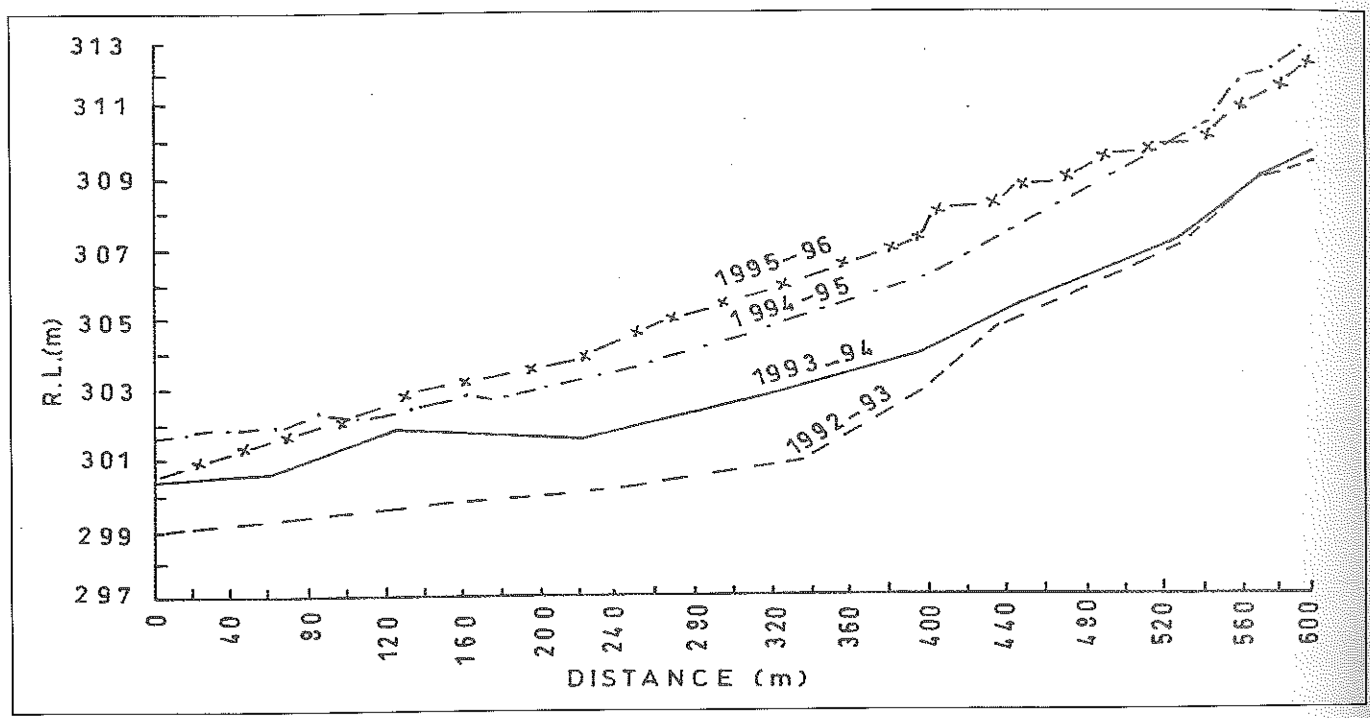
and stabilizing the channel at Relmajra watershed (Ropar, Punjab). A silt load of 2.54 ha-m (38,900 t) was retained by these measures from flowing down to fields and reservoir.

Figure 4: L-Section of Badholi Choe behind reservoir at Relmajra



D. Land development/improvement indices

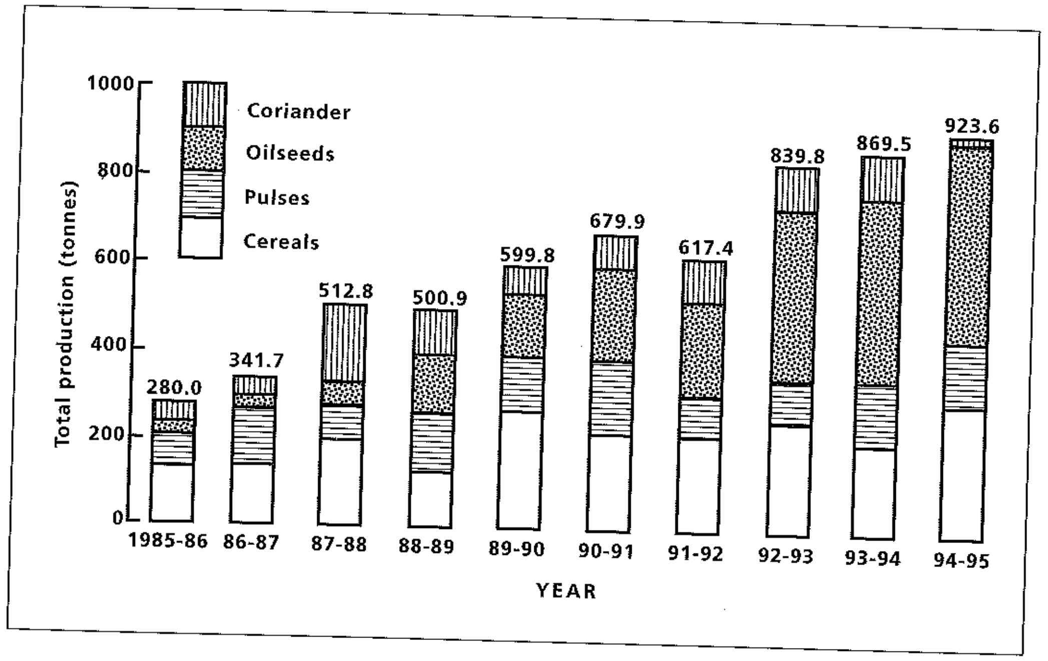
In watershed management projects, measures such as bunding, terracing, land shaping, land levelling are commonly adopted. It is better to know the extent of area treated and degree of improvement, including physical conditions of bunds. Sikka et al (1998) evolved and demonstrated "Land Improvement Index (LI)" in evaluating the impact of the watershed project at Relmajra on land development. The LI (ratio of recommended safe limit of slope to the existing field slope) was computed for each sample field using the data of field slopes. The overall weighted area LI was found to have increased from a low of 0.23 to 0.65 in just two years after project implementation, thus suggesting a significant improvement. It is also important to note that levelling and field bunding was done by farmers on their own and hence this index also suggests the higher level of community participation in the watershed management project.

E. Agricultural crop indices

i) **Increased production**: Increase in crop yields after the programme implementation and/or its comparison with that of an outside neighbouring watershed is one of the direct measures of watershed condition improvement. Figure 5, for example, illustrates significant increase in total grain production after watershed management at Chhajawa watershed in Rajasthan (Prasad et al, 1996). Similarly increase in fodder yield, fruit yield and increased biomass production from different land use systems is considered a good index of impact assessment. Increase in cropping intensity and fertilizer use are other measures in this regard.

ii) **Diversification index**: This index reflects the diversification of crops, from less economical to cash or commercial crops after implementation of watershed programmes. Diversification Index (DI) is defined as:

Figure 5: Increased production in Chhajawa Watershed



$$Di = \sum_{i=1}^{N} + Pi + \log\left(\frac{1}{Pi}\right)$$

Where Pi is proportion of area shown under crop i. Di close to 1 indicates complete diversification.

Agnihotri and Samra (1996) used this index at Relmajra watershed during the Kharif and Rabi seasons before and after the project. The DI values as given below show considerable increase in crop diversification, mainly due to availability of harvested rainwater for supplemental irrigation and land improvement after the project.

Diversification Index (Relmajra)		
Years	Kharif	Rabi
1992-93	0.407	0.224
1993-94	0.300	0.655
1994-95	0.635	0.701
1995-96	0.815	0.715

F. Soils (nutrient indices):

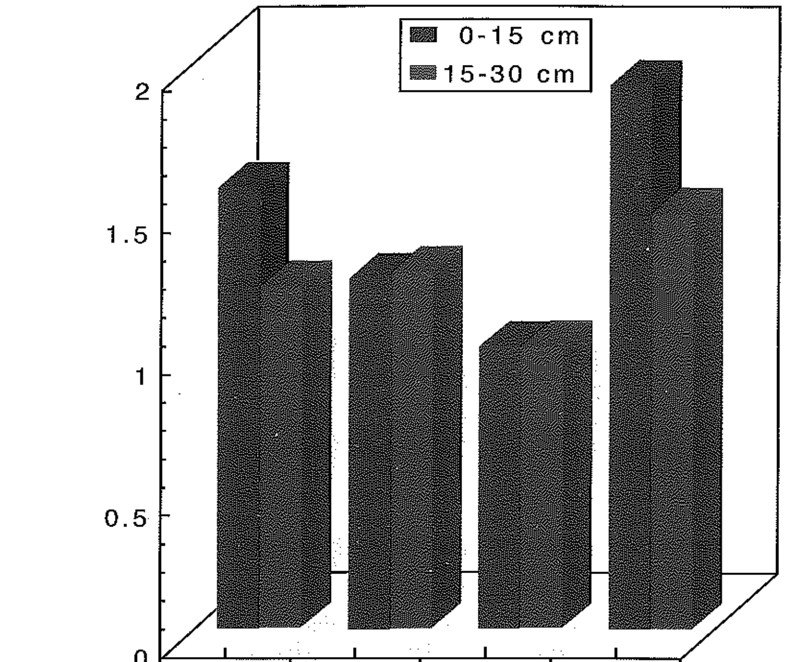
Changes in organic carbon and major nutrient status in the soils can be assessed, before and after the project for impact assessment. This is a rather rigorous exercise and depending upon resources and objective it can be attempted. This would involve collection of soil samples across space and time and their analysis in the laboratory.

Nutrient index for each of the nutrients can be determined as follows:

$$N = \frac{Ni + 2\,Nm + 3\,Nh}{Ni + Nm + Nh}$$

N = Nutrient Index
NI, Nm & Nh = No. of soil samples falling in the category of low, medium and high nutrient status.

Nutrient indices for Salaiyur watershed (Coimbatore district, Tamil Nadu) before initiation of Integrated Wasteland Development Project are illustrated in Figure 6.



	OC	N	P	K
0-15 cm	1.56	1.24	1	1.92
15-30 cm	1.21	1.26	1	1.47

N Ratings **Low(<1.5)** **Med.(1.5-2.5)** **High(>2.5)**

Figure 6: Nutrient indices of the Salaiyur watershed

G. Biodiversity indices:

A number of biodiversity indices such as species richness, general diversity, dominance concentration, evenness index can be found in literature. Importance Value Index (IVI) or Relative Value Index (RVI), an integrated measure of the relative frequency, density and basal area of vegetation species was used at Relmajra watershed to study impact of watershed management measures on vegetation (Samra et al 1995).

Results are given as below:

	Tree		Shrub		Climber		Grass	
	1990	1993	1990	1993	1990	1993	1990	1993
RVI	6.6	18.1	19.6	35.5	0.8	0.4	73.0	46.1

RVI of trees and shrubs increased by three and two times, respectively. RVI of grasses decreased by 37% indicating that succession took place in favour of more economical species due to reduced biotic interference and better moisture regime. This also showed effectiveness of watershed protection by people's participation in promoting more tree and brush growth, ensuring ecological security.

H. Socio-economic indices/measures

There are a number of direct and also indirect outcomes of the project that can be associated with the impact of watershed management. As a result of this, the level of awareness, education, buying capacity for household assets, infrastructural development is likely to improve. Some of the important socio-economic measures (possession of assets, consumer durables, per capita availability of watershed produce, housing pattern, literacy), being used in our watershed management project for impact assessment are presented in Table 6. Per capita availability of agricultural and horticultural produce, milk, etc., can also be taken as a surrogate index. Dhyani et al (1997) found that per capita total watershed produce increased from a low of 728 gm/day (pre-project period) to 3150 gm/day (after financial withdrawal of the project) at Fakot watershed, Tehri Garhwal, with the milk production going up from 290 ml to 850 ml/day.

Growth of infrastructure and developmental institutions is also taken as an indirect measure of watershed impact.

Table 6: Changes in some socio-economic measures as a result of WSM Project at Bunga, Ambala in Haryana (Arya & Samra, 1995)

Item	Before the project	After the project
Assets		
Tractors	..	3
Threshers	1	6
Chaff cutter	60	129
Bullock carts	32	103
Tubewells	..	3
Scooters	..	13
Shops	3	7
Consumer durables		
Televisions	..	12
Ceiling and table fans	..	90
Sewing machines	20	89
House electrified	..	111
Housing pattern *(covered area in Sq.m)*		
a. Mud roof, wall and floor	8244	1688
b. Mud roof, and floor with pucca wall	575	3198
c. Brick roof and wall with mud floor	239	2384
d. Brick roof, wall and cemented floor	108	4362
Literacy rate (%)		
Male	19	46
Female	7	20
Overall	14	35

I. Economic measures/indices

Economic measures evaluate the project worth by comparing the value of goods and services generated or conserved with the cost for assessing its effect on social welfare needs and viability. Discounting measures such as (a) present worth, (b) benefit cost ratio and (c) internal rate of return is used for this purpose. Economic evaluation of watershed management projects in different regions have shown encouraging results with benefit cost ratio ranging from 1.5 to 3.9. However, in most of the economic studies protective benefits could not be analysed while inclusion of protective or reclamative benefits individually or in combination with production benefits, affect the overall economic perspective.

CONCLUSIONS

There is no universally acceptable single index or measure that could be used to assess the impact of watershed management programmes. Since these watershed management projects generate social, economic and environmental benefits, surrogate measures or a set of indices can at best be used to assess impact of watershed programmes. A set of biophysical and socio-economic indicators and indices presented in this paper have been field tested in a number of watershed projects undertaken by the Central Soil & Water Conservation Research & Training Institute and its Research Centres. Biophysical indices including measures of productivity, land improvement, hydrologic condition, soil erosion, water resource availability and biodiversity demonstrated their application in assessing the impact of watershed management measures on physical and environmental conditions of watersheds. Use of socio-economic measures such as possession of assets, consumer durables, per capita availability of watershed produce, housing pattern, literacy level, growth of infrastructural facilities is demonstrated to assess watershed impact on social and economic conditions. Attempts would also be made to develop an overall watershed condition index by combining effects of individual indices following additive or multiplicative algorithm giving due weightage to each individual index.

Though these measures and indices work, these may not always be quick, cheap and easy to work with especially if supporting benchmark data collection is not properly conceived and planned. Depending upon the objectives, time and resource availability, these indicators and indices can be used to evaluate physical and socio-economic impacts of watershed management projects. There is a strong need to have built-in mechanisms of data monitoring and impact evaluation in watershed projects.

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MONITORING AND EVALUATION OF SOIL AND WATER CONSERVATION PROGRAMMES

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INTRODUCTION

India has embarked upon varied and extensive soil and water conservation programmes since the start of planned development in the early 1950s. These programmes are implemented by State and Union Territory Governments, covering all agro-ecological conditions from hot semi-arid to sub-humid to tropical zones, and from plains to hills and mountains. The programmes are backed by technological innovations, research support, a package of practices, training facilities, etc. Soil conservation programmes are projected to yield short-term to long-term, on-site to off-site, and direct-indirect benefits either to the individuals or to the community at large.

Essentially, the programmes are oriented towards checking land deterioration, improving moisture regimes and reclaiming already degraded land to improve and increase its productivity. Such programmes are envisaged and implemented as multi-disciplinary and integrated land resource conservation, development and management of activities which are complex and costly. The Government of India (GoI) Departments of Agriculture and Cooperation, Rural Development and Forestry and Environment have remained engaged in the nationwide task of policy framing, planning and implementation of various soil and water conservation programmes. State and Union Territory Governments implement these programmes.

Both the Central and State Governments have recognised the need for monitoring and evaluating these programmes and have built up institutional infrastructure for the same. The Central and the State Government departments concerned with the programmes would invariably have a Monitoring & Evaluation (M&E) Wing/Section attached. Such wings, wherever existing have the responsibility to see that the programmes envisaged are monitored and evaluated both in space and time.

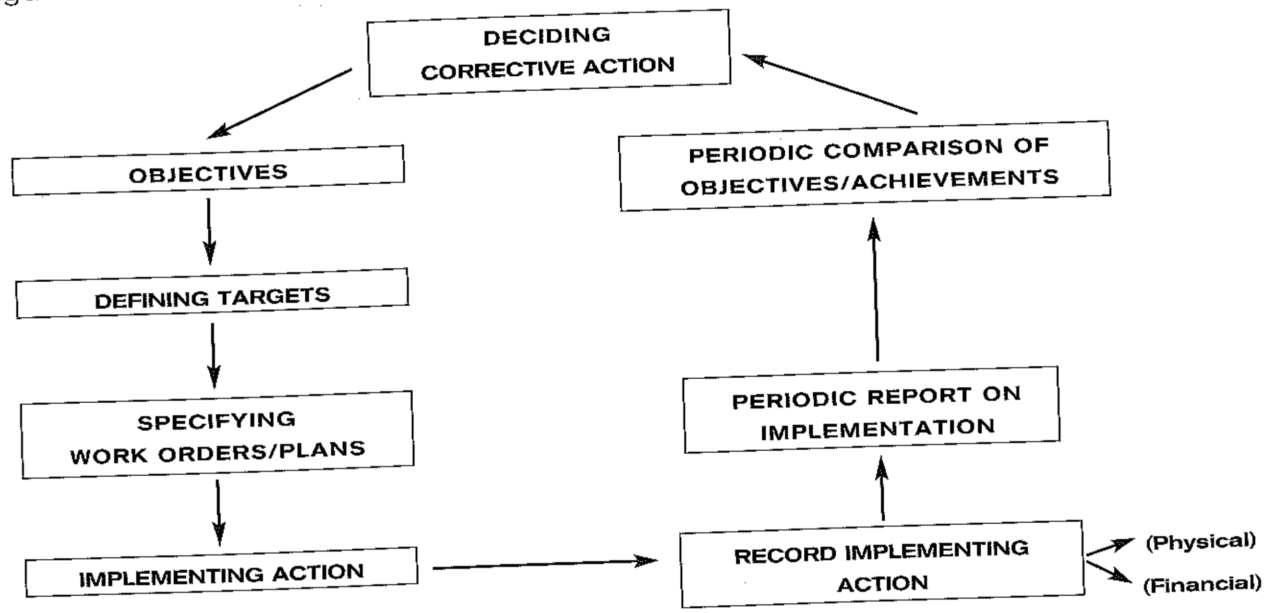
CONCEPTUAL AND CURRENT FRAMEWORK OF MONITORING AND EVALUATION

Soil and water conservation programmes are complex in nature, have definite objectives and comprise several activities and events planned in proper sequence. These have pre-determined scales of operation, implementation methodology, locational aspects, input of resources and time-scheduling for implementation. Continuous monitoring and evaluation of the aforesaid aspects of operation are considered necessary to steer the programme efficiently and for achieving the physical, fiscal and socio economic goals.

Monitoring involves a regular and methodological checking of the physical implementation of the project, its progress and keeping a close watch on the area covered and funds spent. It ascertains if the inputs and outputs are adequately streamlined and proceeding as per plan, and whether mid-course alterations are carried out if something goes wrong. Monitoring carried out periodically is an internal function. This is a kind of tool or mechanism to arrange for a systematic feed-back of information from the field to the project management to keep it alert and posted with the latest and up-to-date status of the results/outcome of various activities. The information feed-back loop is illustrated in Figure 1.

Monitoring has the distinct function of routinely recording, reporting and processing data on actual events and activities undertaken and the outputs achieved. It provides the essential data for building up a "Management Information System (MIS) " in a project, necessary for reporting achievements and programming future activities.

Figure 1: Information feed-back loop



Evaluation is a more ambiguous term. It is often taken as meaning a major study undertaken at intervals

Very often, monitoring and progress-reporting are considered to be one and the same thing by the management. Such an interpretation is not correct. Progress-reporting forms only one component of the various operations prescribed under monitoring, because monitoring carried out periodically is nothing but another form of concurrent evaluation and is, therefore, something more than mere progress-reporting (Rajakutty, 1992).

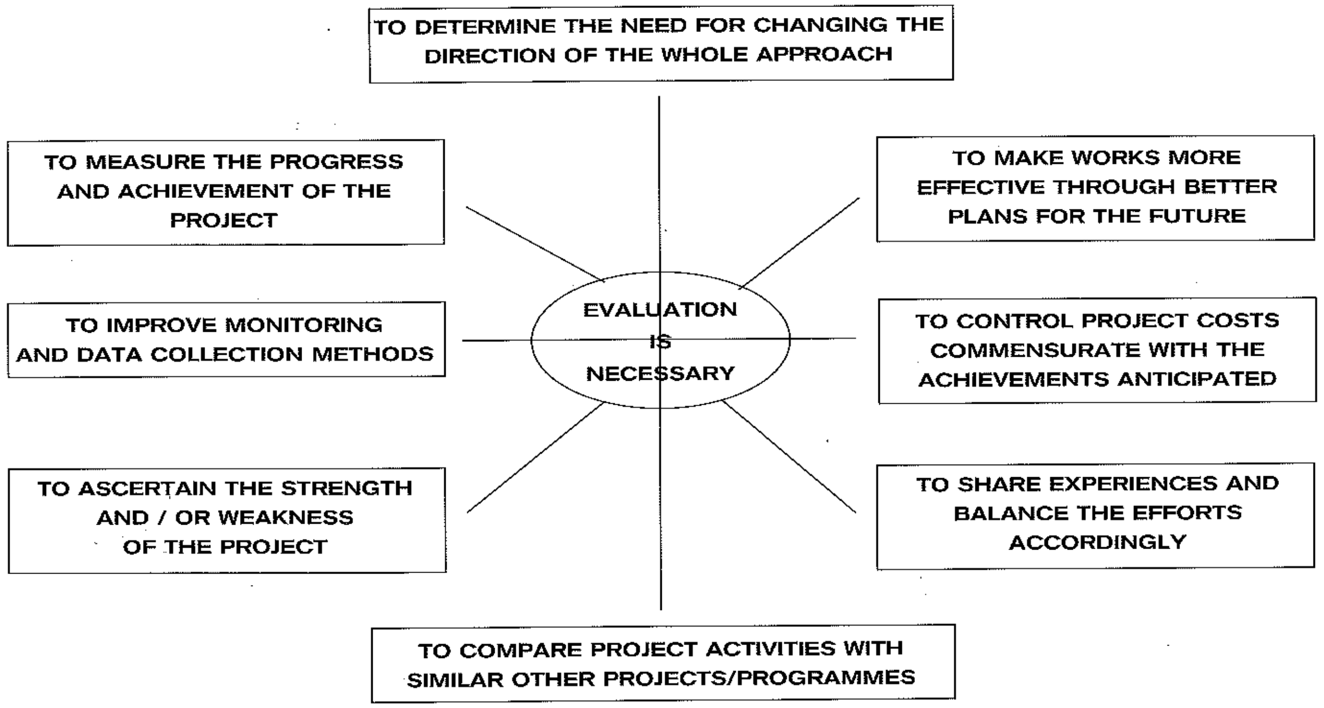
Evaluation is a more ambiguous term. It is often taken as meaning a major study undertaken at intervals. There can be a pre-project evaluation or base-line study to assess the situation prior to any project activity taking place, a mid-term evaluation to assess whether the anticipated effects of a project are materializing and an ex-post evaluation at the end of the project to assess the overall achievements. A mid-term evaluation will provide insight into the changes which can enable a project to meet its objectives more efficiently, whereas, an ex-post evaluation can be useful in planning future, similar projects.

The term "evaluation" is also used to refer to routine checks to see whether monitoring returns are being compiled correctly. To avoid any ambiguity, this could be considered as "concurrent evaluation". While concurrent evaluation is the responsibility of the M&E cell of the organisation implementing the project, mid-term and ex-post evaluations are entrusted to competent external agencies for ensuring efficient and unbiased assessment of the physical, social, economic and environmental impacts of the project (Mukherjee , 1993).

Regular and methodical information collected during monitoring is the best material for evaluation. In the case of projects funded internally, the concerned government departments function as the supervising agency whereas evaluation of externally aided projects can be most effective if the evaluation team comprises internal and external agencies, project staff and a representative of the beneficiary target group as well.

Soil and water conservation programmes are multidimensional, multi-disciplinary, costly and labour-intensive. Projects are seasonal and spread over a number of years. National programmes having inter-state ramifications like soil conservation in the catchments of River Valley Projects (RVP)/integrated watershed management in the Flood-Prone River catchments (FPR) as also a good number of state sector programmes prolong over 7-15 years for catchment stabilization. Therefore, projects with long operational periods need to be continuously monitored and concurrently evaluated. A visual representation giving the imperativeness of undertaking evaluation of such projects is shown in Fig. 2.

Figure 2: Need for undertaking evaluation (from Rajkutty, 1992)



CASE STUDIES

Till the end of the VII five-year plan (1990), out of a total problem area of 175 million hectares only about 34 million hectares was treated with soil and water conservation measures at a cost of Rs. 21,091 million under various Central and State level programmes. Some of the important Central/Centrally sponsored schemes being implemented under Ministry of Agriculture (MOA) are: 1) Soil conservation in the catchments of river valley projects, 2) Integrated watershed management in the catchments of flood prone rivers, 3) Reclamation and development of ravinous areas, 4) Control of shifting cultivation, 5) Amendment of saline-alkali soils etc. With the passage of time, on realizing the urgent need to rehabilitate larger areas of degraded lands, to conserve the production base, and to increase production of food, fodder and fuelwood, GoI has diversified into many activities with respect to land and water resource conservation, development and management. Programmes like Drought Prone Area Programme (DPAP) and Desert Development Programme (DDP) are being implemented by the Ministry of Rural Development (MORD) since the early seventies. With a view to giving policy support to these programmes and to tackle the problem areas with a multipronged approach, new institutions like the National Land Use and Conservation Boards (NLUCB), State Land Use Boards (SLUB), National Wasteland Development Board (NWDB), National Afforestation and Eco-Development Board (NAEB) have been established and innovative schemes like Dryland Farming, Wasteland Development and Management, National Watershed Development Project for Rainfed Areas (NWDPRA), etc. have been initiated.

The issues raised are at policy, institutional and operational levels; they address the issues of planning, implementation, fiscal management, impacts, benefits, people's participation, human resource development, gender issues, etc

Since the 1980s, a few of the internally aided projects being implemented under the aegis of MOA have been evaluated externally (ASCI, 1987.1991a, 1991b, 1991c; AFC 1991, 1991a, 1992b; IRDAS 1993; CMD, 1992). The issues raised are at policy, institutional and operational levels; they address the issues of planning, implementation, fiscal management, impacts, benefits, people's participation, human resource development, gender issues, etc.

The Department of Agriculture and Cooperation, Government of India has since been in the process of selecting suitable outside agencies like the Administrative Staff College of India (ASCI), Hyderabad, Agricultural Finance Corporation (AFC), Bombay, Institute of Resource Development and Social Management (IRDAS), Hyderabad, Centre of Management Development (CMD), Trivandrum and entrusting them with evaluation studies of the centrally sponsored schemes of soil conservation in river valley projects/flood-prone river catchments. These agencies have already brought out a number of reports that have been placed before the Ministry of Agriculture for review and follow up.

The Planning Commission has also been undertaking evaluation studies of watershed development programmes through its Programme Evaluation Organization (PEO) from time to time. One such recent study worth mentioning is the Evaluation study of Western Ghats Development Programme in TamilNadu jointly undertaken by the Evaluation and Applied Research Development (DEAR), Government of TamilNadu, Chennai and the Regional Evaluation Office, PEO, Chennai. The report was published in 1993.

The Rural Development Ministry on the other hand has been getting the centrally sponsored schemes of DPAP and DDP reviewed periodically by setting up different task forces headed by eminent persons such as Dr. D.S. Minhas, Dr. Y.K. Alagh and Shri L.C. Jain, all of whom were one-time members of the Planning Commission and Dr. M.S. Swaminathan. Of late, it has constituted a technical committee under the chairmanship of Shri C. H. Hanumantha Rao, former member, Planning Commission to review the aforesaid programmes and recommend suitable measures for further improvement. The committee brought out its review report in April, 1994.

In this paper, however, case studies relating only to the two main schemes of RVP and FPR being handled by the MoA are enunicated.

Evaluation study of soil conservation works in river valley project catchments

Case 1: Chambal catchment (AFC, 1992) Like the evaluation study of any other major project, evaluation of soil and water conservation works in this catchment was also based on field visits, inspection of sites, collection of basic primary data, interviews with beneficiary farmers and discussions with concerned officers of the project in the states of Rajasthan and Madhya Pradesh.

Soil and Water Conservation works initiated in this catchment in 1964 –65 were aimed at assessing the effectiveness of the treatments in terms of moderation of siltation hazards in the reservoirs of Gandhisagar, Rana Prathap Sagar and Jawahar Sagar dams, increasing productivity through optimum land management, additional water resource generation including recharging of ground water, increasing the forest and tree cover of the area, and generation of employment opportunities. The evaluation report states that hydrographic survey carried out in 1976 and repeat survey in 1989 have revealed that the sediment inflow rate (SIR) in the reservoirs has decreased considerably from 10.73 to 2.38 ham/100 sq.km/y as a result of soil and water conservation measures over the years.

Farming practices and cropping intensity in the agricultural sector increased by about 28 per cent; farmers were motivated to use more fertilizers, high-yielding varieties of seeds and improved agricultural implements; afforestation, closure and pasture development efforts showed positive results; sizeable casual employment opportunities were generated and the overall benefit-cost ratio was quite encouraging. Yet, there have been certain deficiencies in the implementation of the programme as listed below which need immediate attention of the project authorities.

- Maintenance of silt-gauging stations was poor.
- In-service training of persons working in hydrology and sediment work was wanting.
- Periodical inspection of gauging stations would be desirable.
- Maintenance of structural works was either poor or was missing altogether.
- Involvement of the people residing in the watershed in the plantation programmes was lacking though it could provide them with more employment opportunities and greater scope for considerations of their choice in the selection of planted species.

Case 2: Kangasabati catchment (AFC, 1992b) Kangsabati reservoir on the river Kasai is situated in the Midnapur district of West Bengal. The scheme in the catchment has been in operation since the III Plan (1961-66). The evaluation report highlighted a number of benefits derived from the project. It has also identified some of the weaknesses and lacunae so that the project authorities could take adequate measures for rectifying the negative results and improve the approach and methodology in future programmes. The main shortcomings were:

- There was need for better technology in the construction of conservation structures.
- There was need for revision and adoption of modern technology for priority delineation of watersheds.
- Larger programmes ought to be envisaged to influence sediment yield.
- Reservoir capacity surveys need to be carried out regularly and at frequent intervals.
- Wastelands are the weakpoints in matters of land utilization and require greater attention to check land degradation.

- Old plantations require proper maintenance and monitoring to prevent destrucion by the people, overgrazing, etc.
- Employment generation should not remain the sole responsibility of the Government as rural employment can be augmented by involving NGOs, voluntary agencies/village-level institutions in the programme.

The report stressed that people maintain what they own and/or find useful. They do not bother for common property. in such a situation it would be advisable to empower the village-level institutions like the 'Village Forest Committees' and Panchayats with requisite financial support for taking over the maintenance of the assets created.

Certain location-specific deficiencies highlighted in the evaluation study reports of some of the other catchments are as follows:

Case 3: Hirakud catchment (AFC, 1992c) Monitoring of depreciated old conservation works was being utterly neglected. This ought to be regularly carried out so that the national figures of conservation problems and treatments reflect the true picture in the field.

Case 4: Ukai catchment (AFC, 1988b)

- The report stressed the need for establishment of a more efficient M&E unit at the state level which should have two cells, namely: Hydrology & Sedimentation Cell; and Socio Economic Evaluation Cell; for continuously monitoring and evaluating the sediment production along with physical, economic and social benefits of the programme.
- Agricultural Extension wing of the Deparment of Agriculture ought to ensure adoption of follow-up conservation agronomy practices and rainfed farming technology.
- Dryland Farming Programme, is now being executed in isolation and not coordinated with soil conservation programmes. At the Centre, the rainfed, farming cell was not functioning as a part of the Soil and Water Conservation Division.

Case 5: Lower Bhavani catchment (CMD, 1992) Soil Conservation Programme in the TamilNadu portion of the catchment started from 1976-77. The evaluation study of the catchment highlighted the following:

- Data for hydrologic analysis like silt index rate etc. was not properly being maintained in all the silt-monitoring stations. Examination of the trends in sedimentation which was limited to three out of six existing stations could be considered as only indicative and not exhaustive to give any meaningful generalization of the picture.
- Villagers in the catchment area had the perception of the weakness of the scheme in matters relating to project planning, quality of works, cooperation from the officials, employment potential, recruitment of labour vis-à-vis over-dependence on machinery and contractors, but to no effect.
- No provision was made for maintenance of assets created which were getting damaged due to heavy rains, movement of cattle, poor quality of materials used, etc.

Evaluation study of soil conservation works in flood-prone river catchments

Case 6: Upper Yamuna catchment (ASCI, 1991c) This is one of the eight flood-prone catchments taken up for implementation of the integrated watershed management scheme since 1980-81.

The evaluation study report of this catchment narrates that in the past few years nearly 21 thousand hectares of non-agricultural and only about 2493 hectares of agricultural land had been treated at the time of study. The report stresses the urgency

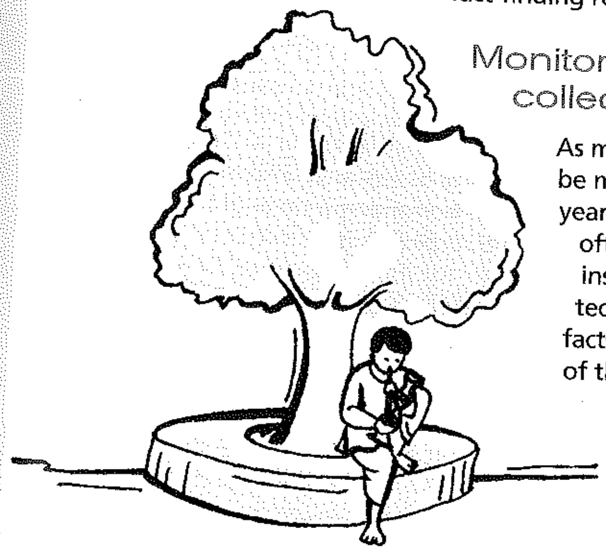
- to rectify the above imbalance between treatments on the two types of land
- to integrate the whole programme and avoid sparesly spreading the efforts
- to safeguard further land degradation and soil erosion problems arising from other developmental activities like road construction works etc.
- to step-up the pace of progress covering larger areas of the catchment by providing additional funds and resources.

Case 7: Ajoy catchment; evaluation study (AFC, 1991) In the Ajoy catchment, the study has brought out a large number of success and failure stories in matters of the technical aspects of the programme implementation which are both location specific, highly realistic and need immediate attention of the project authorities. There would be a very long list to accommodate them in this report. Criticism of the organisational structure and varioius lacunae thereof which hamper programme implementation, are, however, narrated hereunder:

- Agriculture and Forestry Departments are implementing the scheme without any format or informal coordination
- Minor Irrigation department does not integrate with the Soil Conservation establishment to ensure integrated watershed management
- Weak contact with people and much less their participation in the programme tells upon the assets created
- Very little involvement of voluntary agencies has weakened the foothold of the programme to the ground
- Lack of technical qualification of engineers undertaking conservation engineering structures has not yielded the desired results

LESSONS LEARNED

Over a period of time a large number of lessons about M&E have been learned, concerning the institutional structure of the M&E units in terms of their strength and quality, their funding, their responsibilities and mode of functioning, their utility and fact-finding role, which help in achieving the goals of monitoring the project.



Monitoring and evaluation activity limited to collection of reports

As mentioned earlier, monitoring of a complex project is often mistaken to be mere collection of periodical progress reports (quarterly/half-yearly/annual) in physical and financial terms. The project authorities most often overlook monitoring such programmes by undertaking routine inspections of works being executed at the site and assessing their technical and economic viabilities and efficiencies. Invariably, the actual facts concerning technical aspects, material inputs and timely completion of the works are not monitored. These three components of monitoring help in determining success or failure of any project. Similarly, while maintenance of the works executed is not provided for, in the scheme beyond some period, the performance aspect and the benefits accruing to or losses incurred by the farmer and people at large, are seldom monitored or evaluated.

Lack of attention to quality of work

A general slackness is observed on the part of the implementing agencies in overseeing the actual project situation and the behaviour, attitude and responsiveness of the beneficiaries. Adequate and timely monitoring is seldom undertaken and it becomes difficult for the project authorities to objectively measure the efficiency of the programme and/or highlight the deficiencies so as to be able to take mid-course corrective measures. The authorities remain busy and concerned more in the attainment of physical and financial targets.

Pre - project evaluation inadequate

With respect to the pre-project evaluation, the lessons learned concern ad hoc project formulation, lack of base-line/benchmark data, improper planning, over estimation of benefits, lack of human-resource planning and training and under estimation of costs to have the project approved, etc.

Concurrent evaluation never practised in its true perspective

Concurrent evaluation is also being neglected in most of the projects, since it is assumed that concurrent monitoring includes evaluation, which of course is not always true.

Mid-term evaluation

Mid-term evaluation of the project funded internally is not undertaken since it usually forms part of a long-term continuing programme. If, however, a project is externally funded, it is generally subject to a mid-term evaluation, as it forms an essential part of the project itself. Extension of such projects to the next phase is also dependent on such evaluation. Preparation and documentation of information gathered for mid-term evaluation is usually better.

Ex-post evaluation

Much has already been said about ex-post evaluation, earlier. To substantiate further, an ex-post evaluation has to make comparison with the pre-project or base-line situation if it is to prove anything. Comparison of ex-post social scenario with pre-project scenario is much more difficult, if a social evaluation is not made early in project life. Also to calculate the benefit: cost ratio, and to prove the success or failure of programme implementation, assessment of facts with or without project situation becomes necessary.

Inadequate organisation

Organisationally too, the M&E wings created either at the Centre or at State levels are generally inadequate both in strength and quality of resource persons. The goals of M&E are neither clearly articulated nor meant to be followed through. Managements are not serious about assigning due responsibilities required for effective M&E and quite frequently deploy the staff for jobs other than monitoring and evaluation. As a result, the staff cannot develop necessary expertise and dedication to the programme. The staffs are also frequently transferred from one station to another and very often do not know their actual roles.

After-care of the projects

The schemes do not provide for maintenance of works executed and assets created. Also, state agencies deviate from the prescribed norms and pay very little attention

towards maintenance. Structures like earthen bunds, dams, gully control and water harvesting structures wither away fast. Similarly, indiscriminate and continued pilferage of branches and twigs, lopping and over-grazing destroy the plantations. People benefiting from soil conservation works take interest in maintenance of assets, only when created on their own lands and never bother for common property. Village institutions having competence and willingness also care little, due to their non-involvement in the programme from the beginning.

Inter-departmental coordination

Soil conservation programmes suffer a lot because of a serious lack of cooperation and coordination between line departments implementing the programmes. Also the project authorities seldom endeavour to involve non-government organizations (NGOs), voluntary agnecies or local villagers to supplement the efforts in executing the programmes.

With the passage of time, the Government of India, realizing the urgent need to rehabilitate the degraded lands, to conserve the productive base and to increase food, fodder and fuelwood production has, however, diversified into many activities with respect to land and water resource conservation, development and management. New institutions like NLUCB, SLUB, NAEB, NWDB etc., have been established, one after the other for framing policies and programmes. But, unfortunately, these institutions and various other line departments are functioning without coordinating their efforts. On many occasions they were duplicating the same and wasting resources, energy and time, resulting in cost and time over-runs.

It may be concluded by saying that when such large number of lessons are learnt and the awarness increases, the system tries to incorporate the desirable changes but the process is slow. To bring about changes it takes vision and a system tuned to experiment with the social, economic and administrative changes, a commitment at socio-political level to support and steer these extensive programmes which achieve only non-dramatic short term gains and invisible long-term gains.

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WATERSHED MANAGEMENT PROGRAMMES: AN EVALUATION OF ALTERNATIVE INSTITUTIONAL AND TECHNOLOGICAL OPTIONS

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INTRODUCTION: WHY WATERSHED MANAGEMENT?

Increased productivity of land and water, have the potential of initiating a logistic growth path in a region even without further investments. This is the sense in which programmes based on natural resource augmentation are superior to traditional investment in employment or asset creating schemes

Efficient programmes of natural resource management derive a considerable part of their relevance from being catalysts for initiating sustainable development processes. This is true in particular in developing countries. Increased productivity of land and water, have the potential of initiating a logistic growth path in a region even without further investments. This is the sense in which programmes based on natural resource augmentation are superior to traditional investment in employment or asset creating schemes[1]. A few preconditions are, however, necessary for this to happen. To begin with, the unit of operation of the programme in question must capture a large part of the externalities which are the essence of natural resource management. This can happen more expeditiously if the unit of operation of the programme is conterminous with the area over which hydrological processes are integrated. This is the *sin qua non* of watershed management as a concept. Any attempt at soil and water conservation within smaller privately owned units fails to account in a complete way for externalities from areas upstream of the watershed and in turn, affects downstream areas and is therefore less likely to succeed.

However, the acceptance of the watershed as the physical unit for planning raises new sets of issues. While the watershed constitutes the area unit over which physical processes are integrated, the villages comprise the social and administrative units. Further, the property rights units, determined by prevalent property rights regimes, may be different from both of these. Most watersheds contain a mix of government, private, common property and open access land. Decisions with respect to use of resources or investment in their conservation are taken by the respective owners in the framework of social and administrative structures. These decisions are taken from the perspective of the respective owners and may not necessarily be in the best interests of sustainable use of resources such as soil or water. This dichotomy between decision making determined by ecological imperatives and by property rights is the starting point for most problems associated with watershed management. The large number of stakeholders in a watershed programme need to come to an agreement with regard to the sharing of benefits and costs. What kinds of institutional processes and arrangements lead to such consensus, in other words, participation in the different components of the programme?

A large body of literature has addressed this question and studies from around the world identify participation of these stakeholders as crucial to the success of soil and water conservation efforts in watersheds. Some studies maintain that accrual of economic benefits results in participation (Chopra et. al 1990): others (White 1992c) feel that participation is not directly correlated to economic benefits. White (1992b) also argues that, for soil and water conservation to be adopted and sustained, it must be an extension of existing cultural and technical behaviors.

Brooks et. al (1990) also state that "the practical means of achieving sustainable projects in watershed management, conversely, cannot ignore land tenure, institutions and the culture of watershed inhabitants". Blaikie (1983 and 1985) has also emphasized the importance of social factors such as institutions – political and economic. He argues that the politics of the state and society (agrarian relations) are

central to soil conservation. An understanding of how and how far the state will implement soil conservation policies requires a careful analysis of whose interests are represented in the various institutions involved. Secondly, an analysis of the politics of agrarian civil society is an essential ingredient of a realistic appraisal of what is possible and what is not.

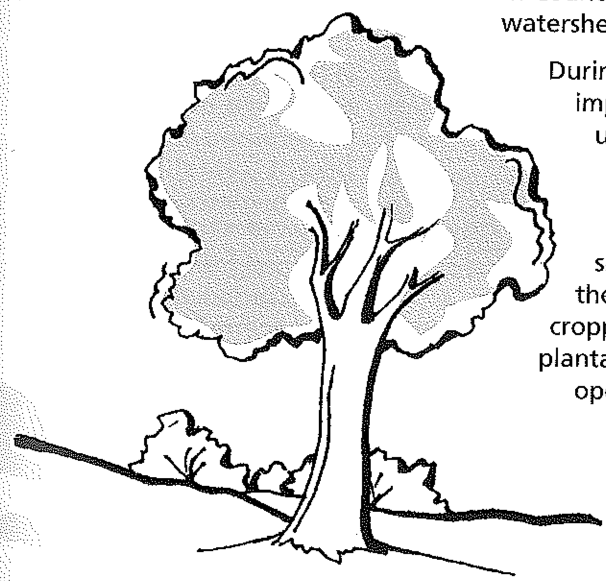
Technology also determines the extent of participation. Watershed development encompasses a large variety of technical and vegetative measures, located in different parts of the terrain. Contour bunding, land leveling, check dams, tree plantation, water harvesting and silt retention structures are some of these. Perceptions with regard to each of these measures vary. Measures located on privately owned land have a larger visibility compared to those constructed on forest land in the interior of the watershed though externalities are of the essence when it comes to their impact. This mosaic of interconnections between technological interventions and institutional aspects in watershed management leads to varying degrees of success and acceptance.

This paper studies technological and institutional aspects of watershed management in the context of three watershed management projects. These projects operationalise similar technological interventions in the semi-arid areas of western India within the context of alternative institutional frameworks. Section 2 provides a review of existing studies using conventional cost-benefit analysis with internal rates of return and benefit cost ratios as the decision criteria. Section 3 gives a brief description of the projects selected for study and Section 4 analyses their impact using multi-criteria analysis to compare the performance of these three projects on different counts. Policy implications for future watershed management projects are put together in the last section.

A REVIEW OF WATERSHED PROGRAMMES IN INDIA AND THEIR EVALUATION

Watershed programmes in India

The earliest experiments in watershed management in India were conducted in the semi-arid tropics under the aegis of ICRISAT. Between 1975 and 1988, fourteen cropping systems were evaluated along with a range of management practices. The Indian Council for Agricultural Research also took up forty-six model watersheds in the dryland areas of the country in 1982.



During the seventies and eighties the thrust of policy shifted to the improvement and stabilization of productivity in rainfed areas. It was understood that in these areas, the main focus of development strategy should be on minimizing risk through appropriate land management systems which ensured greater retention of soil moisture for increased production. The emphasis was therefore shifted to the area development approach taking watersheds[2] as the unit of development. The components include appropriate cropping systems, dryland horticulture, fodder and economically viable plantations in an integrated manner. Four pilot projects were operationalised from 1984 with World Bank assistance to provide an integrated approach. Furthermore, the National Watershed Development Programme for Rainfed Areas was launched in 1986-87. The programme is being implemented in sixteen states and extends to ninety-nine districts. Around 2328 watersheds are receiving treatment under this programme[3].

The idea of integrated treatment of the watershed was also behind the centrally sponsored schemes aimed at reducing the sediment inflow into the river valley projects and flood prone rivers. Two such schemes are currently in operation, one in the catchment of River Valley Projects (RVP) and the second as an integrated watershed management scheme in the catchments of Flood Prone Rivers (FPR) in about 900 priority watersheds of 35 catchments spread all over India (GOI, 1990).

In an integrated watershed development programme all principal practices *viz*. soil and water conservation, improved farming systems, dryland horticulture, pasture land development and forestry need to be taken up simultaneously. In the implementation of these practices, two phases can be identified. The first one involves fairly long term public and private investment. This should be followed by a phase of efficient management of resources and technologies on a sustainable basis. Both these aspects of investment and management of watershed practices are influenced by several factors. Once these practices are identified, the impact of these watershed measures and the factors influencing the adoption are most significant in economic analysis. Therefore analysis needs to be focused on the impact of technologies, costs, benefits and distributional aspects.

Evaluation of watershed programmes in India

Diverse approaches have been adopted in the evaluation of watershed programmes in India. A large number of studies identify technological components of the watershed programme and then list the impact of each component. Others use the technology of financial or social cost-benefit analysis to arrive at rates of return to individual components of projects. A brief review of these studies is attempted in this section. It is important to keep in mind that unit costs of watershed management projects may vary considerably. The cost per hectare of area varies between Rs. 1000-Rs. 9500 as reported by Vaidyanathan (1991)[4].

Studies by Saksena et al. (1989) in the plateau and hill regions of Western Maharashtra State that a benefit cost ratio of 1.28 and an internal rates of return of 12.33% could be obtained from a project which included water harvesting. In the same region, Nawadhakar and Shaikh (1989) reported increases in net sown area of about 14% with land shaping, contour bunding and moisture conservation as the major project components.

On the basis of group interaction with farmers in Karnataka, Ramanna (1991) contended that the farmers were convinced of the benefit of the programmes of watershed management both on arable and non-arable lands in the form of rise in water table level in wells and reduced siltation of tanks. However, some farmers

expressed apprehension that the tanks did not receive their due share of water and it was not possible for them to raise paddy crop under the tanks. Establishment of micro-watershed sanghas in Karnataka has demonstrated how an NGO can involve people in watershed development. The yield of groundnut increased from 8.95 to 12.75 q/ha in Chitravati watershed area in 1987-88. He concludes that considering the distributive effects of the gains and the beneficial impact on the environment of the watershed approach, an average expenditure of about Rs. 2,500 per hectare in the watersheds is quite nominal and the farmers in the watershed areas could justifiably demand this expenditure as a subsidy.

ASCI (1990) found that in the Maheswaram watershed in Andhra Pradesh, the yields of jowar and castor per hectare increased substantially from 5.5 and 4.8 quintals to 10.3 and 9.59 quintals with watershed technologies. However, about 75% of the subabul plants, comprising part of the plantation component of the project did not survive. Even in those places where the plants survived, their growth rate was poor.

Chopra et. al (1990) reported that in the lower Shiwalik region of northern India, the emergence of participation resulted in fairly high rates of return to watershed management, greater than 12%, the cut-off social rate of discount usually adopted by the Indian Planning Commission. Further, the incremental income accrued to different sets of beneficiaries. Between households and village societies, about 71 to 82% of net benefits were shared by the project region. Externalities accruing to the government comprised 18 to 29% of net benefits. This estimation of benefits to the project region has allowed for the direct and indirect impact of participatory institutions on incomes of the people as well as of government agencies.

Katar Singh (1990) reviewed the experience of four watershed projects, namely, Mitternmari and PIDOW in Karnataka, Ralegaon-Siddhi in Maharashtra and Sukhomajri in Haryana. The review reiterates that the most important pre-requisite for people's participation is that the expected private benefits from participation must substantially exceed the expected private costs of participation. Programme interventions that seek to enhance the expected benefits to people or reduce the expected costs are likely to elicit more of people's participation. Other determinants are organization of people into small groups as in PIDOW and leadership as in Maharashtra, equitable sharing of benefits from collective action as found in Sukhomajri and availability of complementary investment from the government.

AFC (1988) estimated the benefits and costs of the Matatila River Valley Project. Matatila dam was constructed in the year 1956 across the river Betwa, a tributary of the Yamuna. This was a fairly large project where 22.4% of the total catchment area of 21.06 lakh hectares was treated for soil conservation. The progressive sediment inflow rate, (SIR) decreased by 19.5% between 1962-64 and 1975-85.

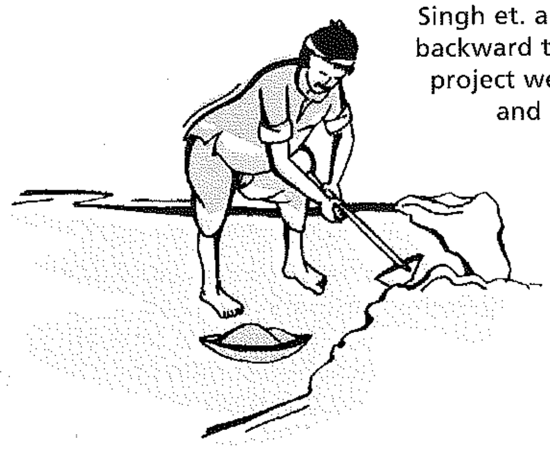
The benefit cost ratio of soil conservation for the project is 1.68 and the internal rates of return is 41% in the sample watershed. The benefits are both protective and productive. Protective benefits include protection of productivity of land @ Rs. 185/ha and protection of water resources (reservoir capacity) @ Rs. 40/ha. Productivity benefits are @ Rs. 78/ha. The benefit cost ratio calculated for the whole catchment for the agricultural sector alone works out to 3.8:1.

The benefit cost ratio for water harvesting structures has been calculated using the discount rate of 12% for the year 1981. The benefit cost ratio for 12 years of active life works out to 1.38:1 and for 20 years life, it is 1.84:1. The internal rates of return for 12 years of active life comes to 32%. The benefit cost ratio of afforestation works out to 4.48:1. Eucalyptus, Sheesham and Khair have been planted in equal ratio in 376 ha. In non-agricultural lands the main engineering structures are the check dams for stabilization of gullies, the water harvesting structures cum silt detention bundhies, etc. Under forestry, trees, namely neem, bamboo, khair, mahua, babul, sheesham, eucalyptus etc. are being raised. Employment benefits also accrue in the form of casual employment from treatment of agricultural and forest lands, regular employment of a permanent nature from increases in cropping intensity and skilled employment from survey planning, design, and execution.

In another study for the Chambal catchment AFC (1992) worked out that the cropping intensity has been increased by 28% while the yield levels increased by 21.6, 62.35 and 46.7% for maize, jowar, wheat and gram respectively. The benefit cost ratio for afforestation works out to 2.3. The number of wells increased by 32% with one to two meters increase in water table level.

Deshpande and Ratna Reddy (1991) selected three micro watersheds from three different regions of Maharashtra to study the locational aspects and the consequent difference in technologies adopted. The watershed in the scarcity zone had land development, horticulture, contour bunding, key line formation and nala training as the main soil and water conservation activities. In the second watershed with modest rainfall, contour and graded bunding, nala bunding and training, afforestation and grass planting received prominence among the components of watershed management. In the last category of watershed with assured rainfall, drainage, water logging and waterways receive prominence. However, in the treated areas of the watershed, there is a shift towards pulses and oilseeds. The significance of commercial crops also remains in all three locations. The analysis suggests that protective irrigation through water harvesting has an impact on total value productivity in both scarcity and moderate rainfall regions. Analyzing the comparative performance of watersheds in the scarcity zone and the transition zone, Deshpande (1997) maintains that.

- Incremental income generated per unit of investment is higher in the scarcity zone than in the transition zone.
- Sources of income generated per household differ substantially in the two zones.
- Income generated from agricultural sector per hectare is inversely related to the size of the holding.
- A higher level of farm asset creation takes place in the scarcity zone as compared to the transition zone.
- The magnitude of reduction in runoff/soil loss is also found to be higher in the scarcity zone.



Singh et. al (1991) studied the Kandi watershed, one of the economically backward tracts of the Punjab state. The different components of this project were forestry, animal husbandry, soil conservation, horticulture, and irrigation and the rates of return on them were 12%, 9%. 10%, 22% and 2% respectively. The overall project ERR of 8% represents a substantial shortfall from the earlier expectations of 12 to 20% according to the feasibility studies. However, the Internal rates of return and benefit cost ratios are 38% and 2.23 for kinnow, 26% and 2.48 for mango, and 44% and 2.30 for guava respectively. Increase in cultivated area was from 80.34 to 99.33% while irrigated area increased from 11.36% to 48.93%.

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The forestry component could have performed better had adequate provisions been made for maintenance, so that the high tree mortality rate could have been significantly avoided. The indifferent performance of the animal husbandry component is mainly due to a sharp drop in milk yields of the high quality cattle provided. This performance could be attributed to defective provision for fodder, inadequate extension services and lack of milk marketing infrastructure. The poor performance of soil conservation components was largely due to the failure of the irrigation component as the attainment of full benefits from this component was contingent upon the availability of timely irrigation. The main reason for the poor performance of the irrigation component in turn was the inordinate delay in implementation and the limited area actually brought under irrigation.

Table 1 presents results obtained from some of the studies reviewed above. It seems that cropping intensity may increase by 5-15% and incremental yields by 0.5 - 1.0 tonnes per hectare.

The selection of appropriate technologies for watershed management, in particular the issue of engineering versus vegetative technologies has also been the focus of some research[5]. Research at ICRISAT compared vegetative (vetiver grass) technology with some barriers, lemon grass and bare ground under natural and artificial rainfall conditions. In all cases vetiver technology was the most effective one, apart from being the low cost option. It reduced runoff by 57% and soil loss by over 80%. It is also reported that vetiver grass will grow in a wide variety of site conditions, is non-competitive with adjacent crops and extremely resistant to pests and diseases. If used for structural strengthening of earth embankments, drainage lines and gullies, it can prove to be a key technology for the sustainability of tropical and semitropical agriculture (Grimshaw and Helfer 1995).

Low cost conservation technologies namely vegetative measures should be adopted on both arable and non-arable lands on a watershed basis instead of on individual farmers' fields. This neutralizes the negative externality effects on downstream areas

The Maheswaram project in Andhra Pradesh (Rao 1993) provides for both engineering structures and vegetative barriers of vetiver grass. The income in the watershed can be increased as much as 18% by adopting optimal land use strategies with more area under vegetative measures. High value commercial crops such as castor can be grown profitably with conservation measures. If the soil loss is to be prevented, as much as 88% of land needs to be brought under vegetative measures. Low cost conservation technologies namely vegetative measures should be adopted on both arable and non-arable lands on a watershed basis instead of on individual farmers' fields. This neutralizes the negative externality effects on downstream areas. However, regular care and maintenance is needed on a collective basis. Shah (1994) illustrated with the help of data from Maharashtra that although vegetative measures are environmentally sound, they should not be implemented in a straitjacket, manner.

In a more recent study, Shah (1997) has examined watershed programmes in Western Gujarat. A yield gain of 20 to 30% is expected with an average investment of about Rs. 6000 per hectare. In terms of the acceptability of different components of watershed technology, she reports that in a dynamic rainfed region, returns from capital intensive measures such as land leveling, water harvesting and commercial plantation are likely to be higher and are also likely to evoke more interest and participation. In situ conservation measures by themselves (including vegetative barriers) may not succeed unless accompanied by measures that are perceived to be income enhancing. She also maintains that farmers need appropriate technology, even if it is not a low cost one.

Table 1: Impact of Soil and Water Conservation Technologies in India

No.	Project location and agro-climatic zone	Source	Nature of Project	Increase in cropping intensity (Percentage)	Increment yield percentage/ quintals per hectare	Gross return (Rs. hec)	Rate of return
1	Maharashtra: western plateau and hill region	Saksena et al (1989)	water reservoir	NA	NA	3900-5000	BC ratio: 1.28 IRR 12.33
2	Maharashtra: western plateau hill region	Nawadkar and Shaikh (1989)	land shaping, contour moisture conservation	NA	NA	2455 (103% increase)	net sown area of 14%
3	Karnataka: southern plateau and hill region	Kulkarni et al. (1989)	soil and run-off conservation	7.45	Kharif sorghum 3.62, groundnut 3.26 chili 12.44, cotton 16.14, rabi sorghum 1.44		net return increase in Kharif sorghum
4	Karnataka: southern plateau and hill region	Singh, Katar (1989)	bunds, graded contour, farm ponds	NA	groundnut na 1.68 (local) groundnut 1.19, finger millet 0.88 finger millet 2.40, (HYV) groundnut na 2.68 (local) pigeon pea, finger millet 5.23, finger millet (HYV) 4.42	incremental net benefit Rs. 9170 per hectare	-
5	Punjab; Himalayan foot hills	Singh et al. (1991)	livestock, development, soil conservation	-	-	-	rate of return 12.5 rate of return on forestry: 15.27%
6	Haryana: Himalayan foot hills	Chopra et al. (1990)	water reservoir, affforestation, creation of new institutions				rate of return 19%
7	Maheswaram: semi-arid agro-climatic zone	Rao (1993)	integrated project covering soil and water conservation measures such as horticulture, pastures and forestry development		engineering measures: Sorghum 1.49 Castor 0.53 vegetation measures: Sorghum 2.47 Castor 0.98	engineering measures Sorghum 1599 Castor 1487 Vegetation measures: Sorghum 1763 Castor 1578	
8	Matatila Ukai	AFC (1988)	RVP, Soil conservation mini storage structures, afforestation	85.6 to 115.4 89.6 to 114.5 89 to 100	10 - 76.2% 2.7 - 11.3% 40.3 - 74.8%	IRR 41% 39% 43.7%	BCR 3.8 1.25 1.36
9	Kandi	Singh et. al (1991)	watershed and area development project for rehabilitation and flood protection	Under orchards increases from 28.10% to 32.07%	-	IRR Kinnow 38 Mangoes 26 Guava 44	BCR Kinnow 2.23 Mango 2.48 Guava 2.30
10	Maharashtra (two agro-climatic zones)	Deshpande (1997)	land development with bunds, tree plantation on farms, pasture development water and soil conservation	Scarcity zone: 111 to 113% transition zone: 126 to 130%	NA	increase in Income per hectare Scarcity zone: 45% transition zone: 30%	Not found
11	Gujarat (two regions)	Shah (1997)	land development, leveling, bunds. check dams, conservation measures	NA	vegetative barriers: 5-6% Land leveling: 18-27% Earth bunding: 21-22%	NA	NA

1. NA, not available; na, net addition in quintals per hectare.
2. Incremental yield is in percentage terms; sorghum is a local grown in both crop seasons, Kharif and Rabi.

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THREE WATERSHEDS: ALTERNATIVE TECHNOLOGIES, LOCATIONS AND INSTITUTIONS

The Sahibi project in Alwar, Sikar and Jaipur districts of Rajasthan[6], a semi-arid region with an average rainfall of 450mm, was undertaken in 1978-79 under the centrally sponsored scheme for integrated watershed management. At about the same time, work was initiated under a non-government initiative in Ralegan Siddhi in Ahmednagar district of Maharashtra[7], a region with an average rainfall of about 574 mm. The focal point of this initiative was also water and soil management in the four watersheds of the area. In both cases, agricultural land constituted a major part of the project area and an increase in agricultural productivity constituted an important objective of the project. This had, however, to be achieved within the parameters set by the externalities of degradation emerging from the presence of areas with unspecified property rights and a rising cattle and human population, elements common to most rainfed regions of the country.

The two projects differed in terms of the institutional set up within which they were carried out. While Ralegan Siddhi was amongst the first non-governmental initiatives in the country, the Sahibi project was executed by the Forest Department of Rajasthan. However, the notion of making people's participation a part of development planning had permeated into the planning process by the time work on the second watershed selected for study was undertaken. Together, the three components selected for study define three levels of institution creation namely,

- A non-government initiative.
- A project executed by a government department and.
- A project executed by a government agency with peoples' participation.

The two sub-watersheds of the Sahibi project, Tatarpur in Alwar district and Pithalpur in Sikar district are selected purposively for evaluation, representing as they do the spectrum of conditions prevailing in the Sahibi project area. The former is " saturated" in the sense that all work that was planned to be done in it has been completed. It was implemented more than a decade ago. The latter was implemented five years ago. Further, these two sub-watersheds are located in two different districts characterized by wide differences in soil characteristics as well as ground water availability. The two sub-watersheds selected are, in a way, representative of conditions seen to prevail in the Sahibi watershed project as a whole. Whereas Tatarpur belongs to the category of "very high priority" areas, Pithalpur is in the next category, termed only as "high priority". It is interesting to note that the level of participation of local communities was far higher in Pithalpur in spite of the fact that soil and other natural conditions seem to be far more inhospitable there. Both secondary information and field visits undertaken to the project area confirmed this.

These two watersheds of the Sahibi project also represent different technological mixes, encompassing both water harvesting and engineering technologies. It is important to understand, in the context of the operational aspects of the project, that the choice of technology was in accordance with the guidelines issued by the Government of India for such projects in 1978. At present, it is being implemented as per the revised guidelines of 1992. This has imposed some restrictions on the choice of the technology[8]. The technology selected under the Ralegan Siddhi project did not operate within any such constraints.

Further, the Sahibi project and the Ralegan Siddhi initiative are located in Rajasthan and Maharashtra respectively, which together comprise a large part of the semi-arid region of the country. From a number of different perspectives, therefore, an evaluation of the comparative performance of these two projects is an appropriate

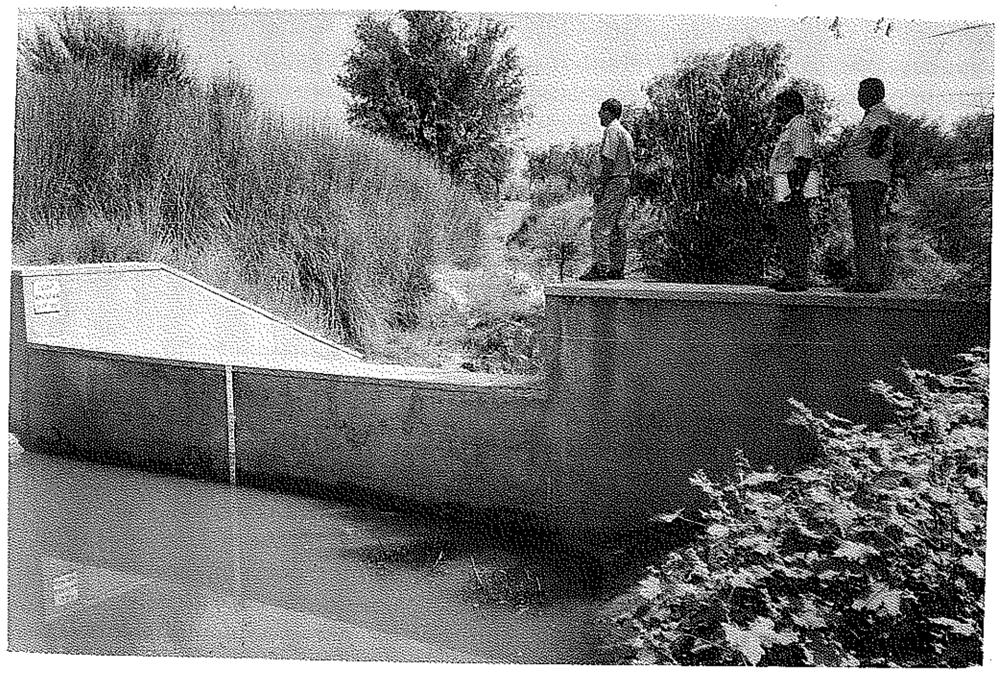
starting point for scenario building with respect to arriving at a policy perspective for watershed management in the semi-arid tropics.

Methodologies for project evaluation

The evolution of techniques to evaluate alternative investments has been one of the central concerns of investment planning literature since the late sixties. This was the outcome, partly, of the accent on centralized planning and its need to choose between various large centrally planned investments. Cost benefit analysis emerged as the most widely used technique at that time. In the initial stages it was used mainly in the analysis of public sector industrial projects[9] which had well specified time frames of benefits and costs. Over time, however, the range of application of the technique was extended to include projects in the private sector and in the areas of agriculture, infrastructure and even social services such as education and health. Each application witnessed innovations in the technique itself to cope with the new range of questions being asked. In the application to investments in the private sector, for instance, time frames of benefits and costs were valued at market prices only. Alternatively, evaluation of public sector projects necessitated the valuing of these time frames at "social" or "shadow" prices. The requirement led to the emergence of literature on the methodology for determining these prices[10].

Further, applications in the area of social services resulted in the development of a variation of the technique itself in the form of cost-effectiveness analysis. In these sectors, the measurement of the benefits provided by the project in the form of education or health services presented a problem. Project analysis was mainly limited to investments which purported to provide similar kinds of services. The "cost-effectiveness" of providing such similar services was examined in the variant of the technique which came to be known as cost effectiveness analysis.

The emergence of environmental impacts as an important dimension in the analysis of projects gave rise to a new set of issues. How were these impacts to be assessed, measured and taken account of within the dimensions of the technique? In view of the longer time horizon in which environmental effects manifest themselves, was it correct to use similar rates of discount and discounting techniques for them as were used for economic costs and benefits? While the latter question stimulated a growing theoretical literature[11], the former was tackled by looking at benefits and costs as they accrued in the context of specific projects.



In some situations, abatement of undesirable environmental effects could be achieved through the adoption of a different technology. The incremental costs of the technology then were attributed to the project in question and a cost-benefit analysis of the usual kind carried out.[12]

Additionally, externalities are crucial in the estimation of environmental effects and the physical unit over which the effect of the investment is spread becomes important. This is in particular true of soil and water conservation projects undertaken within watersheds. When groups to whom benefits or costs accrue as principal or externall benefits or costs can be identified, the effects on them measure the externall benefits or costs[13]. Some other exercises distinguish between on site and off-site effects of investment, the former being measured by direct evaluation of increased productivity[14] and the latter by benefit from silt retention as approximated by saving on alternative investments (such as mechanical dredging of downstream water bodies).

It can be concluded that most analysis of environmental effects within the framework of cost-benefit analysis approximates the effects in indirect ways. This is fine as long as these effects are treated as externalities arising out of the operation of the project. One recent approach to environmental problems maintains that they impose a constraint on the scale of economic activity due to the crossing of acceptable threshold levels of intervention in the environment[15]. Such a view implies that cost-benefit analysis becomes somewhat irrelevant as it views only marginal impacts without examining the scale problem.

It can be concluded that most analysis of environmental effects within the framework of cost-benefit analysis approximates the effects in indirect ways

In addition to the above, certain methodologies, controversies and inadequacies have come up time and again in the context of the application of this technique. One among them is the issue of its relevance as a method for ex-post evaluation of projects. At the outset, cost-benefit analysis was viewed primarily as a method for making an "ex-ante" evaluation of projects, it being based on a projected stream of benefits and costs. Over time, however, the technique came to be used as an ex-post evaluation procedure, the assumption being that expected time streams of costs and benefits were realised.[16] It must be mentioned, however, that some applications did attempt to correct for this by allowing for uncertainty in accrual of benefits and costs.

Simultaneously, evaluation exercises deviated into using other methodologies. Some preferred a simple listing of the effects of the projects in question[17]. New methodologies such as multi-criteria analysis with supporting software packages also emerged so that project analysis now had some options available to them.

Multi-criteria analysis (MCA) has been used for evaluation of alternative projects in this report. It has been selected in preference to cost-benefit analysis on a number of counts. Cost-benefit analysis arrives at rates of return or net present values of projects envisaging a certain amount of initial investment. The outcome is a kind of judgement on the desirability or otherwise of investment in alternative projects. In this exercise, the objective is different. It is to rank projects embodying different technologies and/or different institutional frameworks in terms of the total impact they have had on a selected set of effects. The multi-objective decisions models, the category to which MCA belongs, allow for more accurate representation. Objectives of watershed projects, for instance, may be reduction of soil loss, increase in in-situ moisture conservation which increases productivity, reduction of non point pollution of surface and ground water, general improvement, etc. Each of these effects may be given different weightage, the weightage to be assigned being determined by user group valuation, rapid appraisal methods ,etc.

Further, accounting for qualitative as well as quantitative variables became a critical factor in the evaluation of the selected projects. Each project impacted environmental and economic variables. Some environmental effects as reduction in sediment yield of the watershed could be measured with precision only in situations where a silt-monitoring station existed or was in working condition. Other variables in this category had just not been measured with quantitative precision. There existed, however, qualitative judgements/estimates regarding them. Economic effects were more amenable to quantitative measurement. Multi criteria analysis enables us to take account of both these sets of variables in the evaluation of projects. Scores are estimated for each project/technology and then a ranking obtained making use

of all kinds of effects that the project may have had. It may be pointed out here that both positive effects of the projects (which can be conceived of as benefits) and negative effects (to be thought of as costs) can be used in the analysis.

This methodology also allows for different weights to be assigned to sets of variables and for a sensitivity analysis of results based on either weights uncertainty or effects uncertainty. All these characteristics of the technique make it suitable for analyzing effects of alternative technologies and/or projects with a fair degree of certainty with respect to the ranges within which these effects lie[18].

Methodology as applied: kinds of impact studied

The methodology of multi-criteria analysis consists of two steps:

- Drawing up of an effects table and.
- Determining ranks and scores for projects on the basis of the effects table.

The effects table itself is a fairly detailed description of the economic and environmental impact of each project alternative. The effects of each project are identified on the basis of four sets of variables; economic, environmental, costs of alternatives and institutional environment. Further, all effects are defined as incremental changes in the variable. This is found by subtracting the value of the benefit in a non-treated area treated as a benchmark from that accruing in the treated area. The approach adopted is similar to the "with" and "without" project formulation used in standard project evaluation literature.[19]

Date on two sets of variables in the "with" and "without" situations was collected, the economic and the environmental. The economic variables were defined to include:

- Crop yields, defined to include the weighted yields of major crops grown in the region, i.e. wheat, bajra, gram and mustard:[20] crops selected vary according to the region in which the project is located.
- Increase in area under cultivation: this accounts for the impact on expansion of agricultural activity.
- Increase/decrease in livestock numbers: this is measured in standard cattle units.[21]
- Increase in milk production.
- Employment benefit, defined as incremental employment from crop production activity, livestock rearing and employment created by the project in the execution of soil and water conservation works including afforestation programmes.[22]
- Increase in area under horticulture/private plantations/fodder and fuel wood availability benefits, to account for the increased availability of these two commodities in the project areas. Such an increase could be attributed to afforestation activity, or to better natural regeneration on account of the retention of sediment and runoff in the watershed. The primary data collected allows for the study of these on a seasonal basis: hence the incremental position as between watershed and non-watershed areas is taken separately for summer, winter and the rainy seasons.

The environmental variables taken are:

- Reduction in sediment yield: there exists data on this based on observations from the silt monitoring stations, one at the foot of the Tatarpur watershed and one in the vicinity of the Pithalpur watershed. A sediment yield index is available as well. This has a value of 1002 for Tatarpur and 561 for Pithalpur. On this basis, ordinal values are given to this variable for all four alternatives.

- Reduction in runoff: here again ordinal values based on secondary information are given.
- Water Table: some quantitative information on increase in number of wells in the area around Pithalpur is available, however, a qualitative index is used.
- Flood control is also taken into account be assuming uniform success in both watersheds of the Sahibi project as reported by the project authorities. However, since flood control was not relevant in Ralegan Siddhi, it is not an objective for that project.

Costs of all three kinds of investment activity - engineering structures, water harvesting structures and afforestation activity is taken from the project authorities, adjusted for inflation and accounted for at 1995-96 prices.

As evidenced from field visits supported by indirect evidence from available documents[23], it is assumed that level of people's participation is higher in Pithalpur as compared with that in Tatarpur. Since Ralegan Siddhi constitutes the NGO initiative, it is taken as being highest there.

Sources of data used are both secondary, provided by the project authorities, independent studies and primary, based on surveys used. Primary survey based data was used in areas where information provided by the project authorities was not exhaustive from the view point of the requirements of the study.

Data obtained from secondary sources

The secondary data used in the study which was obtained from the project authorities are investment on soil conservation structures including engineering and water harvesting structures and afforestation programmes. Meteorological data such as rainfall, relative humidity and temperature for the Sahibi project are obtained from the Paota station.

Data on sediment yield index is obtained from secondary sources and the Paota observatory. Water table data are provided by project authorities[24] augmented by field observation. Information on flood control is given by project authorities by qualitative observations during discussions at the time of field visits.

Investments on soil conservation works including afforestation pertain to two years in Tatarpur sub watershed, (namely 1984-85 and 1985-86) and are made over a period of three years, 1990-91 to 1992-93,in Pithalpur sub-watershed area. These investments are adjusted for inflation and calculated for the year,1995-96.

Benefits from treatment with soil and water conservation measures are found on the basis of a sample of households selected on the basis of random sampling in the villages where a maximum number of people are known to have benefited from the project. In Tatarpur the sample of 21 households belongs to two villages, namely Tatarpur and Raipur. A sample of households is selected in Tatarpur village (Badli and Rundh hamlets) which benefited from engineering structures such as bunds, checks dams etc. In Raipur village, five households are selected from amongst those who have benefited from water harvesting structures. In the non beneficiary category sample households are selected in Bahram Ka Bas village which is situated at a distance of 25 km away from the watershed area. In Pithalpur sub-watershed area a group of 20 beneficiaries were interviewed in two villages, namely, Pithalpur and Hamirsing

Ki Dhani, to capture the benefits from the adoption of engineering and water harvesting structures respectively. A sample size of 10 households was selected in Triveni Nursery area which is 20 km from the Pithalpur watershed area to represent from the non beneficiary category.

Tables 2 and 3 put together the data obtained on incremental benefits and costs for Tatarpur and Pithalpur sub-watersheds with respect to engineering and water harvesting technologies. Three levels are identified for each project, the level in the project area, that outside the project area and the net change.

The incremental benefits are taken into account to judge the ranking of projects and technologies. To calculate the incremental benefits, the benefits accruing in the non watershed area are deducted from the benefits accruing due to implementation of watershed project.

Table 2: Economic impact of investment in Tatarpur sub-watershed

Effect	Unit	Within Project Area		Outside Project Area	Net Change	
		Engineering	Water Harvesting		Engineering	Water Harvesting
Yield Group						
a) Bajra	kg/bigha	355.40	328.90	294.20	61.20	34.70
b) Wheat	"	1098.90	1058.10	870.40	228.50	187.70
c) Mustard	"	383.0	305.90	278.00	105.0	27.90
d) Gram	"	390.6	340.00	280.00	110.60	60.00
Additional Area	bigha per family	1.38	0.0	0.0	1.38	0.0
Milk production	Lit/buf/y	1580	1722	644	936	1078
Livestock	Nos. in SCU	0.77	1.00	0.33	0.44	0.67
Fodder Collection						
Summer	tonnes	23.28	6.08	11.33	11.94	-5.25
Winter	tonnes	19.08	2.24	20.90	-1.82	-18.66
Rainy Season	tonnes	15.38	9.44	79.03	-63.65	-69.59
Fuel Collection						
Summer	tonnes	5.83	4.60	27.00	-12.17	-22.40
Winter	tonnes	23.76	7.00	13.20	10.56	-6.20
Rainy Season	tonnes	3.95	0.00	27.20	-23.25	-27.20
Employment Created	mandays/year/ family	75	142	-	75	142
Investment (1995-96 price)	Eng:Rs/ha	2072.70				
	WHS:Rs/unit		120,000			
	AFF:Rs/ha	811.70	817.70			

Table 3: Economic impact of investment in Pithalpur sub-watershed

Effect	Unit	Within Project Area		Outside Project Area	Net Change	
		Engineering	Water Harvesting		Engineering	Water Harvesting
Yield Group						
a) Bajra	Kg/bigha	216	440	175.2	41	264
b) Wheat	"	465	800	44.40	21	356
c) Mustard	"					
d) Gram	"					
Additional Area	bigha per family	0	0.75	0.0	0	0.75
Milk Production	Lit/buf/y	523	720	564	-41	1078
Livestock	Nos. in SCU	0.60	-0.48	0.48	0.60	0.67
Fodder Collection						
Summer	tonnes	0	0	96.0	-96.00	-96.00
Winter	tonnes	24.0	60.0	33.20	-9.20	26.80
Rainy Season	tonnes	0	0	96.0	-96.00	-96.00
Fuel Collection						
Summer	tonnes	12.80	24.80	4.50	8.30	19.50
Winter	tonnes	24.00	24.00	14.10	9.90	9.90
Rainy Season	tonnes	0	0.00	4.50	-4.50	-4.50
Employment Created	manday/year				41.30	41.30
Investment (1995-96 price)	Rs/ha	3837.80	-			
	Rs/unit	-	69500			
	Rs/ha	893.80	893.80			

A similar estimate of net change in the selected variables for Ralegan Siddhi enables us to set up the effects table for all five alternatives. This is given in Table 4. It is seen from the table that bajra yield is highest for the water harvesting option in Pithalpur, is so are wheat yield increases. Increase in mustard and gram yield, on the other hand are highest in the engineering option in Tatarpur. Jowar and onion yield increases are relevant only for Ralegan Siddhi. So is increase in area under horticulture and plant protection. In the Sahibi watersheds (for both the engineering and water harvesting technologies, the incremental fuel and fodder benefits can be identified on a seasonal basis and is duly accounted for as an effect. Wherever fuel or fodder availability has decreased in a particular season, it is recorded as a cost. Further, livestock numbers seem to have decreased in Ralegan Siddhi, but milk yields have gone up more than in other watersheds.

Table 4: Effects of alternative technological and institutional scenarios

EFFECTS	UNIT	TAT-EN	TAT-WH	PIT-EN	PIT-WH	RS
ECONOMIC VARIABLES						
Bajra yld	kg/bigha	61.00	35.00	41.00	264.00	65.00
Wheat yld benef	kg/bigha	228.00	188.00	21.00	356.00	
Mustart yld ben	kg/bigha	105.00	28.00	1.0E-03	1.0E-03	
Gram yld ben	kg/bigha	111.00	60.00	1.0E-03	1.0E-03	
Livestock No.	0.44	0.67	0.60	1.0E-03	2.60	
Incr in area	bigha	1.38	1.0E-03	1.0E-03	0.75	1.51
Milk increase	lt/be/yr	936.00	178.00	1.0E-03	156.00	1050.00
Employment	dys/yr/h	75.00	142.00	41.30	41.30	105.00
Fodder (s)	benef	quintal	11.94	1.0E-03	1.0E-03	
Fodder (s) cost	quintal		-5.25			
Fodder (w) benef	quintal				26.80	
Fodder (w) cost	quintal	-1.82	-18.66	-9.20		
Fodder (r) cost	quintal	-63.65	-70.00	-1.0E-03	-1.0E-03	
Fuel (s) ben	quintal			8.30	19.50	
Fuel (S) cost	quintal	-21.17	-22.40			
Fuel (w) ben	quintal	10.56		9.90	9.90	
Fuel (w) cost	quintal		-6.00			
Fuel (r) cost	quintal	-23.25	-27.00	-1.0E.03	-1.0E.03	
Livestock decrea No.				0.48		
Jowar yield	kg/bigha					163.93
Onion yield	tons/hct					4.10
Area und hortic	hectares					26.00
Area und plt prt	hectares					220.00
Environmental Variables						
Wat tab in Raj	---/+++	+	++	+	++	0
Redn in sed yiel	---/+++	++	+	++	+	++
Roff red in Raj	---/+++	+	+	+	++	0
Flood control	---/+++	+	+	+	+	0
Wat tab in Mahr	---/+++	0	0	0	0	+++
Roff red in Mahr	---/+++	0	0	0	0	+++
Investment Costs						
Cost of eng str	RC/HC/YR	-2072.70	-3837.80			-1921.22
Cost of wat har	RC/STR	-1.2E+05		-6.9E+04		-2.6E+06
Cost of afforest	RC/HC/YR	-811.70	-811.70	-893.80	-893.80	-394.21
Participation						
People participation	---/+++	+	+	+++	+++	+++

Notes: TAT-EN : Tatarpur, the engineering option
TAT-WH: Tatarpur, the water harvest option
PIT-EN: Pithalpur, the engineering option
PIT-WH: Pithalpur, the water harvest option
RS: Ralegan Siddhi.
Each effect is identified in terms of its own units and units are given against it. All projects may n to have similar effects.

Ranking of projects

The effects table, when interpreted on the basis of the expected value method, generates scores and ranks for the five alternative being examined. The results are arrived at on the basis of:

- Different values of weights given to alternative effects, and.
- Different levels of uncertainty assigned to sets of effects.

Three sets of results are obtained with variables measuring environmental effects being given higher weightage than the same weightage as and less weightage than those measuring economic effects. These are given in Tables 5, 6 and 7 respectively.

Further, three alternative levels of effects uncertainty are taken into account. These are,

no uncertainty with respect to any effects,

a low level of uncertainty defined as follows: economic effects defined to be subject to an uncertainty level of 5%, environmental effects to a 10% uncertainty level and the variable depicting people's participation to about 20% uncertainty. Costs which were incurred in the past are, of course assumed to be known with certainty.

a high level of uncertainty, with the three sets of variables, environmental, economic and participatory being assumed to be subject to uncertainty levels of 10%, 25-30 percent and 50%.

Further, environmental effects are given, successively, higher, equal and lower weights than the economic effects.

Table 5: Ranks and scores with higher weightage to environmental than economic variables

	TAT-EN	TAT-WH	PIT-EN	PIT-WH	RS
No Uncertainty Scores Ranks	0.65 3	0.53 5	0.59 4	0.67 2	0.68 1
Low Uncertainty	2	4	3	1	1
High Uncertainty	2	4	3	1	1

With a higher weightage being given to environmental effects than to economic effects, it is found that Ralegan Siddhi with a score of 0.68 gets the first rank. Pithalpur water harvesting follows as a close second with a score of 0.6. Tatarpur engineering is third, Pithalpur engineering fourth and the water harvesting in Tatarpur appears at the fifth rank. These results also assume that there exists perfect certainty with respect to the operation of different effects.

When uncertainty at two levels, low and high, is introduced, the situation changes somewhat with Pithalpur water harvesting and Ralegan Siddhi being bracketed as first. The rest of the ordering remains unchanged. It is interesting to note that the cases of low and high uncertainty[25] yield precisely the same ordering. With uncertainty, the performance of Pithalpur, a project planned and executed by government departments improves vis-a-vis that of Ralegan Siddhi. This can be interpreted to imply that the technology there is perhaps more robust and can withstand some degree of variation in levels of accrual of benefits. Note, however, that even in the case where Pithalpur water harvesting is given a second rank, its score is very close to that of Ralegan Siddhi.

With economic variables being accorded the same weightage as environmental ones (as in Table 6), the score of Pithalpur water harvesting is 0.59, considerably lower than 0.65, that of Ralegan Siddhi, though the rank still remains at the second. Ranks of the other locational and technological alternatives are also left unaltered. The introduction of uncertainty-at two levels, low and high, improves the rank of Pithalpur water harvesting, bringing it to the first place, together with Ralegan Siddhi.

Table 6: Ranks and scores (equal weightage to all variables)

	TAT-EN	TAT-WH	PIT-EN	PIT-WH	RS
No uncertainty Scores Ranks	0.56 3	0.37 5	0.46 4	0.59 2	0.65 1
Low Uncertainty Ranks	2	4	3	1	1
High Uncertainty Ranks	3	5	4	2	1

This set of results has two implications. With a higher weightage to economic variables, the score of Ralegan Siddhi improves relative to Pithalpur. This tendency may have its origin in the more people-centered development process seen to have taken place in Ralegan Siddhi. Economic variables receive a larger emphasis in this project. Secondly, Pithalpur has an in-built capacity to cater to uncertainties. This aspect seems to be a characteristic of the designing of Pithalpur water-harvesting.

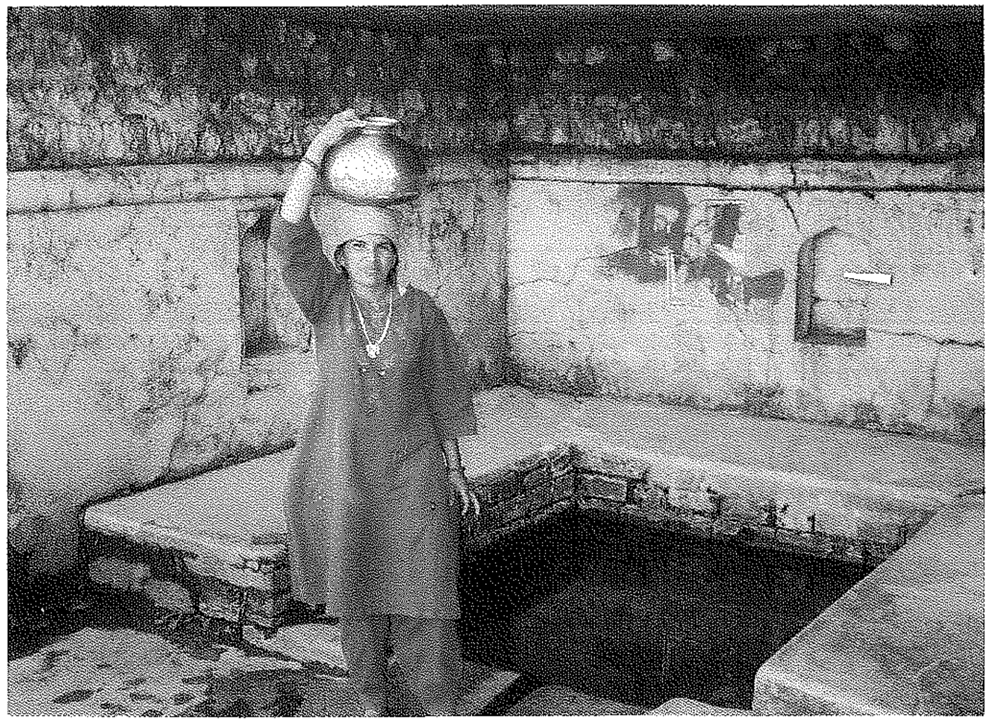
Table 7: Ranks and scores with higher weightage to economic variables

	TAT-EN	TAT-WH	PIT-EN	PIT-WH	RS
No Uncertainty Scores Ranks	0.53 3	0.27 5	0.37 4	0.53 2	0.63 1
Low Uncertainty	3	5	4	2	1
High Uncertainty	3	5	4	2	1

Table 7 gives the results with a higher weightage being given to the economic variables. The findings in this case corroborate the directional change introduced by the set in which the two sets of variables are given equal weight. Greater emphasis on the economic aspects of watershed management only reiterates the relative superiority of Ralegan Siddhi. This happens in all situations considered with respect to the level of uncertainty, whether a low level of uncertainty, no uncertainty or a high level of uncertainty.

CONCLUSIONS AND POLICY IMPLICATIONS

The main feature of developments in the last few decades in the area of watershed management has been the co-existence of government run programs based on technology emerging from pilot projects, and experiments carried out by non-governmental organizations. While the former have focused on the different possible components of the technology of watershed management, the latter have



dealt with the social and property rights aspects. In an attempt to formulate a strategy for watershed management, the present study examines both these initiatives. Due to the large variation in the situation with regard to soil and water conservation and consequently its differential effect on productivity as between different agro-climatic regions, such an examination must, of necessity, be made with reference to experiments in different parts of the country. Section 2 reviews a cross section of projects in the light of their effect on productivity and environmental preservation. The later section provide the building towards and arriving at a comprehensive approach to problems encountered in watershed management.

The key elements of a strategy with respect to soil and water conservation are technology and institutional structure. While the first addresses the issue of the best possible method of capturing runoffs and decreasing sediment yields, the second examines the issue of how best to provide for sustainability of the results achieved through an appropriate ordering of the property rights structure on privately owned, government owned and commonly owned land. In the absence of such sustainability, the productivity increases achieved through appropriate technology are often frittered away with time.

While the paper reviews and documents the experiences of a number of projects in watershed management in different parts of the country[26], the policy recommended is built up on the basis of an in-depth examination of two representative projects, the Sahibi project in Rajasthan and the Ralegan Siddhi experiment in Maharashtra.

Agricultural productivity increases in a watershed primarily when the level of moisture and top soil retained within its boundaries increases. Capture of runoff and increased agricultural productivity in the short run sets off a series of effects of both ecological and economic nature which need to be studied in order to arrive at an overall evaluation of the project. Issues regarding the long run stability of the initial increases in productivity depend on the nature of these diverse effects. The technique of multi-criteria analysis has been used in the present study for the evaluation of the programs of watershed management in the two projects, Sahibi and Ralegan Siddhi on the basis of economic, environmental, cost and participatory variables.

Four alternatives standing for different technolgies[27] and locations[28] in the Sahibi project spread over the districts of Alwar, Sikar and Jaipur are studied. Alternative institutional structures are also analyzed on the basis of Ralegan Siddhi in Ahmednagar district of Maharashtra. With assumptions of different levels of project uncertainty and different values of weights given to economic and environmental effects[29], the following results are obtained:

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- On Technology Options: Comparing Tatarpur and Pithalpur, the engineering option at Tatarpur is considered to be the best, if the policy maker considers economic effects to be of greater significance than environmental effects. This is followed by Pithalpur water harvesting. When a high degree of effect uncertainty is introduced, the two alternatives of the construction of water harvesting structures in Pithalpur and engineering structures in Tatarpur are equally attractive propositions.

With environmental effects being given higher weights and no uncertainty in the effects of the project, the alternative of water harvesting at Pithalpur gets the first rank. It is followed closely by Tatarpur engineering. The other two options are ranked third and fourth with low scores. The introduction of a low level of uncertainty does not change the ranking of the alternatives. However, if a high level of uncertainty is introduced, Tatarpur engineering is selected as the first best alternative.

- On Locational Options: A comparison between different locations is also useful. It appears that at Tatarpur, the engineering technology has been more successful than the water-harvesting technology. At Pithalpur, it is the other way round. This may be due to the locational characteristics of the two places.

In an overall comparison between all four alternatives, relative weightage given to economic and environmental variables acquires significance. The option that succeeds in building a closer integration between economic and environmental variables is preferred even when valuation is done on the basis of all effects.

- On Institutional Options: The results with respect to this are obtained by comparing five options: the earlier four together with that of Ralegan Siddhi, a project which used broadly similar technology of watershed management but operated under a different institutional regime, that of non-governmental initiative. This set of results is significant in that it compares a much cited non-governmental project with one carried out within the government sector with people's participation introduced as an important component.

With a higher weightage being given to environmental effects than to economic effects and no uncertainty assumed with respect to project effects, it is found that Ralegan Siddhi gets the first rank. Water harvesting in Pithalpur follows as a close second. Tatarur engineering is third, Pithalpur engineering fourth and the water harvesting technology in Tatarpur appears at the fifth rank. When uncertainty at two levels, low and high, is introduced, the situation changes somewhat with the first two projects being bracketed together. The rest of the ordering remains unchanged.

It is interesting to note that the case of low and high uncertainty[30] yield has precisely the same ordering. With uncertainty, the performance of Pithalpur, a project planned and executed by government departments improves vis-a-vis that of Ralegan Siddhi. This can be interpreted to imply that the technology adopted therein is perhaps more robust and can withstand some degree of variation in levels of uncertainty. Note ,however, that even in the case where Pithalpur water harvesting is given a second rank, its score is very close to that of Ralegan Siddhi.

The findings in the case where a greater emphasis is placed on the economic aspects of watershed management only reiterate the relative superiority of Ralegan Siddhi. This happens in all situations, irrespective of the level of uncertainty.

This set of results has two implications. With a higher weightage to economic variables, the score of Ralegan Siddhi improves relative to Pithalpur. This tendency may have its origin in the more people-centered development process seen to have taken place in Ralegan Siddhi. Economic variables received a larger emphasis in this project, mainly on account of its people's orientation. Secondly, an inbuilt capacity to cater to uncertainties seems to be more in the designing of Pithalpur water harvesting. The findings of this study indicate the building blocks for policy formulation.

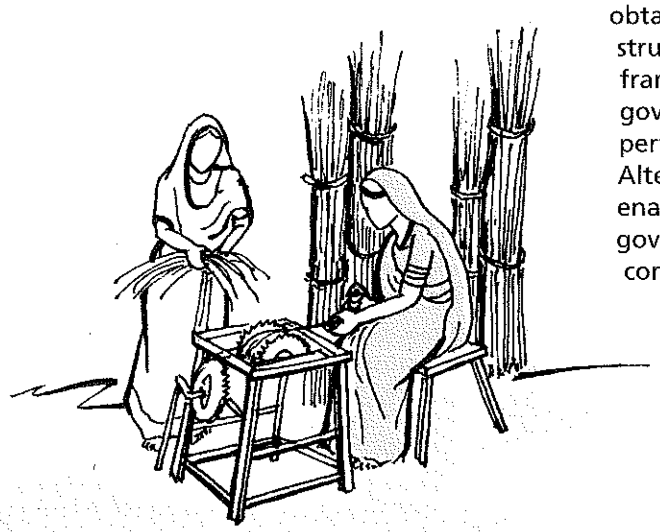
The watershed comprises the appropriate unit for planning projects on degraded land, primarily because externallyeffects of soil and water movements between watersheds are limited in comparison with those within watersheds. This may imply some initial work with respect to arriving at correspondences between administrative units such as villages and talukas and the relevant watersheds but will ensure sustainability of the environmental and consequently the economic benefits.

The comparison across projects and the ranking obtained as a consequence suggest that the components of technology are location specific. While engineering methods (such as check dams, retaining walls, etc.) may comprise the better option in some cases, water-harvesting in larger tanks may be the option preferred in some others. It can be concluded that the policy needs to be implemented in a decentralized fashion with considerable inputs from the local level.

Vegetative measures, (both afforestation and plantation of grasses controlling erosion on field boundaries) must be an integral part of all technology. They are cost-effective, increase the seasonal availability of fuel and fodder and comprise an important economic benefit from the people's view point. These can easily be treated as complementary with the other two components, engineering and water-harvesting.

Further, the levels of certainty with which project effects can be expected to accrue is significant in determining the ranking of the project in terms of its performance. Here, the range of technology available with government organizations as a consequence of experience in diverse environments puts them at an advantage as compared to non-governmental organizations. This advantage needs to be capitalized on.

Policy also needs to take cognizance of the wealth of experience now available in the non-governmental sector. In some sense this has already been done by stressing the people's participation aspect of all government projects. Except in some projects, however, this is done in a somewhat superficial manner. A method has to be found which ensures that the best of the two sectors is brought together in the execution of projects, in particular those impinging on private, common and forest land as in a watershed. The results obtained on a comparison of different institutional structures reveal that whereas the non-governmental framework performs better than run-of-the-mill government projects, the latter set-up can approximate the performance of the former with some ingenuity. Alternatively, the government can take on the role of an enabler in the dissemination of technology to the non-governmental sector. The best of the two sectors has to come together to make a success of this important policy initiative. This is significant in the context of the tremendous input of organization required in order to set in motion a large scale program of watershed management, which alone will have perceptible economic and environmental effects.



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APPENDIX I: BACKGROUND OF SAHIBI PROJECT

Background

The Sahibi river catchment was taken up under the centrally sponsored scheme of integrated watershed management in the catchment of the flood prone rivers on the recommendation of the working group set up by the Government of India for flood control in Indo-Gangetic Basin. This catchment was taken up under the centrally sponsored scheme of integrated watershed management in the catchment of flood prone rivers in 1983-84 and was to be implemented by the Forest Department of the Government of Rajasthan. The main objectives of the project are:

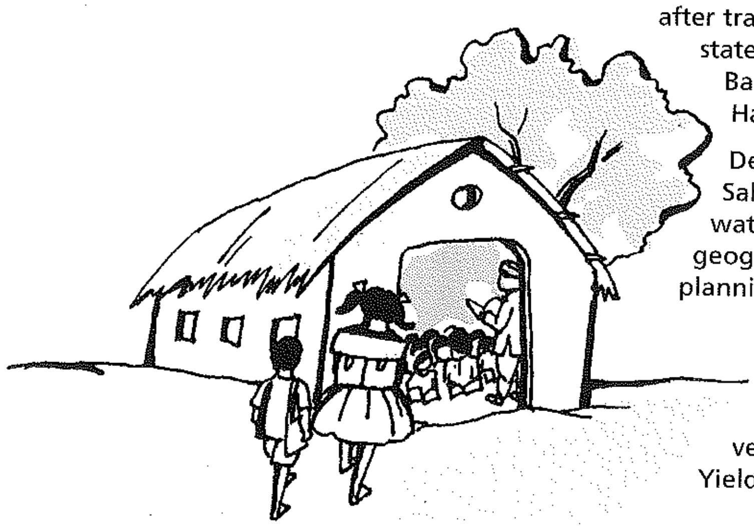
- To reduce flood hazards in the catchment area of Sahibi river and.
- To reduce silt flow in the main river thereby increasing the life span of the Masani Barrage downstream.

The series of engineering, afforestation and vegetative measures undertaken as a part of integrated watershed management are directed towards the achievement of these ecological objectives. They have, in addition, a number of important effects on livelihoods of the people of the region. The catchment area of Sahibi river lies between 75° 45' and 77 latitude and 27° 15' to 28° 15' longitude. It consists of 7 sub catchments, 27 watersheds and 206 sub-watersheds in Rajasthan and covers parts of Jaipur, Alwar and Sikar districts in Rajasthan as seen in Table A 1.

Table A1: Districts and Tehsils under Sahibi catchment in Rajasthan

S. No.	District Name	Tehsil
1	Sikar	Neem ka Thana and Srimadhopur
2	Alwar	Bansoor, Mundawar, Kishangarwas, Tijara and Behror
3	Jaipur	Virtnagar and Kotputli

The total area of the catchment is 4, 57, 768 ha, divided into watersheds, sub-watersheds and micro watersheds. In Rajasthan, it is drained by Shabi and Sota tributaries. These two streams join to form the Sahibi River near Jalalpura after traversing a distance of 75 kms. After crossing the state boundary, the Sahibi drains into the Masani Barrage situated near National Highway No. 8 in Haryana state.



Detailed integrated watershed management in the Sahibi catchment is being carried out on micro-watershed basis, though a sub-watershed is the geographic unit for survey, priority delineation, planning and execution of soil conservation measures. These micro watersheds vary in area from 500 to 1000 hectares. The All India Soil and Land Use Survey, (ALSLUS) has categorized watersheds in the basin into very high, high, medium, low and very low priority watersheds on the basis of the Silt Yield Index (SYI) method. The number of watersheds falling in each category and the area they cover is indicated in Table A2. The watershed