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Management Applications of Perspectives on Risk and Fertility of Dry Lands Reclamation in India

***Dr. C. Anbalagan, ** Andinet Asmalesh, *** Dawit Daniel**
*Professor of Accounting & Finance, Editor-in-Chief of Reputed International Journals
Research Advisor and Consultant, School of Management & Accounting, Hawassa University, Hawassa, Ethiopia, East Africa, +251-932319331, E-mail: dr.chinlakshanbu@gmail.com
** Lecturer in Accounting & Finance, School of Management & Accounting, Hawassa University, Hawassa, Ethiopia, East Africa
*** Associate Registrar, Hawassa University, Hawassa, Ethiopia, East Africa

Abstract

In the present context, dry land/rain fed agriculture has been broadly classified on the basis of proportion of cropped area irrigated. Based on the National Sample Survey Organization (NSSO) regions, areas with less than 25 percent of irrigation were classified as dry land areas while those with more than 25 percent irrigation were considered as irrigated regions. Considering this classification, all the 58 regions, covering major states in India, for which information about important indicators was available, half of the regions were identified as dry land. The watershed is a continuous area whose runoff water drains to a common point, so that it facilitates water harvesting and moisture concentration. A river basin is the largest watershed that can be imagined but for the purpose of dryland agricultural development the areas chosen are usually around smaller streams and are denoted as mini or micro-watersheds of about 500 hectares, equivalent to more or less the average area of a village.

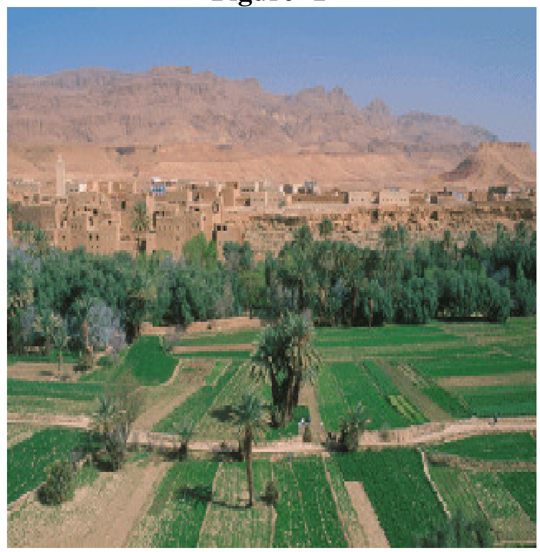
Key words: *dry land/rain fed- NSSO- irrigated- information- watershed- agricultural- micro*

Introduction

The main aim of any agricultural development programmes is to maintain sustainable growth in agricultural production for ensuring food security, including nutritional security, to growing population and generate adequate surplus for export. Besides, it is expected to generate sufficient employment opportunities in the agriculture and allied sector. As demand for various products increases the total availability of the resources remaining the same, the various demands compete for the use of same resource leading to environmental degradation. Environmental degradation and rural poverty are mutually reinforcing factors and thus necessary for effective implementation of all poverty alleviation programmes. During the last three decades, there has been substantial increase in agricultural production, especially food grains, mainly superior cereals such as wheat, rice, and some cash crops. Most of the gains in increased agricultural production were realized due to increase in agricultural productivity with interaction of seed-irrigation-fertilizer technology and farmers' initiatives rather than area expansion. However, this growth in agricultural production remained concentrated mostly in high production environments with developed infrastructure, irrigation facilities and assured rainfall. A large tract of area dependent on rain with low or negligible irrigation facilities and poor resource base could not keep pace with other regions. Rain fed farming, more popularly known as "dry land agriculture" means raising crops with rainwater is spread in four continents covering almost 48 countries. Worldwide, 6510 million hectares (mha) of land is under rain fed agriculture of which approximately 60 percent are in the developing countries. India ranks first among the dry land agricultural countries in terms of both extent and value of produce. Out of every three hectares of cultivated land in India, nearly two hectares are under the influence of rain fed agriculture. Out of a total 142.1 million hectares of cultivated area in India, dry land accounts for 91.0 million hectares and in the foreseeable future also nearly 60% of our population will still continue to depend on dry land agriculture.

Weather-induced problem of low and unstable crop production has acted as a principal factor for perpetuating the economic stagnation of dry areas. Besides, earlier policies for stressing intensification of resource use have led to recurrent floods, droughts, and excessive runoff.

Figure- 1



Characteristics of Dry land Agriculture

The traditional farming system in dry land region is more a survival mechanism rather than growth-oriented activity. These are resource-intensive systems and had been evolved for low input use. Earlier, the dry land farming system, because of its risky nature was dependent on locally available inputs and used to grow a number of crops, which were able to withstand the drought-like situation. But over time, the cropping system has changed and presently farmers in these dry land areas have limited options and have started growing high value crops, which require intensive use of costly inputs and find it difficult to manage the resources on their own. Since the income and saving potential of dry land farmers is low and uncertain, investment in farming is also quite low. Hence, external financial support from credit institutions and subsidized inputs are crucial for the development of dry land agriculture.

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Some of the important characteristics of dry land agriculture given in Table 1 show that dry land is less densely populated compared to irrigated areas but the proportion of landless households and agricultural labourers is quite high. These dry land regions have limited irrigation, that is, about 15 percent compared to 48 percent in irrigated regions. The land and labour productivity both are considerably low in dry land regions and more than 37 percent of people are poor. Due to low opportunities and higher population of landless households and agricultural labourers as well as low productivity of land and labour, poverty is concentrated in these regions. These are the regions, which have low infrastructure facilities like markets and roads. Per capita consumption expenditure on foodgrains in the dry land regions is almost half the level of consumption expenditure in irrigated areas.

Table -1
Characteristics of Dry land and Irrigated Regions in India

Particular	DRY Regions (29)	WET Regions (29)	All Regions (58)
Population density (persons per sq kms)	163	297	230
	30	28	29
Proportion of agricultural labour (%) Proportion of small farms (%)	52	76	69
Proportion of landless households (%)	43	44	44
Literacy - male (%)	47	47	47
Proportion of irrigated area (%)	15	48	32
Poverty ratio, Headcount (%)	37	33	35
Land productivity (Rs./ha)	5716	8017	6867
Labour productivity (Rs./ha)	6842	9830	8336
Per capita consumption (kg/year) of:	240	459	350
Cereals	20	12	16
Pulses Total Foodgrains	260	471	365
Per capita monthly consumption expenses (Rs.)	279	297	288
Share of food in total consumption (%)	65	62	63
Real wage rate for men (Rs./day)	25	27	26
Market density	2.86	3.69	3.28
Road density	3.79	6.99	5.89
Gini ratio in consumption	0.25	0.27	0.26
Bank credit (Rs./ha)	1050	1650	1350
Cooperative credit (Rs./ha)	816	1038	925
Social Development Index	0.43	0.44	0.43

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Infrastructure Development Index	0.30	0.40	0.35

A more comprehensive social and infrastructure development index clearly indicates that compared to irrigated regions, dry land regions are less developed. All these

indicators clearly indicate that dry land areas have remained neglected after 50 years of dependence. However, dry land is not a homogenous region and varies in terms of soil type, rainfall, cropping pattern, literacy, land and labor productivity, etc. It is always not true that all the dry land regions are much inferior in terms of productivity and

Infrastructure or level of development, but in general, this is true.

Constraints to Dry land Agriculture

Rain fed/dry land areas are harsh environment and suffer from a number of constraints such as low and uncertain rainfall, limited irrigation, low moisture, poor and degraded resource base, declining soil fertility, low income and low saving capacity, lack of infrastructure, lack of adequate and timely credit, low capital formation, dominance of low value crops, low productivity, and inadequate attention paid by policy makers and scientists, etc. However, the basic problem of dry land areas is one of a vicious cycle that starts with degradation of the natural resource base through poor management leading to low productivity, low income, low surplus, and low investment. This, in turn, leads to over-exploitation of the existing natural resources and further degradation.

Unlike irrigated agriculture, rainfed farming is mixed with livestock farming, which provides a dependable source of income to dry land farmers. Nearly two-thirds of the total 450 million heads of livestock in India thrive in rainfed regions. With the increasing pressure of growing population of man and his animal, the natural resource base over the years has declined in both quantity and quality. The immense pressure on India's natural resources can be seen from the fact that India constitutes 18 percent of the world's population, and owns 15 percent of world's livestock. Against this, India possesses merely 2 percent of the world's geographical area, 1 percent of rainwater, 1 percent of forest area and 0.5 percent of the pastures.

These constraints can be broadly classified into three groups namely, biophysical, socio-economic and technological and extension, etc. Some of the major constraints faced by dry land agriculture are as given under

Bio-physical

. Inherent poor quality land and degraded natural resource base
i. Low and erratic rainfall, droughts
ii. Shallow soils and low moisture holding capacity
iii. Sparse vegetative cover
iv. Poor rainwater management

Socio-economic and Infrastructural

i. Extreme poverty and low purchasing power
ii. Low literacy and resistance to change from traditional system
iii. Socio-political conflict
iv. Inadequate credit facilities
v. Subsistence orientation and dominance of low vale crops
vi. Low risk bearing ability

vii. Large scale out-migration of active adult male workers
viii. Lack of infrastructure like road, irrigation, transport, market, storage and telecommunications
ix. Restriction to free movement of farm produce
x. Lack of legal protection for sharing of natural resource on equity basis

Technological and Extension Constraints

i. Top down approach
ii. Inherent weakness of resource management technologies
iii. Excessive emphasis on commodity research
iv. Low level of mechanization
v. Weather dependence of technologies
vi. Lack of integration of livestock research and inadequate appreciation of farming system perspective
vii. Low preference of scientists and policymakers
viii. Adhocism in development efforts and bias to short term gains
ix. Lack of technological options to suit diverse environment and meet the requirement of farmers
x. Lack of appreciation for incorporating traditional wisdom in development of technologies
xi. Inadequate research-extension-farmers linkage and lack of updated information of extension personnel
xii. Inadequate HRD initiatives for extension personnel leading to low motivation of extension staff
xiii. Larger dependence on input supplying activities than on-farm development technologies
xiv. Lack of balanced focus on resource-centered and crop-centered technologies

Land Degradation

Dry land areas face a major challenge of declining soil fertility due to severe land degradation. Poor soil fertility is the outcome of mainly severe erosion and degradation of top fertile soils leading to low organic matter in the rain fed dry land soils. Current estimates on land degradation show that around 66 percent of the geographical area suffers from soil erosion, water logging and salinity problems. Water and wind are the leading (47%) cause of rampant soil degradation. Loss of vegetative cover promoted by long periods of aridity (periods during which evaporative water loss exceeds the water inputs) and openness of lands to de-vegetation by man and over-grazing by cattle makes dry land highly susceptible to erosive forces.

Risk in Dry land Agriculture

Farmers in rain fed/dry land regions often face mainly two types of risks, that is, climatic and yield risks, which makes these regions vulnerable. Both types of risks are highly correlated. The vagaries of the monsoon affect the most, the area falling in the low rainfall zone with droughts being a frequent occurrence. In the medium and high rainfall zones, even though severe droughts do not occur as frequently as in the low rainfall zone, rainfall uncertainty, especially at the time of planting causes great variability in cropped area from year to year, and affect cropping patterns. The yield risk in dryland is quite high and leads to instability in agricultural production. Farmers in dryland areas exploit vertical, horizontal and temporal dimensions of natural resource base to reduce production risk. They follow mainly two types of strategies namely risk-reducing and risk-diffusion or loss management adjustment mechanism to cope with various types of risks. Spatial diversification, crop diversification, intercropping and plot diversification, tenancy (crop-sharing arrangement and cash rental) are some of the strategies adopted by the farmers to minimize risk in dryland areas.

Productivity

In general, productivity is positively and significantly correlated with natural soil fertility, access to irrigation, soil moisture, level of fertilizer use, availability of suitable cultivars and farmers' risk bearing ability, etc. India has little potential for increasing production through expansion of area under cultivation. Increased production has to come mainly from increasing the output per unit of land through technical change and intensification of agricultural resource use (Sharma and Gandhi 1990). But intensive use of agricultural resource has hastened the degradation of soil and water resources. Therefore, there is serious trade-off between technical change and intensification of resources for increasing agricultural productivity, and the long-term sustainability of its resource base.

The agricultural productivity in dry land regions is quite low compared to irrigated areas and there is a large difference in the yield between irrigated and unirrigated fields. The productivity of dry land crops could not increase partly due to severe agro-ecological constraints and partly due to failure of researchers and policymakers to understand the reasons behind the complexities of traditional farming system they seek to improve (Put et al. 1990). The attitudes of the policymakers and farmers are quite often conflicting as farmers are constantly busy negotiating the problem of low but stable production through available adjustment mechanism while policymakers awaken when problems get aggravated.

Improved Seeds

Because of harsher environment in dry land agriculture, there is generally less scope for abrupt technical change. One of the main sources of productivity growth in dryland agriculture in India would be varietal change. The demand for improved seeds is strong in dryland agriculture as they are the cutting edge of technical change in agriculture and are easier for farmers to adopt than other improved components and recommendations. Seeds are divisible; farmers can plant them on as much or as little land as they want.

Despite considerable efforts made by agricultural universities and research stations and also substantial growth in seed industry, still a large portion of cropped land does not have access to improved seeds. Besides, low and uncertain rainfall and the fragile soils in the dryland regions often limit the potential for increase in productivity. In these areas, improved management of soils and water resources are more critical for increasing productivity than improved cropping systems. In medium rainfall areas, intercropping in the kharif season could increase land use intensity and hence productivity. Similarly, land use intensity could be increased on deep alfisols with high rainfall by double cropping in the kharif and post-rainy (rabi) season. Whereas in high rainfall regions (>500 mm) double cropping systems is more advantageous. However, yield based growth require adequate availability of major as well as minor nutrients. In general, Indian soils suffer from nitrogen. Phosphorous and potash availability is also not rare but deficiency of micronutrients is evident at many locations. The development of these dry land regions very much depends upon the adoption of improved but low input-based cost effective technologies, adequate infrastructure, and improvement in resource management system, especially soil and water.

High yielding varieties, including hybrids perform invariably superior over traditional varieties even in rain fed areas also but differences become less conspicuous in the falling rainfall years. However, performance of hybrids has an edge over varieties. On all India basis, 53% sorghum, 55% pearl millet, 50% maize, and 63% ragi is planted with HYV. Maximum HYV coverage under sorghum is seen in Maharashtra (68%); pearl millet in Maharashtra (90%) and Gujarat (78%); maize in Karnataka (90%), Bihar and Andhra Pradesh (83% each), and ragi in Karnataka (98%). Expansion of HYV rice in rainfed has also been very rapid, especially in eastern India, where it has surpassed the HYV spread under irrigation. Besides, cotton, soybean and sunflower HYV and hybrids have grown faster in dryland areas and about half of the groundnut is now with HYV. Moreover, large regional disparities exist in adoption of HYVs as nearly half of the cultivated area is still under traditional varieties. The concentration is primarily in the difficult rainfed area with low rainfall and receding moisture during rabi. Use of HYV has triggered the use other inputs.

Despite the generally highly impressive potential yield superiority of HYVs, their achievement in terms of replacing the local varieties has been far from encouraging. The net situation is that HYVs have not so far been able to offer viable technology for vast portions of the dry areas. The price factor tends to offset some of the economic gains from HYVs as a result of their superior physical yields at recommended levels of input packages. The superiority of HYVs over local varieties at certain inputs use levels in terms of physical yields, net returns and cost-yield ratios is well recognized and documented by now. But the real question normally ignored is the possibility of obtaining such gains on average dry-farm where per acre total availability of capital (including accessibility to external credit) is much lower than per acre capital intensively required by HYVs. To the extent such gap persists, limited spread of HYVs in dry areas is quite understandable.

The element, which contributes to a greater degree of risk in HYVs in dry areas, is the relative fixity of package of practices governing HYVs compared to more flexible practices characterizing traditional farming. Traditional farming system through crop diversification, adjustable crop calendars and very flexible operation schedules as well as input usages, has developed an adjustment mechanism to weather variability. However, the situation is materially different in the case of HYVs. The standard packages based on the experience of irrigated and stable areas seldom fit to the highly variable situations

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encountered. The most important perquisites for making HYV technology in the dry areas is to adjust as much variability and flexibility in the technology which warranted by spatial and temporal agro-climatic variability which conditions cropping patterns and practices throughout dry areas. The biological component has been stated in terms of (1) need for generating low cost technology to ensure low risk and high profit for low value crops, and (2) injecting greater flexibility in the HYV package to suit to high degree of crop-sectional variability in dry areas. Unless these requirements are satisfied HYVs may not offer much hope for the dry areas.

Growth rates in productivity of rainfed crops lagged behind that of irrigated area and can be enhanced via rainwater conservation, harvesting and recycling as the most important aspect of overall management strategies.

Soil Fertility Management

Most of the dryland areas suffer from severe nutrient deficiency. Fertilizer is a crucial input for increasing productivity and its use is highly correlated with the level of irrigation and types of crops grown. In dryland regions, average use of fertilizer is still quite low and varies between 32 kg per hectare to 137 kg per hectare compared to 100 to 175 kg per hectare in irrigated area. Bulk of the fertilizer (85%) is used in irrigated areas, which account for about 30 percent of the total cropped area whereas dryland regions, which account for about 70 percent of the cropped area receive only about 15 percent of the total fertilizer use.

Though some improvement in fertilizer use in dryland is visible but it is still quite low. However, the balanced use of fertilizer in terms of nutrients is not proper. The ratio of N, P and K use in 1985-86 was 7:2:5:1, which improved marginally to 5:9:2:4:1 in 1991-92. But changes in fertilizer policy relating to prices of fertilizers again distorted the balance use of nutrients. In 1992-93, the ratio of N, P, K became 9.5:3:2:1. However, some marginal improvement was noticed in 1994-95, when the ratio of N, P, K reduced to 8.9:2.8:1. But it is to be noted that compared to potash, use of phosphorous was two times and use of nitrogen was almost nine times. This indicates that, still the nutrients are not used in balanced manner. Dependence on fertilizer use could be reduced by appropriate integration of fertilizers with organic manures, and adopting the traditional practice of crop rotation of legume with cereals, which can add upto 10 to 30 kgs N/ha.

Water Management

Moisture is one of the major limiting factors for agricultural production in dryland areas. Lack of irrigation facilities adversely affects the adoption of modern inputs and proper management of this scarce resource in dryland agriculture, which is crucial for its development. But management of water alone is impossible without proper land management and vice versa. Rainfed farmers have developed and practiced soil and water management systems over centuries. Some of the large sized border bunds in high rainfall areas (Chhatisgarh); Haveli system in Madhya Pradesh to harvest water in kharif for rabi planting; Khadins in Rajasthan whereby rocky catchments are used to collect runoff which is allowed to percolate in the soil to raise soil stored moisture for rabi crops; Kunds in Rajasthan and Haryana (typically for drinking water); and Terracing of sloppy lands for rice cultivation.

Watershed Approach

It has been found that low yield in dryland is also associated with high degree of land degradation and there is strong need to develop technologies to reduce the degradation and improve the productive capacity of natural resources, especially land. Besides, moisture is the most limiting factor to adoption of improved technologies. Treatment of dryland areas on a watershed basis has been adopted as a comprehensive approach to conserve soil moisture through effective land and water management technique.

For all practical purposes, natural unit for planning and work is a micro watershed, not the river basin and the key to success lies in ensuring that both runoff and soil loss are reduced to the minimum in each of our million of small watersheds, cost effective, sustainable development is possible. It has been rightly said that limitation is the mother of good management. Hence, management of natural resources by both public and government becomes crucial.
Evidence indicates that treated watershed reduces runoff appreciably (from 60 to 90%) and also reduces soil erosion and increases soil moisture. This helps in improving and stabilizing the agricultural production, which in turn improves the tree cover in the farmland and CPRs. Both the productive work, which satisfies minimum net return criterion and the protective works, which are undertaken mainly for affording protection to crops against drought and commercial profitability are equally important. Besides, community based approach to management of water and land has opportunities to reduce poverty. However, degree of incompatibility between the natural resource centered planning and management pattern of land resources, and the institutionally or customarily determined pattern of land use poses a serious problem for the new approach.

Principles of Watershed Management

The main principles of watershed management are:

i. Utilizing land according to its capacity.
ii. Putting adequate vegetal cover on the soil.
iii. Conserving as much rainwater as possible at the place where it falls both at farmlands and common property resources: In-situ conservation.
iv. Draining out excess water with a safe velocity and diverting it to storage ponds and storing it for future use.
v. Avoiding gully formation and putting checks at suitable intervals to control soil erosion and recharge ground water.
vi. Maximizing productivity per unit of area, per unit of time, and per unit of water.
vii. Increasing cropping intensity and land equivalent ratio through intercropping and sequence cropping.
viii. Safe productive utilization of marginal lands through alternate land use system.
ix. Ensuring sustainability of the eco-systems benefiting the man-animal-plant-land-water-complex in the watershed.

x. Maximizing the combined income from the interrelated and dynamic crop-livestock-tree-labour-complex over the years.
xi. Stabilizing the total income and cut down risks during aberrant weather situation.
xii. Improving infrastructural facilities like storage, transportation and marketing.

In the past, a number of approaches such as farm-family approach, component-wise approach, and community approach have been suggested for translating the watershed approach into development programmes. But, it was realized that development of dryland requires a holistic approach for overall improvement in the natural resource base and development of land based on crop suitability. As has been mentioned that dryland regions are not homogenous and vary to a large extent in terms of social set-up, soil type, rainfall pattern, cropping system and topography, etc. Watershed programmes look simple but are often quite complex.

Limited success of watershed programme indicates that it was mainly due to:

i. Inadequate analysis of physical and socio-economic environment;
ii. Indifference to farmers' circumstances;
iii. Strong bias towards crop production;
iv. Lack of farmers' involvement; and no flexibility in the technological options to suit farmers' needs and their resources.
v. Lack of continuation of the soil and water conservation measures up to the point of financial support;
vi. Poor acceptance of contour-based water conservation measures due to their disregard to ownership boundaries;
vii. Antipathy of farmers to maintain structures like diversion drains, which cost money and resources to some farmers but benefited others;
viii. Inadequate arrangement on social fencing to protect forestry and pasture lands;
ix. Lack of focus to address the problems of livelihoods of landless labourers;
x. Disregard to indigenously known and practiced methods of soil and water conservation; and
xi. Lack of clear arrangements and understanding on sharing of the harvested water.

In addition to these constraints, inadequate subsidies, inadequate arrangement of modern inputs, lack of group action, poor marketing and processing facilities of new products, inadequate price incentive, timely and inadequate credit facilities, etc. were responsible for the partial success of these programmes.

Watershed approach requires lump sum investment depending upon the severity of the problem of land water. Often it is not possible for most of the individual farmers, especially small and marginal farmers, to invest in such activities, as they are not much convinced about the perceived benefit from these investments in the short run. Also, the opportunity cost of such efforts is much high for them. Many small farmers are reluctant to accept some of the

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components of watershed technology. For example, they feel that contour bunds occupy too much space, create awkward concerns in their plots that hamper cultural operations, and cause soil beneath the bund to be lost to farmers down the slope. As a result of these factors, it has been found that many farmers had plowed over bunds introduced on their fields. It is also to be noted that if one section of a contour bund is not maintained, then the entire structure becomes useless, since water flows through the breach and none is conserved. In general, watershed technologies are likely to fail if they divide benefits unevenly but require near-universal co-operation to make them work (Sanghi 1987). Moreover, poor adoption of watershed practices is due to imposition of standardized technologies on diverse locations with widely varying conditions.

The economic impact of watershed approach is always not dramatic but the dormant non-price benefits are quite important. Sustenance of the flow of benefits as well as impact parameters is the direct function of community participation. Hence, the main focus of watershed approach should be a socio-economic transformation of the entire region and improvement in the quality of life of all people as well as fullest use of available land and water resources. Active participation of local people in these programmes is critical. Risk is an extremely important factor that needs consideration in designing and recommending new technology, especially in the rainfed agricultural regions of India. The results of economic analysis indicate that improved technology reduces variability of profits. The steps in technology experiments conducted at ICRISAT indicates that with improved varieties and fertilizers, the improved soil-and-crop-management steps can increase net benefits considerably compared to treatments featuring improved varieties, fertilizers, and traditional soil-and-crop-management practices. Timely availability of strong bullocks; drainage improvement; markets; timely availability of adequate credit; infrastructure; and training of extension officers and farmers helps in adoption of different components of watershed technology. Moreover, adoption of available technologies not only depends upon availability of adequate credit in time alone but also on active support by the bankers and right type of intervention by the government.

Reliability

i. There are many success stories about watershed projects but people on a wider scale without government or NGO support have not adopted them. Hence, there is need to identify the reasons and rethink methods and modifications. A few of the issues that need to be addressed are:
ii. Should the participation of local people be in creased in the design and implementation of the project by enlisting involvement of Panchayati Raj Institutions (PRIs)? With PRIs, the advantage will be to garner contributions of all stakeholders in mind, especially labour.
iii. How can the professional and farmers be brought together so that they act as collaborators in watershed development?
iv. Should fewer but location specific components of soil and water management be included to increase relevance and acceptance?

v. Is there any need to revise institutional mechanisms so that project designs are replicable over wider areas and are sustainable on long-term basis?
vi. Should a class of socio stimulants (like the characteristic leadership in Ralegaon Siddhi) be built up to guide the implementation of watershed projects?

Future Initiatives

Rainfed areas are highly diverse and compared to irrigated agriculture still not over used. The package of treatment has to be a combination of structural, biological and at some places chemical ones as well. Intensity of treatment directly increases the cost per unit of area, hence it is necessary to optimize the combination of treatments and strive for higher degree of cost-effectiveness and not necessarily low-cost ones. However, for successful implementation of watershed technologies, it is necessary to focus on the following aspects:

i. Assess problems relevant to physical, social, economic needs of the people and region. Monitoring should be in-built since inception and should include indicators for important assessment of ecologically, socially and economically.
ii. Build local capacity at the farmer's level and local level institutions for strong community action involving Panchayati Raj Institutions through empowering them and active involvement of credit institutions for facilitating adoption of new technologies. Also, develop a team of "Farmer-Jankars" (wise farmers) through capacity building for farmer-led transfer of technology like Mitra Kisan concept.
iii. Promote participatory, bottom up approach to farming system research in dryland, by greater involvement of NGOs and user groups to make it cost effective, clientele-centred and sensitive to local environment. This may also help in incorporating traditional knowledge of local people, which is often bypassed under top-down approach. However, location specific research, considering diversity in dryland agriculture would facilitate easy adoption of technologies developed by research scientists.
iv. Multiplicity of agencies should be avoided as they lack integrated approach. A single watershed agency at the state level should be developed to have better integration and develop a flexible policy that can meet thee requirement of every sector of society and suit the agro-climatic environment. Besides, it should provide adequate scope for local initiative for innovations in project planning and management. This agency must help in proper characterization of watershed for effective planning of the watershed and regulate use of underground water.

v. Improve partnership between NGOs and private sector in agricultural research, to reduce not only the overall cost but also reduce the dependence on public sector research. Promote participatory varietal selections and participatory varietal breeding. This is different from the demonstration trials, which essentially duplicate in farmers' field what researchers have done under the ideal conditions of an experiment station.

vi. Make a systematic study to evolve the technological packages and techniques, which are cost effective and suitable to location specific. Uniform and universal technologies are not very effective in solving the problem of diverse situations.

vii. Incorporate refined traditional/indigenous knowledge of land and water management techniques for wider acceptability.

viii. Agricultural diversification involving dryland horticulture crops like ber, guava, custard apple, pomegranate, aonlal (gooseberry) have greater degree of adaptation to a range of rainfed environments. In low rainfall (less than 500 mm rainfall) linking arable farming with animal husbandry for sustenance and adoption of arid horticulture to augment farm income is necessary, whereas in high rainfall regions (more than 1000 mm) double cropping system is advantageous.

ix. Adopt farming system approach with close linkage between arable and animal farming. Besides, diversify land uses for fodder production and plantation of fruit trees and integrate species of crop/tree interblend with local relevance, need and interest of all segments of society. Developing models offering combination of plant cover management, both perennial and annual; through agro forestry models would be more appropriate.

x. Diversify cropping system and income opportunities incorporating other enterprises like poultry, dairy, horticulture, sericulture at least 40% income should come from these enterprises. The alternate crop choices should be guided by the value of output rather than the biological yield alone. However, promote economic activities through integrating small-scale household and micro enterprises using various biomass produced from cultivated and non-cultivated land. Agricultural growth combined with income diversification through more profitable enterprises by shifting from commodity approach towards a natural resource management centered approach will be essential in solving the problems of poverty and building a sustainable food security system.

xi. Develop a holistic policy to examine relationship between status of watershed and yield of water reservoir for hydrological interventions and afforestation (plant cover management).

xii. Introduce high-tech water use technique (drip irrigation) to economize use of water for high value agriculture as a viable strategy. Suitable water extraction mechanism and use methods, particularly irrigation of post-rainy season crops, will make harvesting a cost effective strategy and benefit all sections of the society.

xiii. Ensure adequate credit at low transaction cost for adoption of new technologies. In this case differential interest rate for dryland and irrigated agriculture would be advisable. Besides, funding and accounting procedures also need to be simplified if community institutions have to play a significant role.

xiv. Introduce basket of technologies instead of uniform champion packages and develop graded technological packages, which respond to varying biophysical and social domains.

xv. Encourage plantation of trees in marginal lands, where land degradation is rampant. Select those species of trees that can meet and assure the fuel requirement in the long run and minimize the degradation of biosphere.

xvi. Efforts should be made to concentrate on those elements of protective technology, which do not require group action. This would mean emphasis on crop improvement technology involving development of low-cost HYVs and associated practices of crops suited to the unstable weather. If the full potential of crop improvement technology is to be achieved, the complimentarily between crop-centered and natural resource-centered technologies cannot be ignored.

xvii. Make the group action requiring technology economically viable and profitable. Create flexibilities in the package of technologies by splitting them to facilitate its adoption in stages depending upon the degree of faith developed in it by adopters of technology and degree of build-up of the resource base following gains from partial adoption of the technology.

xviii. Arrange proper distribution of potential costs and gains amongst the participants in group activity. Incorporation of these elements in generation and extension of resource-centered technologies for dryland would help in reducing transaction cost of group formation and group action.

Policy Interventions

With the watershed concept remaining the same, the approach may require some change depending upon the physical, social and economic condition of the region. Besides, improving the productivity of rain fed agriculture base on the watershed approach, some other policy interventions may help dry land agriculture. A few broad policy interventions for sustainable growth of dry land agriculture are given below:

i. Dry land regions are harsh environment and vary to a large extent in terms of extent of irrigation, soil type, rainfall distribution and cropping pattern. Moisture is the most limiting factors in these regions and in the absence of reliable rainfall and assured irrigation water farmers grow mainly low value subsistence crops. Most of the farmers face severe risk of crop failure mainly due to climatic variability. The other risks such as price risk is not that important in these regions. Crop productivity in dryland region is very low and needs concerted efforts to improve productivity based on regional specificities.

ii. Poverty and malnutrition is concentrated in dryland regions. The improved crop varieties should provide more protein in addition to calories to ensure food security including nutritional security. This requires improvement in the input delivery system, especially improved crop varieties, fertilizers and credit. Many farmers suffer great risk largely due to use of spurious seeds, fertilizers and pesticides, etc. Hence, it is not only the quantity but also the quality of inputs that is important.

iii. Many of the technologies available in these regions are not affordable by the farmers due to their low income. Also, easy accessibility of these technologies to the farmers is constrained by lack of adequate extension support. In addition, lack of information about availability of improved technologies and farm practices as well as information about markets are major constraints faced by the farmers in these dryland regions. There is a need to provide basic minimum information about various aspects of technologies and markets on priority basis.

iv. The development of rainfed/dryland regions requires a fresh approach and new initiatives that can help in providing adequate and timely credit to the farmers at regular intervals. This will even require different types of credit institutions and delivery system, exclusively for these regions.

v. There are many traditional technologies available in dryland regions, which have been tested over time under stress conditions. These technologies can be improved and incorporated in the package of technologies offered to the farmers. Also, a number of crops that used to be grown in dryland areas, which were able to withstand climatic risk have disappeared over time. There is a need to improve these crops and incorporate them in the cropping system of dryland farmers. They may have wider acceptability and adaptability in these regions.

vi. Adoption of improved varieties has limited role in improving the agricultural production in dryland regions unless they are supported by other inputs and focus is on resource management. Evidence suggests that a mix of crop-centred and resource-centred technologies would be more useful in improving the dryland agriculture. Dryland is not a homogenous area and hence there is need to develop technologies that are suitable to diverse agro-climatic and socio-economic environment. The crop varieties developed for these regions should produce not only higher yield but also more stable yield under moisture stress. Besides, fertilizer responsive varieties at low level of nutrient use may be affordable to the farmers.

vii. It is often said that both small and large farmers are equally risk averse and technology is neutral to scale, but in practice it is not only the risk behaviour or ability of the farmers that affects the agricultural production but access to quality inputs is equally important. Hence, efforts should be made to ensure timely availability of required quality inputs at affordable cost.

viii. Moisture is the most limiting factor in these regions and it is necessary to make judicious use of water. It has been found that whenever water is available farmers switch over to more remunerative crops requiring more water. Most of the available water is used for a few crops and that too by a few of the large and rich farmers with access to credit facilities. These rich and large farmers control the water and sell to the small farmers. This has created a sort of water-lordism in some of the areas. Ground water is a common property and excessive use by a few private individuals should be avoided. However, the same limited amount of water can be used to irrigate more crops with wide coverage of area.

ix. There is a need to have effective control on excessive use of ground water in these areas through some legislative measures as well as organizing the farmers on the lines of "Water Users Association" for regulating use of water both for drinking and irrigation purposes to ensure equitable gains to all the categories of farmers. However, emphasis should be more on minor irrigation and construction of percolation tanks, especially medium to deep vertisol areas with higher and assured rainfall.

x. Dry land regions face serious problem of land degradation. Farmers due to their low income and high opportunity cost find it difficult to invest in resource improvement technologies. There is a need to increase public investment for resource management, especially conservation of soil and water. In this regard, implementation of watershed development programme as a holistic approach needs to be encouraged in all the regions. In this regard, the role of local level institutions, especially Panchayat and other institutions such as Community Based Organizations (CBOs) and Voluntary Organizations (VOs/NGOs) becomes much more important in managing natural resources such as land and water. However, the success of watershed programme and judicious use of natural resources would very much depend upon active participation of people of the areas and better linkage between local level institutions, public representatives, administrators and voluntary organizations. However, this will be more effective through group action and greater involvement of all the sections of the society. Hence, community approach, where extension officials and bankers work in close co-operation with people would be necessary.

xi. Evidence clearly shows that dry land farming holds considerable untapped development potential. However, this is a major challenge before the bankers to create a viable credit market in dry land regions, which accounts for more than 70 percent of the total area of the country. The role of credit institutions, especially commercial banks, including RRBs and NABARD will be crucial in providing, not only credit, but proper technical guidance also to the farmers through regular monitoring of the use of credit. Hence, effective linkage between formal credit institutions, scientists, farmers, Panchayats and voluntary organizations would be helpful in improving dry land agriculture in a holistic way.

xii. Close interaction between bankers and farmers is most effective in the formulation of credit packages for the farmers and providing adequate credit well in time. Bankers and credit institutions should devise alternative strategies of multi-enterprise approach and diversification of agriculture to minimize the risk to farmers in an unstable environment like dry land areas. The normal banking approach to finance each activity separately may not be appropriate for financing the dry land farmers. The poor dry land farmer does not treat his household, farm and other activities as independent pursuits. Farmers' strategies to spread risk by managing diversified portfolio of activity help in minimizing risks and generate adequate income. Actual assessment of credit needs of each individual farmer in a holistic way to cover all the production activities, including consumption needs, is necessary.

xiii. The interest rate from informal credit institutions is quite high in rural areas. The type and amount of credit, time and cost of credit (interest rate) are most crucial elements, especially in dry land agriculture. Often differential rate of interest for small and large farmers is advocated but there is no conclusive evidence that lower rate of interest to small farmers improves the adoption of new technologies. However, considering the economic condition of dry land farmers and level of development as

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well as risky environment of dry land, there is need to maintain lower rate of interest to small farmers. Emphasis should be to ensure adequate credit at the time of need and without many procedural wrangles. The regular monitoring of credit use is another aspect, which requires proper attention of the bankers.

The interest rates charged form dry land farmers should be linked to the level of productivity and rate of return from the investment in dry land agriculture, allowing some margin for the nature and extent of risk. This means differential rate of interest for different enterprises based on their risky nature can be considered for ensuring credit for dry land farmers. Similarly, the payment schedule can be made flexible in a staggered manner over season and even years.

xiv. Dry land regions face serious problem of land degradation. Farmers due to their low income and high opportunity cost find it difficult to invest in resource improvement technologies. There is a need to increase public investment for resource management, especially conservation of soil and water. In this regard, implementation of watershed development programme as a holistic approach needs to be encouraged in all the regions. In this regard, the role of local level institutions, especially Panchayat and other institutions such as Community Based Organizations (CBOs) and Voluntary Organizations (VOs/NGOs) becomes much more important in managing natural resources such as land and water. However, the success of watershed programme and judicious use of natural resources would very much depend upon active participation of people of the areas and better linkage between local level institutions, public representatives, administrators and voluntary organizations. However, this will be more effective through group action and greater involvement of all the sections of the society. Hence, community approach, where extension officials and bankers work in close co-operation with people would be necessary.

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Conclusion

The interest rate from informal credit institutions is quite high in rural areas. The type and amount of credit, time and cost of credit (interest rate) are most crucial elements, especially in dry land agriculture. Often differential rate of interest for small and large farmers is advocated but there is no conclusive evidence that lower rate of interest to small farmers improves the adoption of new technologies. However, considering the economic condition of dry land farmers and level of development as well as risky environment of dry land, there is needed to maintain lower rate of interest to small farmers. Emphasis should be to ensure adequate credit at the time of need and without many procedural wrangles. The regular monitoring of credit use is another aspect, which requires proper attention of the bankers. The interest rates charged form dry land farmers should be linked to the level of productivity and rate of return from the investment in dry land agriculture, allowing some margin for the nature and extent of risk. This means differential rate of interest for different enterprises based on their risky nature can be considered for ensuring credit for dry land farmers. Similarly, the payment schedule can be made flexible in a staggered manner over season and even years.

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