analysis indicated that there was an increase in all factors in watershed areas villages compared to non-watershed area villages. However, there is no significant difference among the project implementing agencies viz., National Watershed Development Programme for Rural Rainfed Agriculture (Ministry of Agriculture), Ministry of Rural Development, with regard to reduction in soil erosion, etc. It is also recommended that Non-Governmental Organizations may be encouraged to take up watershed programme works on their own funds only. Government of India, Indian Council of Agricultural Research and Non-Governmental Organizations has succeeded in achieving the results in watershed development programme. Logic regression equations were fitted to different factors in relation in additional income per hectare, but distance to market was found to be significant but other factors were no significant. Finally it is recommended that water harvesting structure may be constructed at suitable places and its essential to establish vegetation for optimal success for the programme.

**SPECIFIC STUDIES**

Numerous studies have highlighted the positive impact of watershed development programme on crop yields cropping intensity and cropping pattern changes. Further, an over whelming majority of the studies have endorsed these programmes in terms of costs and benefits (Table 1.2). All the studies have shown that net incomes have gone up substantially and have favorable benefit cost ratios. Recent years have revealed stabilization of B – C ratios at around 1.75 some studies also highlight the quantifiable ecological benefits (Singh, 1994; Desh Pande and Ratna Reddy 1991; Chopra, Kadei Kodi and Murthy 1998; Deshpande and Raja Sekhar 1995) these studies not only indicated the economic viability of the programmes but also underlined watershed as the only alternative to the development of rain fed agriculture in India. Infact some of the studies even proved that watershed development programmes scored over the traditional development programmes like IRDP/JRY/NREP in terms of employment.
generation and national capital generation in moderately degraded regions (Chopra and Kadekodi, 1993). In fact, it was suggested that JRY should adopt the watershed development programmes (Bhatnagar, 1996). Besides, watershed development is more appropriate in providing ecological sustainability in the long.

Significant changes in the household economy were noted in an analysis of the state level development programmes of Comprehensive Watershed Development Programmes (COWDEP) in Maharashtra (Deshpande and Ratna Reddy, 1991). The study analyzed data covering 30 blocks in the state and pointed out concentration of a few components but overall good results of the watershed technology. It was noted that employment generated in each of the watersheds ranged between two and thirty thousand man days depending on the agro-climatic conditions and that the crop pattern, crop intensity, proportion of wasteland and yield per hectare changed substantially. Increased moisture availability has been reported in the watershed regions the studies also made a comparative analysis of the cases of active beneficiary participation as against the passive participation. It was noted that participation process acts as a powerful catalyst for the programmes by the results supported by Singh (1991) and Chopra et al., (1989).

Review of existing studies in this regard indicates variations in the magnitude of impact across regions and crops (Table). In a detailed study of Maharashtra (Deshpande and Ratna Reddy, 1991) covering three agro climatic zones (Scarcity, moderate rainfall and assured rainfall), revealed differential impact of watershed technology. In the scarcity zone watershed technology has led to intensification of agriculture, higher diversification risk spreading and increased stability in yield levels small and marginal farmers of the project area gained on income front compared to their peers from the non-project areas. Moderate rainfall zones also showed similar results. Except in the case of Jowar and Paddy the watershed region had a distinct edge over the control region although the latter had a slightly higher area under irrigation. Beneficiary group also showed higher net incomes. However, the level of income inequality was higher in the programme areas while the reverse was true in the case of scarcity
zone. Assured rainfall zone with in the watershed region also showed lower inequalities. This zone is characterized by high intensive agricultural practices and high remunerative crops. Farmers response in this zone indicated increased yield rates with growth stabilization, increased income, higher wages and employment. Finally the study concluded that the impact of watershed technology is observed to be more effective in scarcity regions when compared to assured rainfall regions. On the other hand adoption of technology itself might be a difficult proposition in extreme scarcity conditions, as poor house holds living on the margins can hardly afford to follow conservation practices such as halting grazing their animals (Singh, 1991). This is mainly due to a long gestation for rearing benefits from the technology. This aspect is further rain forced by an exhaustive review of 311 case studies (Joshi et al., 2005) that cost benefit ratios are found to be largely positive in medium rainfall (701-900 mm) and low income regions. In the drier areas, while water scarcity encourages collective harvesting, the extreme shortage of water and low rainfall patterns seem to diminish the returns from watershed interventions. In areas with high rainfall, the marginal net benefits from improved water and soil management seem to be quite modest.

The magnitude of impact is also dependent on the nature of the components adopted. Impact of watershed technology can best be accomplished by incorporating all the components. The studies of Sukhauajiri watershed (Joshi and Seckler, 1981; Chopra et al., 1989) showed exemplary results of the integrated programmes. The incremental benefits ranged from Rs.1800 to Rs.2000 per hectare. In a similar experiment, watershed projects in Hyderabad, Solapur and Akola districts (Sarin and Rayan, 1983) recorded stabilization of cash flow and substantial increase in productivity, incremental income and employment. Walker et al (1990) also reviewed the overall impact of the application of watershed – based technologies at different locations in Maharastra, Madhya Pradesh and Karnataka. Their results indicated incremental net income ranging between 49 and 203 percent of the base level. The B – C ratio worked out in the range of 1.08 to 3.81 across the locations.
A recent study of Maharastra and Andhra Pradesh (Kerr, 2002) brought out the impact differentials across different types of watershed projects. It was observed that NGO and NGO-Go watershed has done exceedingly well in terms of net farm returns compared to government watersheds or even World Bank / ICAR watersheds. NGO watersheds are implemented with the support of external funding, while NGO-GO watersheds are implemented by NGOs with government funding. Government watersheds are funded by the State Government and implemented by the line departments as per the existing guidelines.

However all the watersheds covered in the studies were implemented prior to the new watershed guidelines came into effect in 1994-95. Further the participation aspect was not emphasized in the earlier guidelines. Moreover every study suggested that collective action and people’s participation were necessary for sustainable watershed management, it remained as a more cursory note at the end of each study. Despite this, collective action and people’s participation had never been central to the implementation of watershed development programmes till the mid -1990s. The review of above existing literature shows that there are gaps in examining the various aspects of watershed development programme in aird, semi-arid-dessert and drought prone districts.

**Statement of the problem**

The period 1994 – 2005 saw the implementation of the first generation programmes under the MoRDs and NWDPRA (MoA) on a very wide scale. During the period from inception to March 2006 a total of 39,221 watershed projects are sanctioned of which 24,363 are under DPAP, 13476 under DDP and 1382 under IWDP. These projects are implemented by the various state government departments and non-governmental organizations to develop lands on watershed basis with the adoption of new guidelines 1994 and 2001 (Prof. Hanmantha Rao Committee guidelines) issued by the Central Government. Before to enlarge on the second generation of watershed based development programmes with heightened targets and expectations, it is important to ensure that the experiences from the first generation of widely implemented watershed
development are fully understood and internalized. Further, the review of existing studies reveal that not many studies are conducted to capture the experiences of watershed programmes which are implemented with the new guidelines. Hence, there is a need to conduct more number of micro studies at village level to understand the effective means of implementing the watersheds and lessons learned in the process and to determine the impacts of the projects on the people as well as the area. Hence, an attempt has been made in the present study to capture important lessons, experiences and impact of the programme in Kurnool district of AP with the following specific objectives.

Objectives of the present study are:

1. To examine the functioning of Watershed Development Programmes (WDPs)
2. Critically examine the recent policy guidelines pertaining to WDP.
3. To analyse the extent of people’s involvement in the planning and implementation of the programme.
4. To examine and assess the impact of the programme in terms of certain physical achievements – increase in ground water levels, the number of wells rejuvenated, additional area brought under cultivation, success of horticulture/afforestation programme, increase in agricultural productivity and in milk yield.
5. To estimate the income and employment generation through watershed development activities.
6. To assess the impact on the reduction of migration in watershed villages and finally
7. To analyse the people’s perceptions on the implementation and impact of the programmes.

Approach:

The functioning of the programme is analysed in terms of examining the organizational structure, formation and working of people’s institutions and participation of local communities in the programme. The impact of the programme is examined by analysing the pre and post project situation. Thus, the study is based on ‘Before and After’ approach. Further, in order to know the influence of the specific programme and PIAs – NGO and Go_ comparative
analysis of IWDP Vs DPAP and NGO Vs GO implemented watersheds have been conducted. A pre-designed interview schedule is used for this purpose.

**Data Base**

The present study is based on the data both from primary and secondary sources. The primary data has been collected from the sample watersheds - records from Watershed Committees (WCs), DRDA records and reports and farmers during the year 2008. Primary data is also collected from 30 members representing large and medium; small and marginal and landless groups selected on random basis from each sample watershed. A pre-designed schedule is used to collect information on crop yields, water levels, wage rates and incomes. Thus, survey method has been adopted for the purpose of the study. Further, group discussions have been made with the people included in the Watershed Committees (WCs), User Groups (UGs) and Self-Help-Groups (SHGs) in the watershed villages regarding different aspects of the programmes. Besides personal visits are made to actual work-spots to have an idea about the quality of works and their present status.

The secondary data has been collected from Annual reports, Action Plans, Reports of various studies and government publications. Secondary data is also collected from various offices like Ministry Rural Development (MoRD), Delhi, Commissionarate Rural Development (CRD), Hyderabad, District Water Management Agency (DWMA), Kurnool etc.

**Sample Design**

For the purpose of the study, a three-stage sampling method is applied in selecting sample watersheds. All the watersheds which are sanctioned during 1995 to 2007 in the Kurnool district are classified into programme-wise-DPAP, EAS, APRLP and IWDP. Only watersheds which are completed during 1990-00 to 2007 under DPAP and IWDP are selected for the purpose of the study. This is because DPAP, IWDP and Hariyali are the specific programmes but not the EAS and APRLP. But the watersheds which are sanctioned under Hariyali Programme are still under implementation with new guidelines (implementation
of the watersheds are delayed due to difficulty in adopting new Haryali guidelines). Accordingly 16 out of 205 under DPAP and 6 out of 30 IWDP watersheds are selected. Further, all watersheds sanctioned under IWDP are sanctioned and implemented in Peapully mandal only, as a result all six watersheds under IWDP are selection from Puapily mandal only. Three mandals one each from three revenue divisions - Kurnool, Adoni and Nandyal are selected. Thus, 15 watersheds are selected from Bethamcherla – Kurnool, Devanakonda – Adoni and Banaganapalli – Nandyal for the purpose of the study. Further, 30 farmers representing large and medium; small and marginal and landless groups are selected on random basis from each sample watershed.

Scope of the study

The study was undertaken in the Kurnool district of Andhra Pradesh which is economically one of the most backward district of Andhra Pradesh. This region is typically a dry track and has been declared as a famine district in South India. Recurrent drought and famines have been occurring in the district of the past ten decades.

Tools of analysis

The percentages, averages and growth rates are calculated to assess the progress of watershed development programme in all respects.

Limitations of the study

Time and money are the natural constraints for a Ph.D dissertation. Further, the present study is a micro level study conducted in one district. Therefore, the conclusions drawn in the study may not be applicable elsewhere.

The present study is presented following five chapters

Chapter – 1 Introduction
Chapter -2 Watershed Development Programmes – Policies and Institutional structures
Chapter-3 Watershed Development Programmes – AndhraPradesh & Kurnool District
Chapter -4 Watershed Development Programmes – Impact
Chapter -5 Summary of findings
References


2. Ibid


5. All India Soil & land Use survey, Ministry of Agriculture, 2004


8. www.wotr.org/wd.htm


10. Mark T and Timothy Hennessey, Environmental Governance in watersheds: The role of collaboration, 2000


15. Bhatkal

16. Srivatsave D.N.


18. http://agricoop.nic.in/study 1.htm#intro

19. Regupta and Ramesh

20. Patnaik


Table 1.1 Area Treated and Investment in Watershed Programmes in India

<table>
<thead>
<tr>
<th>Programmes</th>
<th>Up to end of 8th Plan</th>
<th>During 9th Plan</th>
<th>During 10th Plan till March 2005</th>
<th>Total (till March 2005)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Area (mha)</td>
<td>Investment (Rs. crore)</td>
<td>Area (mha)</td>
<td>Investment (Rs. crore)</td>
</tr>
<tr>
<td>I  Ministry of Agriculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) National Watershed Development Project for Rainfed Areas (NWDPRA)</td>
<td>4.22</td>
<td>967.93</td>
<td>2.77</td>
<td>911.01</td>
</tr>
<tr>
<td>(b) River Valley Project (RVP) and Flood-Prone Regions (FPR)</td>
<td>3.89</td>
<td>819.95</td>
<td>1.60</td>
<td>696.26</td>
</tr>
<tr>
<td>(c) Watershed Development Project in Shifting Cultivation Areas (WSDSCA)</td>
<td>0.07</td>
<td>93.73</td>
<td>0.15</td>
<td>82.01</td>
</tr>
<tr>
<td>(d) Alkali Soils</td>
<td>0.48</td>
<td>62.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Externally Aided Project (EAP)</td>
<td>1.00</td>
<td>646.00</td>
<td>0.50</td>
<td>1425.01</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>9.66</td>
<td>2589.90</td>
<td>5.02</td>
<td>3114.29</td>
</tr>
<tr>
<td>II Department of Land Resources (MORD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Drought Prone Areas Programme (DPAP)</td>
<td>6.86</td>
<td>1109.95</td>
<td>4.49</td>
<td>668.26</td>
</tr>
<tr>
<td>(b) Desert Development Programme (DDP)</td>
<td>0.85</td>
<td>722.79</td>
<td>2.48</td>
<td>519.80</td>
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<tr>
<td>(c) Integrated Watershed Development Programme (IWDP)</td>
<td>0.28</td>
<td>216.16</td>
<td>3.58</td>
<td>943.88</td>
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<table>
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<tr>
<th>(d) Externally Aided Project (EAP)</th>
<th>0.14</th>
<th>18.39</th>
<th>0.22</th>
<th>194.28</th>
<th>0.36</th>
<th>212.67</th>
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<tr>
<td>Sub-Total</td>
<td>7.99</td>
<td>2048.90</td>
<td>10.69</td>
<td>2150.33</td>
<td>8.84</td>
<td>2656.43</td>
</tr>
<tr>
<td>III Ministry of Environmental &amp; Forests (MOEF)</td>
<td>0.30</td>
<td>203.12</td>
<td>0.12</td>
<td>141.54</td>
<td>0.40</td>
<td>469.07</td>
</tr>
<tr>
<td>(a) Integrated Afforestation &amp; Eco-Development Projects Scheme (IAEPS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>17.95</td>
<td>4841.92</td>
<td>15.83</td>
<td>5406.16</td>
<td>11.80</td>
<td>6789.34</td>
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</table>

<table>
<thead>
<tr>
<th>Study/ Year</th>
<th>Region</th>
<th>Activity</th>
<th>Crops</th>
<th>Impact on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yield</td>
</tr>
</tbody>
</table>
| 1. Ram Mohan Rao et. al., (1967) | Maharashtra  
Tamil Nadu | Contour Bunding | Jowar (R)  
Bajra  
Jowar (R)  
Bajra | +25percent  
+25percent  
+36percent  
+25percent |
|                        |                        |                           |                         | Net Income       |
| 2. Lal Gupta et. al., (1970) | Varanasi (UP) | Soil Conservation | All crops | +112percent  
215percent |
| 3. Joshi and Seckler (1981) | Chandigarh | Rainwater Harvesting | All crops | -  
Rs. |
Solapur (Maharashtra) | Integrated Watershed  
Watershed | All crops  
Sorghum  
Castor  
Sorghum | +4-300percent  
+517percent  
+600percent  
+300percent |
Medak (AP)  
Akola (maharashtra)  
Gulbarga (Karnataka) | -do-  
do-  
do-  
do- | All crops  
All crops  
All crops  
All crops | +203percent  
+130percent  
+52percent  
+52percent | 1.37  
3.81  
3.02  
1.08 |
|                        |                        |                           |                         | B-CR             |
|                        |                        |                           |                         | 4.6             |

Table 1.2 Economic Impact of Watershed Technology: Review of Studies
<p>| 6. Ghodke (1981) | Tadapally (Andhra Pradesh) | -do- | All crops Sorghum Pulses Pigeon Pea Fodder | - | +71 percent -45 percent +1000 percent +960 percent +230 percent | - |
| 7. Gupta and Mohan (1982) | Rajasthan | Tree Plantation | Trees | - | Rs.1640/ha | - |
| 8. Tejwani and Babu (1982) | Farm Pond | Farm Pond | Jowar | - | - | 1.45 1.30 |
| 10. Agnihotri (1985) | Shivalik Hills | Vegetative Cover | All crops 64 q/ha | - to 85 q/ha | - |
| 11. Govt. of Punjab (1986) | Punjab | Soil Conservation | All crops Maize Paddy Wheat Potato | -13 percent -30 percent +16 +4 | 84 percent | - |
| 12. Itnal and Narayan (1987) | Bijapur (Karnataka) | Farm Pond | Jowar Sunflower | - | +Rs.1300/ha +Rs.1800/ha | 0.95 1.11 |
| 13. Pant (1989) | Madhya Pradesh | Integrated Watershed | Sorghum Wheat | +127 percent +111 percent | - | - |
| 14. Deshpande and Reddy (1990) | Maharashtra | Integrated Watershed | Paddy Ragi Pulses | +18 percent +34 percent +7 percent | - | - |</p>
<table>
<thead>
<tr>
<th>Source</th>
<th>Region</th>
<th>Activity</th>
<th>Crops</th>
<th>Bajra Wheat Jowar Sunflower</th>
<th>Paddy (K) Paddy (R) Sorghum Pigeon Pea Castor</th>
<th>Gross Margin</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. Rao (1990)</td>
<td>Andhra Pradesh</td>
<td>-do-</td>
<td>Paddy (K)</td>
<td>+46 percent</td>
<td>+54 percent</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Paddy (R)</td>
<td>+11 percent</td>
<td>+135 percent</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sorghum</td>
<td>-2 percent</td>
<td>+17 percent</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pigeon Pea</td>
<td>+2 percent</td>
<td>+7 percent</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Castor</td>
<td>+64 percent</td>
<td>61 percent</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Integrated Watershed</td>
<td></td>
<td>Gross Margin</td>
<td>0.90</td>
<td>7.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maize</td>
<td>+21 percent</td>
<td></td>
<td>-</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wheat</td>
<td>+20 percent</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oilseeds</td>
<td>+52 percent</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>18. Mahnot et. al., (1992)</td>
<td>Rajasthan</td>
<td></td>
<td>Maize</td>
<td>+5-14 q/ha</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Paddy</td>
<td>+5-13 q/ha</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Balckgram</td>
<td>+4-6 q/ha</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wheat</td>
<td>+8-22 q/ha</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gram</td>
<td>+4-9 q/ha</td>
<td></td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Mustard</td>
<td>0-8 q/ha</td>
<td></td>
<td>-</td>
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Rao (1990)
Singh (1991)
Mahnot et. al., (1992)
Singh et. al., (1993)
<table>
<thead>
<tr>
<th>Study Reference</th>
<th>Location</th>
<th>Crop</th>
<th>Yield Increase</th>
<th>Yearly Increase</th>
<th>Yearly Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>20. Singh et al., (1993)</td>
<td>Udaipur (Rajasthan)</td>
<td>-do-</td>
<td>Maize</td>
<td>+2 q/ha</td>
<td>+50 percent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Paddy</td>
<td>+2 q/ha</td>
<td>1.75 (avg.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jowar</td>
<td>+2 q/ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blackgram</td>
<td>+4 q/ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wheat</td>
<td>+2 q/ha</td>
<td></td>
</tr>
<tr>
<td>21. Nalatawadmath et al., (1997)</td>
<td>Bellary (Karnataka)</td>
<td>-do-</td>
<td>Bajra</td>
<td>+16 q/ha</td>
<td>+50 percent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jowar</td>
<td>-13 q/ha</td>
<td>1.75 (avg.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blackgram</td>
<td>+22 q/ha</td>
<td></td>
</tr>
<tr>
<td>22. Joshi and Bantilan (1997)</td>
<td>ICRISAT Asia Centre</td>
<td>-do-</td>
<td>Sunflower</td>
<td>-</td>
<td>+40 percent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chickpea</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>All plots</td>
<td>-</td>
<td>+12 percent</td>
</tr>
</tbody>
</table>

Source: Till the year 1991 studies are taken from Deshpande and Reddy (1991a). # Gross income.