CHAPTER 1

INTRODUCTION
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Dryland Agriculture: Its Significance and the Issues

The importance of dryland agriculture to the Indian economy cannot be disputed. More than 70 per cent of the country’s gross sown area is in the rainfed dry regions. They contribute about 42 per cent of the country’s total foodgrain output which includes bulk of its coarse cereal output, over 80 per cent of its oilseeds and pulses output, apart from several other agricultural commodities.¹ Large sections of India’s poor consisting of small and marginal farmers as well as the landless reside and depend on agriculture and related activities in the dry regions for their livelihood. The development and prosperity of the dry regions thus holds the key to the economic development and prosperity of the country as a whole.

Dryland regions are those where agriculture is mainly rainfed and having little or negligible area under irrigation. The Fourth Five Year Plan defines dry lands as follows: "Dry lands are those areas which receive annual rainfall ranging from 375 mm to 1125 mm and with very limited irrigation facilities". About 128 districts in the country fall under this category. Out of these 128 districts, 25 districts belong to the very high intensity dry land areas, 12 districts have been brought under comfortable irrigation position and the remaining 91 districts with mostly dry condition are mainly spread over the states of Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Uttar Pradesh, parts of Haryana and Tamil Nadu.2

Dryland agriculture has, however, been relatively neglected in the development priorities of the country until recently. Though the green revolution of the mid-sixties enabled the country to curtail, if not eliminate, food imports through a significant rise in domestic foodgrain output, it has still gaps to be filled in terms of the spread of its impact. The new

agricultural strategy concentrated on the relatively well-endowed regions and farms with surface irrigation and other infrastructure, to the disadvantage of the dry regions and dryland farmers. Also wheat and rice benefitted the most from the green revolution, whereas coarse cereals, oilseeds until recently and pulses - crops which are mostly concentrated in the dry belt had to bear the brunt of the backlash effects of the green revolution by recording relatively low or negative growth rates. The growth was thus uneven across regions, crops and farms. This, therefore, led to a widening of inter-personal and regional disparities between irrigated and dry regions, as also between well-endowed farmers and dryland farmers. 3

Equity and food security needs apart, the limited prospects of irrigated regions in meeting India's future food requirements as well as the prohibitive costs of future irrigation investments necessitate more attention than hitherto to development of dryland agriculture. Moreover, if production of pulses and oilseeds — the main source of proteins and fats for large sections of India's population — which are lagging behind domestic demand for these commodities, is to be boosted up, there is a need for more attention and resources for development of dryland agriculture. India's population which is presently around 850 million is expected to cross 1 billion by the end of the present century. To meet the future needs of the growing population, India's foodgrain output will have to increase from the present level of around 172 million tonnes to about 225-240 million tonnes by the year 2000. There is general skepticism as to whether India will be able to reach this target or not. Inspite of massive investments in irrigation during the last four decades, irrigation still covers only around 30 per

cent of India's total cropped area. Even if the ultimate irrigation potential is realised it may at best cover only about 50 to 60 per cent of the country's total cropped area. Rainfed dry regions will, therefore, have to play a major role in meeting the country's future food needs. According to some experts if available conservation and production technologies are properly adopted, dryland agriculture in the country has the potential to yield between 144 to 200 million tonnes of foodgrains. The above factors have prompted a major shift in the country's development priorities in recent years, as a result of which more attention is being paid to improve production and productivity in dry regions. This is being done by implementing special area development programmes like Drought Prone Areas Programme and also by disseminating technologies suitable for dry regions evolved by various research institutions. The development activities in drylands has recently been given further impetus through implementation of the watershed management approach for dryland farming.

The development of dryland agriculture, however, poses immense challenges because of a host of constraints specific to the dry regions. Dry regions being among the high ecologically fragile zones, dryland agriculture is highly vulnerable to environmental stresses and shocks. The dry regions are known for their poor resource base with low and highly variable rainfall concentrated within a short duration. Generally this is followed by a long dry spell which results in depletion of the groundwater resources and exhaustion of soil moisture. The soil types which vary from deep black to red sandy are deficient in various soil nutrients. Intensification of agriculture along with demographic and economic pressure have contributed to extreme stresses on the natural resources of these regions resulting in land degradation, a decline in the water-table, growing desertification, etc. Denudation of the land of its vegetative or protective cover due to various activities has resulted in the top soil being exposed to wind and water erosion which in turn affects

the production and productivity of agriculture.Whatever rainfall these areas receive will go waste along with the top soil without contributing much to soil moisture. It is estimated that about 174 million hectares of land in the country is degraded primarily on account of soil erosion. Because of this it is estimated that the country loses about 5334 million tonnes of top soil annually or an average of 16.35 tonnes of top soil per hectare annually. Lands taken up so far for conservation measures are a small fraction of the total land that needs treatment. Only 31 million hectares out of 174 million hectares were reported as treated till 1986-87 under various soil conservation

The direct cost of soil erosion to the country which loses annually about 8.4 million tonnes of soil nutrients is estimated at US $ 6 million in terms of chemical fertiliser replacement. There is, therefore, lot of risk and uncertainty associated with agriculture in the dry regions due to weather and other environmental constraints, apart from other socio-economic and technical constraints. Added to this, the natural resources base of the dry regions are at various stages of degradation due to intensification of agriculture, extension of cultivation to marginal lands, overgrazing, and other economic activities in the dry regions, as mentioned earlier. Conservation of soil and water assume greater importance in the ecologically fragile areas like the dry land regions. These regions characterised by low and uncertain rainfall along with high run off rates of 20 to 30 per cent need to be developed along with appropriate conservation packages. For maximum infiltration of the rain water to improve


moisture availability in the soil, the soil surface needs to be maintained in a receptive condition and surplus water diverted along gentle gradients by reducing erosive resistant surface drainages. For effective conservation of soil and water the whole valley needs to be treated irrespective of ownership rights and status of land.\textsuperscript{11}

The development of the rainfed dry regions which are characterised by poor resource base, therefore, needs an approach which not only aims at improving the resource base of the region but also rationale use of these resources to support the economic growth of the region without disturbing the ecological balance. Watershed management approach for dryland development assumes importance in the context of promoting environmentally sound development strategies. Before discussing about the significance of watershed management approach to dryland development, we may briefly review the approaches and policy efforts attempted in the past for development of dryland areas and agriculture.

Development of Dryland Agriculture in India: A Review of Past Approaches

Policy efforts to tackle the problems of dryland areas in India can be traced back to the last century when following the three devastating famines which struck the country towards the end of the 19th century, the British India Government decided to take up protective irrigation works in the drought-prone regions, in accordance with the recommendations of the First Famine Commission (1880). These protective works were undertaken mainly for affording protection to crops against droughts. A number of irrigation works in the traditional drought-prone areas were undertaken and financed partly out of a special fund known as the 'Famine Relief and Insurance Fund'. Upto 1945-46 a total of Rs 450 million was spent on protective works and such works during the same year irrigated 2.2 million hectares out of 11.4 million hectares served by public irrigation works in British India. Notwithstanding this, efforts for promoting dry land research and development of agriculture received

13 Cited in Jodha, 1979, Ibid.
priority much later, only in 1970-71 with the establishment of the All India Co-ordinated Research Project on Dryland Agriculture (AICRPDA). The past approaches towards development of dryland agriculture may be categorised as follows:— (i) Resource Base Development Approach, (ii) High Yielding Variety Approach, and (iii) Integrated Approach.

(i) **Resource Base Development Approach**

The important problems faced by the farmers in dryland areas are lack of soil moisture during dry weather and loss of fertile soil during rains. Hence, conservation and development of soil and water resources assume a critical importance in stabilising crop production in the dry regions. The first systematic and scientific attempt to tackle the problems of dry regions was made in the then Bombay Presidency during the British period. The then Imperial Council of Agricultural Research (now renamed as the Indian Council of Agricultural Research) set up five regional research centres during the 1930s at Sholapur and Bijapur (in

the former Bombay State), Hagari (near Bellary in the then Madras State), Raichur (then Hyderabad State) and Rohtak (then Punjab State), to investigate and evolve a package of practices suitable for dry land agriculture. Based on the experiments carried out at these centres a package of practices was evolved for widespread adoption which was referred to as the "Bombay Dry Farming Practices".\textsuperscript{15}

Though it advocated both mechanical as well as other soil and water conservation measures, contour bunding became the principal activity of the scheme. It was demonstrated at the research centres that these bunds were able to increase the crop yields substantially.\textsuperscript{16} However, farmers resisted the formation of bunds as these interfered with their property boundaries. To overcome this difficulty, a compromise of approach bunding i.e., field bunds came into existence. This however, was totally against the logic behind the contour bunds.\textsuperscript{17} The efforts initiated under the Bombay Dry Farming Practices came to an abrupt end in the 1940s when all activities unrelated to the

\textsuperscript{15} Kanitkar, et. al. Ibid.
\textsuperscript{16} Kanitkar, et. al., Ibid., Chapter IX, P. 159.
\textsuperscript{17} Jodha, 1979, Op. Cit., p. 492.
war efforts of the British Government were terminated, much before scientists could fully conceive of relevant technology options.\textsuperscript{18} Though these practices were sought to be popularised in several states through demonstration at 45 dry farming projects, these did not succeed due to various problems.

The soil conservation programme, however, was assigned importance in the initial Five Year Plans as the main component of soil and water conservation measure. Till the Fifth Five Year Plan the total area of agricultural lands covered under soil conservation was 15 million hectares and the cumulative allocation for this up to the Fifth Plan was around Rs. 552 crores.\textsuperscript{19}

All these measures were, however, not successful in bringing about the desired results due to lack of supporting role from biological component along with mechanical conservation measures, non-availability

\textsuperscript{18} Jodha, 1979, Ibid.

\textsuperscript{19} If the total expenditure is spread over the area covered after deducting for the expenditure on establishment, it can be seen that the investment per hectare made under this programme is very low and insufficient to yield any dramatic results.
of HYVs, their suitability to different agro-climatic conditions, lack of flexibility in the technology and lack of location-specific technology.

(ii) **High Yielding Variety Approach**

Next came the HYV approach. Though the HYV strategy initiated in the country during the mid-sixties mostly benefitted cereal crops like wheat and paddy and the irrigated and well endowed regions, crops grown in dry areas like sorghum (jowar), pearl millet (bajra) and maize also partly benefitted from this new strategy. Only sorghum and pearl millet reported an increasing trend in their productivity. However, the growth rates of other crops like small millet, pulses, oilseeds until recently either remained stagnant or even declined. The share of some of these crops excluding oilseeds is also declining though not rapidly. The HYV strategy has failed to bring about any significant impact on dry regions and crops; on the contrary the backlash effects of the green revolution affected coarse cereals and pulses resulting in their slow growth. Also the HYVs did not perform uniformly in different regions due to

wide variations in the agro-climatic environment across the dry regions of the country. Hence in the case of dry regions there was a need to evolve crop varieties and technologies that were location-specific and tolerant of drought and other stresses. After initiation of the All-India Co-ordinated Research Project for Dry Land Agriculture (AICRPDA) in 1970-71 the conditions of these crops have improved and efforts are being made to evolve HYVs suitable for dry land areas that are location-specific and tolerant of droughts and other stresses. But the growth rates and area under these crops continued to lag behind that of rice and wheat due to various factors. The proportion of area of HYVs under these crops taking jowar, bajra and maize is not more than 22.66 per cent of the total area covered by five major cereal crops during 1984-85. 21

(iii) Integrated Approach

Both the mechanical and HYV approaches failed to stabilise the crop production under rainfed conditions and rainfed crops due to total neglect of the

complementarity in the measures suggested and their implementation in a disintegrated manner. A real breakthrough in the development strategy for dry land areas appeared with the establishment of All India Coordinated Research Project for Dryland Agriculture in 1970-71. It initiated 24 pilot projects to test the research findings under field conditions. Unlike earlier efforts, the new approach to dry farming research took an integrated view of the farming system. Under this, both land and water resource management technologies and crop improvement technologies are jointly emphasised. In addition to contour bunding, several other measures like broadbed and furrows, graded bunds, broad based terraces, contour cultivation, ridging on flat, vertical mulching and various degrees of land smoothing were tried to suit different soil-rainfall conditions. In Situ moisture conservation, proper drainage, runoff collection and recycling of supplemental irrigation were also tried. The multiple alternatives for resource conservation and management were complimented by developing agro-biological

components, such as developing a wide range of crop varieties and technologies with different attributes to suit various agro-climatic situations in the dry regions. Treatment of both arable and non-arable lands in dry areas simultaneously with integrated approach was emphasised by the researchers under this programme. These technologies included mechanical and biological conservation structures, improved tillage practices, adoption of HYV seeds suitable for different agro-climatic regions with adequate dose of fertiliser and pesticides, etc. 23

Till 1982 these were implemented taking the revenue district as a unit for development. However, due to heterogeneity in resource endowments of the dry regions, there was a need for a different approach to dryland development. Watershed which is a compact resource region was considered as a suitable unit for initiating developmental activities. Thus from the 1980s there was a major shift in the development approach for dryland areas, with the adoption of 'watershed' as an appropriate unit for development purposes. Upto 1987-88, 23,525 micro-watersheds

23. Jodha, Ibid.
covering an area of 253.9 lakh hectares have been taken up for development in the country.24

Watershed Management Approach

A watershed or catchment basin as it is otherwise known, is an area having common drainage where the rainwater falling in an area coming within a ridge line can be harvested and flow out of this through a single point. Unlike traditional approaches to development where the revenue or administrative boundary is adopted as the unit for development purposes, under watershed management approach for dry land development the watershed is chosen as the appropriate unit area for development.

There is no prescribed size for the watershed but it depends upon the topography of the area and the drainage point. The size of a watershed could vary from 500 ha. to 1000 thousand ha. On the basis of information about the harvestable rainwater in the watershed area and also the characteristics of the watershed such as

soil type, slope, depth of soil, vegetative cover, etc., it is possible to prepare a water budget for the watershed from the ridge down to the valley. Watershed aims at optimum water-budgeting for each piece of land starting from the ridge down to the valley. The amount of water that is entering a particular piece of the land, the maximum that can be retained in the soil profile and that which will inevitably flow out of it as harvestable, can be fairly estimated. Water budgeting will help in proper use of the land and other resources.

Secondly, the watershed approach for dryland development considers the organic boundary rather than the administrative or ownership boundary as the suitable unit for development. This means that the development of government, forest, community or private lands falling within a watershed cannot be considered in isolation because of close linkages between them. Watershed development, therefore, aims at improving all types of land, namely, forest lands in the upper reaches, government lands in the middle reaches and community and private lands in the lower reaches. Each land type would be treated based on their capability to bring in permanent improvement. The management of all land within the drainage for improved soil and moisture conservation will in turn help to achieve better crop
and range, land husbandry and reforestation of land. The activities involved are treatment of arable and non-arable lands in watershed, improvement of vegetative cover in the forest and government lands, proper use of community lands. Watershed development programme is not a mere soil and water conservation or forestry programme but a programme to increase the overall productivity of a given area dependent on rainfall.

Thirdly, watershed approach for dryland development calls for an integrated approach involving several agencies and also with peoples' participation. Various government departments like agriculture, forest, horticulture along with other experts are involved in the programme. The programme is, in a way, an exercise in manpower organisation along with farmer support to map out the development plan for the watershed.

The watershed development programme endeavours to improve and sustain production and productivity in a watershed at higher levels and also meet the community needs for fodder, fuel, fruit and timber. The specific objectives of the programme thus are as follows:

(i) To promote soil and moisture conservation.

(ii) Use lands optimally with a view to increase the productivity of lands.
(iii) To promote proper management of non-arable lands which are community owned for soil and moisture conservation and also to store the excess of run-off. It also intends to ensure the growth of the required bio-mass to maintain the ecological balance and also meet the needs of local people with respect to fodder, fuel, fibre and timber requirements. Thus the rationale in selecting the watershed as an unit of area for development will lie in the fact that it tries to improve the productivity of all types of land so as to increase the economic returns of both individual and the community as a whole dwelling in the watersheds.

Watershed management approach thus seems to offer a ray of hope to the disadvantaged dryland farmers to benefit from appropriate technologies for dry regions.

A Brief Review of Literature

Before spelling out the objectives of this study a brief review of literature related to watershed development approach to dryland agriculture would be worth attempting. We may study them under the following groups.
1. General studies on watershed development mostly based on secondary sources of information and data or impressionistic accounts with a macro perspective covering a cross-section of regions and watershed projects.

2. Micro level studies based on primary data at watershed or farm household level.

Both the above groups of studies have attempted to study the impact of watershed development programmes on dryland agriculture/development by following a 'before and after' or 'pre and post' project approach or 'with and without watershed' project approach.

1. General Studies

The studies in this group are mostly descriptive in nature giving a detailed account of the physiographic features of the watershed projects, their objectives, techniques and individual components and activities, etc., of the watershed development programme. However, a few of these studies have also examined the impact of the watershed development programmes on crop yields and production, income, etc.
Some studies also looked into the basics of watershed development planning and implementation such as inter-sectoral co-ordination and integration of different departments like agricultural, forestry, horticultural, animal husbandry, etc., for planning and implementation of the watershed development programme. Two studies in particular looked into the above mentioned aspects covering a cross section of watersheds situated across the country. These studies threw up diverse findings.

In Nannaj and Pimpalner watersheds of Sholapur district in Maharashtra a study observed that in both planning and implementation stages of the watershed development activities neither inter-sectoral co-ordination nor the integration of sectoral activities existed; each sector worked independent of the other. As a result there was no comprehensive plan and a composite team to execute the watershed development activities.25 In another instance relating to the Rampur Bhatia model watershed in Jodhpur district of Rajasthan the expected inter-sectoral co-ordination was missing; here the Department of Agriculture played a prime role, starting from identification of the watershed to implementation of the

development activities. In Vaghradi and Umaria Watersheds of Amreli district in Gujarat inter-sectoral integration was achieved to a limited extent during field planning. In contrast to these the experience of G R Halli model watershed in Chitradurga district in Karnataka was different where a comprehensive plan was prepared and watershed development activities were implemented through an integrated approach. According to some studies lack of knowledge among the officials about the integrated approach, lack of training and absence of proper guidelines for planning and implementation of watershed developmental activities were the main causes for lack of inter-sectoral co-ordination and integration.

The impact of watershed development programmes on crop yields across different watersheds received attention in some studies. Overall these studies indicated that the watershed development programmes had positive impact on crop yields. For instance, during 1985 in the Kabalanala Watershed of Bangalore district

in Karnataka the per hectare yields of ragi and groundnut were 17.90 and 10.29 quintals respectively, as against only 5.28 and 3.94 quintals per hectare respectively, outside the watershed. Similarly the per hectare yields of jowar across different jowar-growing districts of Karnataka were higher in the watersheds as compared to jowar yields obtained outside the watershed areas. For instance, in Gulbarga district jowar yields obtained within watershed area was 9.35 quintals per hectare as against 7.37 quintals in non-watershed areas. 27 Another study using data for two points of time observed that HYV of ragi and groundnut grown both as mono and inter-crops obtained higher yields as compared to local Varieties in Mittemari Watershed of Kolar district in Karnataka. For instance, during 1984-85 the per hectare yields of local groundnut was 1.6 quintals as against 1.99 quintals in the case of HYV groundnut. Crop mixture of groundnut (local) + pigeon pea obtained 2.00 + 1.11 quintals per hectare as against 4.16 + 1.10 quintals per hectare in the case where HYV

groundnut was used in the crop mixture. During 1986-87 which was the third year of the project, yields of these crops were still higher as compared to the yields obtained during 1984-85. The per hectare yields of groundnut (local) + pigeon pea was 3.35 + 1.53 quintals as against 4.68 + 0.95 quintals per hectare in respect of groundnut (HYV) + pigeon pea. In deep black soil watershed of Joladarasi in Karnataka yield of jowar realised within the watershed was 22 per cent higher than outside the watershed area during the year 1984-85. Crops like coriander and safflower both as inter-crop and mixed crops recorded higher yields in watershed area as compared to yields obtained from outside the watersheds. 28

Another study relating to Mittemari and Gonur Watersheds in Karnataka too indicated better yields in watershed areas as compared to those obtained outside the watershed. The per hectare yields of ragi and groundnut in the Mittemari Watershed which were 12.3 and 13.2 quintals respectively, were more than in non-watershed areas which were 9.6 quintals each. Yields of

sorghum in Bonur Watershed was 8.5 quintals per hectare as against 6 quintals in non-watershed area. In the case of groundnut grown as a mixed crop with red gram the yield in the watershed was 5.5 + 2.1 quintals as against 2.8 + 0.5 quintals the non-watershed area. 29

Other benefits reported from watershed development programmes were an increase in groundwater recharge, a reduction in sedimentation run off rates, an increase in the availability of fodder, fuel, fruits, etc. The enhanced groundwater availability increased the numbers of bore wells from 5 to 28 and open wells from 11 to 18 in Mittemari Watershed area. Due to this the area under irrigation increased from the initial 60 hectare to 150 hectares; a forestry plantation covering 167 hectare was raised which was expected to generate a net income of Rs 150 per hectare in the form of fuel wood and Rs 6000 per hectare benefit from final harvest of timber after a period of 10 to 15 years in the Mittemari Watershed. 30


Another study pertaining to Sukhomajiri Watershed observed that the watershed project reduced the per year sedimentation runoff rates to 1.76 hectare meters from the initial 40 hectare meters. Similarly the per hectare yield of fodder increased to 3.4 quintals from 2 quintals. In Kandi Watershed area in Punjab an ex-ante economic analysis of the forestry component indicated the net present worth at efficiency price to be positive; the B/C ratio was more than unity at 12 per cent discount rate; the IRR was estimated at 11.38 per cent and ERR at 13.01 per cent. This Project was expected to provide employment to 4000 persons annually. Thus, this study established the economic viability of the forestry programme in the watershed areas.

2. Micro Level Studies

In this group, we find two types of studies
(a) Studies based on experiments or field trials conducted at farmers fields to test the impact of


32 Kanchan Chopra et. al., "Participatory Development; People and Common Property Resources", Sage, New Delhi, 1990.
watershed-based technologies developed at research centres, and (b) Studies by researchers based on primary data collected from individual watershed projects or farm households. As mentioned earlier, these studies adopted a 'before and after project' or 'with and without project' approach to study the impact of the watershed development programmes on dryland agriculture/development.

(a) **Experimental Data-based Studies**

In this group there are two important studies to cite. One of this pertained to Karnataka State and the other a study by the ICRISAT, Hyderabad. The Karnataka study reported results obtained from the experiments conducted at developed watersheds in Bijapur, Chitradurga and Bellary districts of the state. This study sought to test the impact of watershed in

both black and red soil areas. The ICRISAT study reported the results obtained from small watersheds developed by the ICRISAT personnel in villages situated at different agroclimatic conditions viz., Aurepalli village in Hyderabad, Shivapur village in Sholapur and Kanzowa village in Ankola district. The areas of these watersheds were respectively 13.5, 13.5 and 12 hectares and number of farmers involved were 8, 8 and 6. The experiments were conducted during 1979-80 and 1980-81.

The Karnataka study was aimed at testing the performance of individual soil and water technologies like graded bunds and contour cultivation. The study noted that in Bijapur district, graded bunds established in a 20 hectare watershed helped to realise additional benefit to the tune of Rs 212 per hectare. In Chitradurga district establishment of graded bunds resulted in additional yields of 92, 126 and 67 kgs per hectare for sunflower, jowar and groundnut, respectively, which were 18 to 33 per cent higher than the corresponding yields obtained from unbunded fields. Similarly, contour cultivation and in situ conservation

practice in the black soil watershed of Bellary district during 1982-83 resulted in a grain yield of 1660 kgs and straw yield of 3450 kgs per hectare, respectively, from HYV jowar. During 1984-85 the same practice with one supplementary irrigation further increased the per hectare grain yield to 2544 kgs and straw yield to 4800 kgs. The same technique in red soil area demonstrated 16 per cent higher yield for groundnut compared to traditional practice. In Chitradurga district the watershed development programme increased the per hectare yields of ragi from 765 kgs to 927 kgs during the post project period; in the case of sunflower and groundnut per hectare yields increased from 257 and 357 kgs respectively, to 479 and 446 kgs after implementation of the watershed project. The net B-C ratio of this watershed in agricultural sector was estimated at 1.52. The ICRISAT study indicated the impact of watershed in the form of net profit for different years compared to traditional technology. In Aurepalli village, during 1979-80 the overall economic performance of the watershed-based technology was not satisfactory, the net profit obtained being only 14 per cent higher than the traditional technology. However, in the case of irrigated crops, net profits obtained were higher as compared to traditional technology, the net profit from groundnut cultivation was Rs. 1630 per
hectare as against only Rs 250 per hectare under traditional technology. In other watersheds like Shivapur and Kanzara the watershed-based technology yielded more profits compared to under traditional technology; however, the net profits were not significant due to the use of fertilizer in unfavourable weather conditions.

(b) Farm Survey-Based Studies:

The research studies covered here relate to a cross section of watersheds situated in different parts of the country. These studies pertain to different regions, heterogeneity of situations involved, differences in the time period of analysis, sample and methodology used, issues covered, scope, etc. These limitations may be noted while comparing the results of these studies. Broadly, these studies sought to evaluate the impact of watershed development on cropping pattern and intensity, crop yields and production, income, employment generated, cost and returns, hydrology, development of non-arable lands, people's participation in watershed development activities, etc. We may briefly review the findings of these studies.
Watershed development activities primarily lay emphasis on diversification of cropping system and a shift to alternate land use systems more suited to the dryland eco-systems as well generate higher returns. Quite a number of studies indicate that watershed development programmes have led to crop diversification from cereals to pulses, oilseeds and other commercial crops and from low to high value crops in almost all watersheds. The level of crop diversification as indicated by the index of crop diversification was reported to be very high in Chevella watershed of Andhra Pradesh and Mittimari watershed in Karnataka, being 90 and 88 respectively. A comparison of the cropping pattern between watershed project area and non project areas indicated the proportion of area under pulses and


oilseeds to be conspicuously higher in watershed areas as compared to in non-watershed area. The percentage of area under pulses to gross cropped area in low, medium and high rainfall zones, respectively, were: 22.51, 11.61 and 39.61 as against 7.59, 8.08 and 31.91 in the non-watershed area. Similarly in the case of oilseeds these proportions were 3.39, 1.86 and 15.59 respectively in the watershed area as against 1.66, 0.70 and 1.3, respectively, for the 3 zones in non-watershed area. Due to watershed development, the gross and double cropped areas recorded an increase to the extent of 7.5 to 15 and 14.95 to 41.76 per cents, respectively. A study pertaining to the B R Halli Watershed in Karnataka showed that the area under oilseeds which was negligible during the pre-project period rose significantly to occupy about 17 per cent of the gross cropped area during the post project period. Area under plantation crops which accounted for only 25.4 per cent of the gross cropped area during the pre-watershed project


period increased to 41.2 per cent during the post project period. In Bankura Watershed of West Bengal, after implementation of watershed project, area under paddy decreased whereas area under vegetables, mustard and potato increased. However, a study from Tamil Nadu indicated no significant difference in the cropping pattern between the pre and post project periods.

Diversification of cropping pattern and improved moisture availability following watershed development activities led to an increase in cropping intensities, as indicated by a number of studies. A study of Gunj Watershed in Maharashtra indicated that cropping intensity increased from 104.97 per cent during the base year to 125.84 per cent during 1989-90. In Anakkati Watershed in Tamil Nadu cropping intensity


increased by 12.68 per cent. In Bankura Village of West Bengal compared to pre-project period cropping intensity increased from 1.09 to 1.18; in the non-watershed area the same was 1.02. Thakarada Watershed in Rajasthan reported an increase in cropping intensity to 144.68. From this it is obvious that watershed development programmes resulted in a shift in the cropping pattern from low to high value crops and also helped in increasing cropping intensities in a number of watersheds, when compared to the pre-project period or non-project areas.

Increasing and stabilising the productivity of crops through both conservation and production technologies is a major objective of watershed development programmes. Most of the research studies probed into this issue which observed that the impact of


watershed development programme on crop yields has been positive. A study of Kollewadi village of Ahmednagar district in Maharashtra, for instance, noted that for almost all crops, yield levels recorded an increase, the percentage increase in per hectare yield of Sorghum and Wheat respectively being 134 and 72 compared to base year. In the Rendhar Watershed of Uttar Pradesh, the productivity of different crops increased by 3 to 5 times as compared to the base year and by 2 to 4 times as compared to non-watershed area during 1987-88.

In Avanashi Watershed of Tamil Nadu the per hectare yield of Fodder Cholam increased from 3437 kgs to 5607 kgs, the percentage increase being 63.34; the productivity of cotton and gingely increased by 23.27 and 19.76 per cents respectively. However, yields of groundnut recorded a decline which farmers attributed to uneven distribution of rainfall during the reference year. Data collected on yields and cost of cultivation for selected crops within G R Halli


Watershed and outside in Karnataka were tested for their statistical significance. Wherever conservation technology was applied, crop yields registered an increase ranging from 17.7 to 32.9 per cent. The improvement in productivity was the maximum in the case of sunflower and minimum in the case of groundnut. Ragi registered an increase in productivity to the extent of 21.2 per cent. The increase in productivity in the case of irrigated crops ranged between 19.5 to 35.5 per cents.

A watershed project in West Bengal reported an increase in the per hectare value productivity of crop production from Rs 1788 to Rs 2776; in the non-project area the same was only Rs 1826.

A number of studies have tried to assess the viability and benefits of watershed development projects by computing the investment and returns, benefit-cost ratios, production function, etc., compared to both the base year of the project and non-watershed areas. An evaluation study of Sukhi Watershed in Gujarat State applied the log linear form of Cobb-Douglas production function.

function analysis both for base year and study year using farm survey data for the project. Its findings indicated that before the project period in the case of unirrigated crops land was a significant factor behind production whereas in the case of irrigated crops in addition to land the fertiliser variable also turned out to be a significant factor. However, more interesting was that in the post project period labour became a significant variable in addition to the above. 50 Many of the dry farm practices and soil and water conservation works are labour-intensive in nature which may account for the variable turning out to be significant after implementation of watershed development programmes. An analysis of the economics of crop cultivation in Chevella and Mittemari Watershed showed that due to crop diversification per hectare cost of cultivation varied from Rs 977 in Sorghum (local) to Rs 1497 in Sorghum (HYV) + Pigeon pea as inter-crop. The respective gross incomes obtained were Rs 1176 and Rs 2780 per hectare. In Mittimari Watershed per hectare cost of Ragi (HYV) and Groundnut (HYV) + Pigeon pea (HYV) were Rs 2038 and Rs 2886 respectively. The corresponding gross incomes were Rs 3271 and Rs 7537.

The respective benefit-cost ratios were 1.30 and 1.41. In Chitravathi Watershed of Kolar district in Karnataka the benefit-cost ratios for different crops varied from year to year; however, it was greater than unity for all crops, the additional benefit-cost ratios for HYV groundnut and ragi with pigeon pea as inter-crop were Rs 1.06 and Rs 1.48 respectively. A study of Watershed development programme in Indore district of Madhya Pradesh analysed the cost and returns for different size groups of farmers in the watershed as compared to that in the non-watershed area. The results revealed that the per hectare cost as also the gross and net returns from crops cultivation by small farmers were higher compared to those reported by medium and large farmers in project area and non-project area. For example, the per hectare cost and net returns of wheat in the watershed project area for small, medium and large farmers were respectively Rs 3612, Rs 3090 and Rs 2541; the corresponding net returns were Rs 4786, Rs 3673 and Rs 3273. The per hectare costs in non-project area were Rs 3573, Rs 2927 and Rs 2412 respectively for small, medium and large farmers and the net returns,

52 Hafeez, et. al., Ibid.
Rs 1344, Rs 792 and Rs 482 respectively. Similarly, though the benefit cost ratios, varied from crop to crop, they were not only higher than unity for all crops in the watershed project area but also they were the highest for small farmers. Though this study does not cite any reason for the higher efficiency of small farmers, this could be due to the more intensity of cropping, crop pattern differences, and better care among small farms as compared to large ones, a point which has been noted in several farm management studies conducted in India.53

A study relating to Avanashi Watershed in Tamil Nadu attempted to evaluate the benefit cost ratios from soil conservation works in four situations, i.e. assuming current level of benefit, alternatively assuming flow of benefits to be at 50 per cent of the current level, or alternatively assuming investment by government alone and in the last scenario assuming investment by both government and farmers at the discount rate of 12 per cent. The benefit cost ratios for all the above four situations were found to be greater than one indicating the financial worthiness of the investment made on the

soil conservation scheme. A number of studies conducted at Chevella, Bothulabguda and Mittimari Watersheds for different years found the benefit cost ratios for all crops cultivated in the watershed areas to be greater than unity and higher than in non-project areas. Performance of G R Halli Watershed development programme using sensitivity analysis with alternate assumptions and discount rates to the flow of benefit and costs in the agricultural sector revealed the NPVs, benefit cost ratios and IRRs to be positive and quite high indicating the financial worthiness of the project. An analysis of the impact of land development programmes on the incomes of three land holding size groups in Kandi Watershed project in Punjab revealed that the farm family income per household from all sources registered a perceptible increase for all size-groups. The percentage increase in farm family


income for small, medium and large holdings were 38.37, 52.99 and 53.41 per cents, respectively, as compared to before project period; however, the increase in income was statistically significant only for medium farms. The yearwise B C Ratios from 1986-87 to 1989-90 were respectively 1.27, 1.53, 1.90 and 2.21. An interesting finding revealed by a study was that even in a drought year such as 1987-88 productivity in watershed area was less affected as compared to non-watershed areas; the crop yield loss in the watershed area was 12.7 per cent as against 49.21 per cent in other areas.

The soil and water conservation activities in watershed region are expected to improve the hydrology of the area and have both economic and environmental spin-offs. The research studies touching on this aspect are however meagre. Of the available studies a few examined the impact of the watershed development on hydrology and related aspects. A study of watershed development activity in Jhansi district of Uttar Pradesh noted an increase in the water table by 3 and 6.5 metres during summer and rainy seasons.


respectively. The average annual increase in the water table was 3.7 metres.\(^{60}\)

Similarly a study of Anakkatti Watershed in Tamil Nadu reported an increase in the ground water level by 10 feet and also an increase in the duration of water stagnation (moisture) in the soil after a rainfall by 20.26 hours. The number of gullies also registered a decline in this watershed area.\(^ {61}\) Another interesting finding revealed by a study conducted in Daate Watershed of Kolhapur district in Maharastra observed that watershed development programme had helped to arrest the soil and nutrient loss substantially ranging from 67.5 to 82.76 per cent in the case of soil loss and nutrient loss checked to the extent of 17.15 to 32.04 per cent. The losses through run off were diverted towards moisture storage, ground water recharge and deep percolation tanks, the respective percentages being 29.6, 80 and 50.\(^ {62}\)


\(^{61}\) Timothy and Ravichandran, op. cit.

The success of watershed development programme depends to a large extent upon the active participation of grassroot level people. The extent of people's participation in watershed development activities has been an issue of enquiry by some studies. These revealed that people's participation at the planning stage was nil and at the implementation stage it was confined to merely giving consent to execute the soil and water conservation works in the concerned farmer's field. Regarding the maintenance of assets differences in attitudes were observed. Maintenance of water harvesting structure received attention of farmers in Amreli district; maintenance of bunds were poor; in some cases the study noted that bunds had been removed to make way for bullock carts in Chitradurga districts. Forest plantation and pasture plots situated in community lands received the least attention of people; however, roadside plantation were maintained well in Amreli district. Peoples' participation in watershed development activities was seen to be effective wherever non-governmental organisations were involved in organising a homogeneous groups/peoples


64 Jaiswal, et. al., 1982, and 1985, op. cit.
associations or sanghas; or wherever people were organised under the guidance of a good enlightened and honest leader and where provision of irrigation helped to organise Sanghas. Another study observed that participation of people was not effective in the Government implemented watershed projects.

The drawbacks of the earlier studies and issues for the present study are briefly indicated in the next section.

**Research Issues**

The review of literature indicates that though there have been quite a number of studies in recent years on the subject, the available studies suffer from a number of drawbacks. These studies indicated the gaps to be filled in as well as the need for further studies with more rigorous empirical and theoretical support. In so far as the general or macro-level studies are concerned they are mostly impressionistic accounts and

65 Kanchan Chopra et. al., op. cit.

too general in nature confining their attention to issues like presenting a descriptive account of the physiographic features of selected watersheds, objectives, techniques, and individual components of watershed planning and implementation of watershed development activities etc. as well as giving impressionistic accounts of the programme's impact on crop yields, soil and water conservation, etc. which, of course, is due to the limited coverage of secondary data. The few available micro level studies at watershed or farm level were limited by the range of issues posed for investigation, the limited coverage of crops, farms and activities in their analysis, etc. Watershed development programmes being a holistic approach to development of dry lands, there is a need for more comprehensive studies covering various components and activities undertaken by the watershed programme. Moreover, these studies were conducted at the early stages of the implementation of the watershed development programmes when its impact was yet or more fully to be realised. They also failed to link up their empirical findings with issues of theoretical importance such as the farm size-productivity debate, whether economies of scale operate in the concerned watersheds, the issue of the efficiency and viability of different land-holding groups, the
question of how costs and benefits have been shared in the watershed among different land holding groups and between upper and lower reaches of the watershed, etc. The present study endeavours to overcome some of these gaps by covering more issues, crops, and holdings as well as link up its empirical findings to issues of theoretical importance. Moreover, it studies a watershed which is in an advanced stage of development as well as use more rigorous methodologies to analyse the economics of Watershed Development Approach to Dryland Agriculture.

In the light of the review of literature, the need for an in-depth analysis of the economics of watershed development approach to dryland agriculture is felt. In particular what has been the impact of the watershed development programme on production and productivity in the selected watershed as also the relative economics of crop cultivation in the watershed vis-a-vis a non-project area viewed in terms of costs and returns secured. This needs to be analysed in detail at disaggregate level for different crops, both dry and irrigated, for both kharif and rabi season crops as well as across different size classes of holdings, using different cost and income concepts. Further, have the benefits from the programme percolated
equally to all areas and farms within the watershed? This calls for an analysis of the economics of crop cultivation in the watershed not only at the aggregate level for the watershed as a whole but also at a disaggregate level for the upper and lower reaches of the given watershed which exhibit distinct physiographic and socio-economic characteristics as also across different land holding groups. The level of adoption of modern inputs and dry farming technologies and practices too needs to be analysed in detail across different size-classes of holdings in the upper and lower reaches of the watershed. The programme's impact on soil and water conservation, on non-arable land development, as also the level of people's participation at various stages of the programme including in the maintenance of soil and water conservation structures and other assets created under the watershed development programme also merit a probe. The farmers' perceptions of the benefits from the programme also need to be noted for appropriate policy formulation and implementation.

**Objectives**

In the light of the above discussion the present study seeks to make an economic analysis of the watershed development approach to dryland agriculture
in Karnataka. Apart from a macro-level analysis of the progress and performance of the watershed development programme in Karnataka, based on secondary data the study also provides an in-depth economic analysis of the watershed development programme using micro-level data for a watershed in comparison with a non-watershed project area.

The specific objectives of the study are as follows:

1. To attempt a macro-level analysis of the programme in Karnataka through a review of the progress and performance of watershed development programme in the state, particularly its physical and financial progress for different activities and components.

2. To analyse the impact of watershed development activities on cropping pattern and intensity, crop yields and production of important crops grown in the region across size-classes of holdings and between the upper and lower reaches of the watershed in comparison with a non-project area (NPA).

3. To analyse the structure of costs and returns from different crops across size-classes of holdings as well as income and employment in the WPA as against in NPA.
4 To examine the level and constraints in adoption of dry farming techniques among different size classes of holdings.

5 To study the extent of development of arable and non-arable lands, the economics of social forestry implemented on non-arable lands as also impact on soil and moisture conservation.

6 To study the nature and extent of farmers' participation in different stages of watershed development activities as well as their awareness and perceptions about the programme's benefits.

Study Region

Karnataka State which is predominantly a dry farming state having five of its ten agro-climatic zones under dry zones stretching across 14 districts and 106 talukas of the state and which has also been in the forefront among different states in India in implementing watershed development programmes is the ideal choice region for conduct of the present study. Of the state's 19 districts, 13 are located in the low and medium rainfall zones. The average annual normal rainfall for the state is 1200 mm; it ranges from 450 to 3932 mm across districts. In spite of massive
investments in irrigation in the state during the last four decades, irrigation still covers only about 20 per cent of the state's total cropped area. Of this irrigated area, only 9 per cent is irrigated by canals, whereas the rest depends on tank and well irrigation which are directly dependent on the annual precipitation. Out of the state's geographical area of 19.04 million ha. over 10.4 million ha. is under cultivation, and of this about 8.2 million ha. is in rainfed regions, particularly regions having low and uncertain rainfall. In other words, almost 80 per cent of the state's cultivated area is rainfed, as noted earlier. Besides the state has 16 per cent of her geographical area under forest cover and over 60 per cent of the total geographical area under cultivation. This indicates that the scope for further extension of cultivation in the state is very limited. Of the state's total cultivated area, 56 per cent is in need of soil conservation measure. Even if the state were to realise its ultimate irrigation potential estimated at around 46 lakh hectares, through exploitation of surface and groundwater resources, it will still cover only around 30 per cent of the state's total cropped area. This means that about two-thirds of the state's cropped area will continue to be rainfed. In fact the contribution of dryland agriculture to the state's
economy is quite significant accounting for as much as 57 per cent of total coarse cereal output, a large proportion of output of oilseeds, pulses and other agricultural commodities. Ensuring access and spread of dry farm technology is, therefore, of paramount importance to Karnataka's economy in particular.

Realising this, the Government of Karnataka in its pioneering efforts is implementing the watershed management approach for development of dryland agriculture in a phased manner from 1983 onwards. At present there are two major parallel programmes going on (1) District Watershed Development Programme (DWDP) and (2) National Watershed Development Programme (NWDP). The Dry Land Development Board is established for implementing district watershed development programme and the Department of Agriculture is responsible for the NWDP. The DWDP utilises the RLEGP, DPAP, and NREP funds whereas the cost of NWDP would be shared by the state and central governments on a 50:50 basis.

District Watershed development programmes are being implemented in all 19 districts of the state, one watershed project in each district. For an intensive study a fully developed watershed, 'Mittemari Watershed' in Kolar district has been selected purposively. In order to make an in-depth farm level
study of the impact of watershed development programmes on crop yields, income, employment, level of adoption of dry farming techniques, farmers' participation, etc. 138 farm households from Mittemari Watershed villages and 55 households from non-project village i.e. a total of 193 farm households have been selected on systematic sampling basis with a random start. These households constitute about 25 per cent of the total households of the concerned areas.

Data and Methodology

Both secondary and primary data have been used to analyse the economics of watershed development approach to dryland agriculture at macro level i.e. state and district level and micro level i.e. farm level in the given watershed. The secondary data were collected from published and unpublished official records from various concerned government departments at state and district level, supplemented by information and data in non-official studies, those of individual researchers, etc. The secondary data have been analysed to examine the performance and progress made in the district watershed development programme in Karnataka. Here year-wise achievement of financial and physical targets of watershed development programme, component
and sectorwise like agriculture, forestry and horticulture, per unit investments, area treated in all the three sectors and also physical progress achieved in individual activities of each sector are also analysed by rainfall zonewise. Using the available secondary data we have also tried to get a broad macro perspective of the impact of watershed development programmes on crop yields, income, employment and on soil and moisture conservation. The macro level analysis is to serve as a useful background and complement the in-depth micro level analysis based on farm level primary data.

Primary data have been collected from selected households of Mittemari Watershed and Non-project area village by using pre-tested schedules following the personal interview and participant observation method during the agricultural year 1989-1990. The survey was conducted during December 1989 to March 1990. The primary data is analysed to examine the socio-economic characteristics of sample households of Mittemari Watershed Villages, economics of crop cultivation separately for major crops, rainfed and irrigated crops, kharif and rabi crops cultivated in the watershed project area and non-project area, rate of adoption of dry farming technology, participation of people in watershed development activities, maintenance of SWC structures, their present position and
constraints in maintaining them, farmers' access to extension education, their perceptions about the benefits from watershed development activities, etc.

For an analysis of this nature, which seeks to analyse the impact of a development programme on selected variables, there are two alternatives in project appraisal, viz. use a 'Before and After Project' approach or alternatively compare the benefits of project area vis-a-vis non-project area i.e. adopt a 'with and without project' approach. We have used both approaches for our appraisal.

The 'before and after approach' have been employed to analyse the impact of watershed development project on cropping pattern, yields, soil moisture, etc., as compared to the before project period (Baseline Survey data). Similarly the 'with and without approach' has been used to analyse the impact of watershed development programme on dryland agriculture like crop yields, costs and returns from crop cultivation, animal husbandry, income and employment, etc. Within the watershed we have also examined the impact of watershed development separately for the upper and lower reaches so as to assess whether benefits have been shared equally.
For analysing the financial and physical progress of watershed development programme across sectors, viz. agriculture, forestry and horticulture sectors, we have categorised the 19 district watershed development project areas into three zones based on their annual average normal precipitation i.e. low rainfall zone (below 750 mm), moderate rainfall zone (between 750 and 1200 mm) and high rainfall zone (above 1200 mm).

To assess the economics of crop cultivation in watershed we have used different cost and income concepts used in the Farm Management Surveys of India with suitable modifications. To analyse the economic viability of crop production we have used Benefit-cost ratios (BC ratio). For analysing the economic viability of social forestry undertaken on the community lands in the watershed, we have used various viability measures like Net Present Value (NPV), BC ratio and Internal Rate of Return (IRR), commonly used in project appraisal. We have used rigorous tests and sensitivity analysis to test the robustness of our estimates. To analyse the spread of dry farm technology we have used "Adoption rate" of each technology like use of HYV seeds, fertilizer, pesticides, improved cultivation practices, etc. As mentioned earlier, the micro-level
analysis is based on a sample survey of farm households selected on systematic sampling basis with a random start from the list of farmers of the villages in the Mittemari Watershed area. The detailed sample design, characteristics and socio-economic background of the sample households and region is discussed in Chapter III. For purposes of analysis the farm households after selection have been grouped into three groups based on the land holding size. The analysis in the present study will employ both inter-farm and intra-farm comparison both within and outside the watershed area as also between the upper and lower reaches within the watershed. Apart from descriptive cum tabular statistics we have used statistical tools such as ratios, percentages, and regression analysis to analyse the questions posed in our study. More details about the methodology and tools used for the analysis are indicated in relevant chapters. The discussion in the study is organised into nine chapters.

Chapter Scheme

Chapter II provides a comparative analysis of the agricultural economy of Karnataka vis-a-vis that of India as a whole followed by a macro-level analysis of the watershed development programme in the state.
covering a discussion about watershed, its objectives, components and activities, financial and physical achievements of watershed development programme in the state. Chapter III presents the sample design and salient features and socio-economic characteristics of the selected watershed area and cultivators to serve as a backdrop to the detailed analysis. Chapter IV analyses the impact of watershed development programme on cropping pattern, cropping intensity and crop yields. Chapter V analyses the costs and returns from crop cultivation with and without watershed project, using different cost and income concepts, followed by an analysis of the returns from animal husbandry activities and labour use. Chapter VI discusses about the level of adoption and constraints to adoption of recommended dry farming technology by size groups of farms. New Technology includes recommended input package and improved cultivation practices for in situ conservation of moisture. Chapter VII analyses the development of arable and non-arable lands for conservation of natural resources in the watershed area. This involves an analysis of the economics of social forestry undertaken on community lands in the watershed. The analysis also examines the present conditions of the soil and water conservation structures and their management, reasons for their present conditions and the constraints in
maintaining them, etc. It also discusses about the impact of watershed development programme on soil moisture, water level in wells and tanks, compared to pre-project period and also farmers' perceptions of its impact on availability of fodder, fuel, small timber, etc. in watershed area. Chapter VIII examines the extent of people's participation in watershed development programme at various levels such as at planning and at implementation stages as well as in respect of maintenance of assets created during the programme. Chapter IX summarises the findings and conclusions of the study.