

Water and Watershed Management in India: Policy Issues and Priority Areas for Future Research

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Abstract.—India's present food requirements of 220 million tonnes will likely increase to 340 million tonnes in 20 years. Expansion in the agriculture sector to meet these demands can be achieved only by devoting greater attention to restoring watershed lands previously degraded by excessive soil erosion to higher productivity and more efficiently utilizing the country's water resources. This challenge is intimately related to the proper management of land, water, and vegetation resources. Management of water and, more comprehensively, watershed resources is paramount to meeting this challenge. Water and watershed management in India are reviewed in this paper within the context of relevant policy issues and priority areas for future research endeavors.

Introduction

India is the seventh largest and second most populous country in the world. Bounded by the Himalayas in the north, the country stretches southwards and, at the Tropic of Cancer, tapers off into the Indian Ocean between the Bay of Bengal on the east and the Arabian Sea to the west. India has an estimated 1 billion people, which is expected to increase to 1.1 billion people in 10 years. With the growing human population and, concurrently, improvements in their consumptive levels, it is estimated that the country's present food requirements of 220 million tonnes will increase to 340 million tonnes in 20 years. Expansion in the agriculture sector to meet these demands can be achieved only by devoting greater attention to restoring watershed lands previously degraded by excessive soil erosion to higher productivity and more efficiently utilizing the country's water resources.

The challenge of restoring degraded lands, preventing soil erosion, and sustaining or, wherever possible, improving the availability of water resources is intimately related to the proper management of land, water, and vegetation resources. Management of water and, more comprehensively, watershed resources is paramount to meeting this challenge. Water and watershed management in India are reviewed in this paper within the context of relevant policy issues and priority areas for future research endeavors.

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Foreign-Assisted Projects

India has a long history of foreign-assisted watershed management projects. These projects have helped the country develop its water and watershed resources include agriculture, livestock, and forestry, and have helped foster the incorporation of watershed management contributions into better stewardship of the country's resources.

Examples

The World Bank assisted Integrated Watershed Development Project (Hills) was initiated in 1991 to lower ecological degradation by promoting sustainable rain-water conservation measures and diversified agricultural production system. This project was designed to address the integrated development of hilly areas, especially of ecologically degraded Shivalik, Karewas ranges in Haryana, Himachal Pradesh, Jammu-Kashmir, and Punjab for a period of seven years; it was subsequently extended to June 1998.

The European Economic Community-assisted Bhimtal Integrated Watershed Management Project was launched in 1991 to halt deforestation and help soil protection in the hilly districts of Uttar Pradesh, which are subjected to local ecological degradation; and to meet needs of local people for fuel, fodder and timber in an ecologically sustainable manner. The Doon Valley Project assisted by European Economic Community was initiated in 1993 to arrest and, as far as possible, reverse on-going degradation of the Doon Valley environment.

The Indo-Swiss Participatory Watershed Development Project, Karnataka, was implemented in December 1995, and continued to March 1998 under support from the Swiss Development Corporation. Under the people's action for watershed management initiatives, Rajasthan, with Swiss Development Corporation support in the first phase (1996-1999), an area of 15,000 ha in the Districts of Chittorgarh and Alwar has been designated to community development. With two NGOs to facilitate planning and execution of the project an area of 1,524 ha has been developed to date.

A German Kreditanstalt for Wiederaufbau (KFW) assisted Watershed Management Project is being implemented in Karnataka to restore 53,633 ha of degraded land. The program was implemented in August 1996 with the active participation of six NGOs, and will continue to the year 2002. KFW assisted watershed management in Maharashtra was implemented through NABARD in April 1992, again, with active participation of NGOs. A project on institutional capacity-building is underway through NGOs working with KFW for replication of watershed management, with a total project cost of Rs. 251,000. The project will create institutional framework for watershed management in cooperation with NGOs.

A DANIDA aided comprehensive watershed management project, Tirunelveli, Tamil Nadu, was launched in 1990-91 to arrest further erosion of badly degraded watershed lands; and to develop sustainable and cost-effective utilization of several types of land to create long term employment opportunities for marginal farmers and landless agricultural laborers. Main components of the project are survey, extension and training, planting of shelterbelts, establishment of demonstration plots, and study tours.

A comprehensive watershed management project, Ramanathapuram, Tamil Nadu, another DANIDA aided project, was launched in 1994-95. The objectives of this project are to enable land-users in priority watersheds to practice dryland agriculture, range management, horticulture and forestry including conservation and use of natural resources on a sustainable basis. Another comprehensive watershed management project, Karnataka, again aided by DANIDA, was launched in 1990-91 to develop an appropriate land-use system through soil and moisture conservation activities; to establish tree plantation to increase the overall production in the area; and to improve the living conditions of landless, small holders and especially rural women, by increasing production of fodder, wood and minor forest products on waste lands.

A comprehensive watershed management project, Korapur, Orissa, aided by DANIDA, was launched in 1993-94. The objectives of the project are to establish sustainable and locally acceptable land-use system which are sustainable and ecologically sound. The land-use systems would enable the poorer rural communities to improve their living conditions and their supply of food, fuel and other essentials without exploiting the natural resources to harmful stress. Another comprehensive watershed management project, Madhya Pradesh, approved by DANIDA is being implemented from March 1997 for a period of five years and covers about 1,34,000 ha area in Jhabua, Dhar, Rathlam, Districts of Western Madhya Pradesh.

Lessons Learned

Lessons learned from foreign assisted watershed management projects indicate that sustainability of watershed management is possible only through peoples' participation. Therefore, to ensure people's participation and cost sharing, project priorities have to be demand-driven with sufficient flexibility. Capacity-building for technical competence of project staffs, all stakeholders from the Government of India (GOI), NGOs, and the beneficiaries for institutional development should start from the planning stage and should be a continuous process. Importantly, the role of women is crucial in watershed management, as demonstrated by the contributions of women to projects in Himachal Pradesh and Rajasthan, and also in tribal districts of Orissa.

Collaboration among donors, and donors with GOI-state governments and NGOs should be established to develop complementarity and uniformity among programs; monitoring and evaluation by independent agencies should be a part of the project activity; and if poverty alleviation and equity are the objectives of a project, the scope of the project should be widened to include infrastructure facilities and other support activities based on local potential, and the approach should be the development of a defined area on watershed basis.

Drought Mitigation Projects

Of special concern to watershed management in India is the occurrence of droughts. The first tract of drought comprising the desert and semi-arid regions in India, approximately 60 million ha in extent, forms a rectangular from Ahmedabad to Kanpur on one side and Kanpur to Jalundhar on the other. Rainfall in this region is less than 750 mm and at some places less than even 400 mm. Some of the areas in this region where irrigation is not provided, are among the worst drought affected tracts of country.

The second tract comprises of the regions east of the Western Ghats to a width of about 300 km known as the shadow areas of the Western Ghats. Rainfall in this region is less than 750 mm and highly erratic. This area is heavily populated and, therefore, the periodic drought conditions cause considerable suffering and damage. This region is bounded on the south by a line passing from Madhya (Karnataka) to Chittor (Andhra Pradesh) and on the coast by a line passing from Chittor to Tapi Basin. The Eastern Ghats are low and highly broken up in the Krishna Basin, and the semi-arid region extends along the Krishna River to within 30 km from the coast. This region is 37 million ha.

Besides the two principal areas indicated above, there are pockets of drought in several parts of India. Some of these are Tirunelveli District, south of Vaigai River, Coimbatore area, Saurashtra and Kutch regions, Mirzapur plateau and Palamau regions, Purulia District of West Bengal, and Kalahandi region of Orissa. The scattered packets total about 10 million ha.

Drought Characteristics

The chief characteristics of drought are associated with a decrease of water availability in a particular period and over a particular area for specific use(s). To a hydrologist, drought can mean below average content in streams, reservoirs, lakes, tanks, groundwater aquifers, and soil moisture. Drought means a prolonged shortage of soil moisture in the crop root-zone to an agriculturist. The meteorologist is concerned with drought in the context of a period of below normal precipitation, and the economist is concerned with drought in the context of a period of low water supply which affects society's productive and consumptive activities.

Droughts have the four components of magnitude (average water deficiency), duration, severity (cumulative water deficiency), and frequency. Another aspect of drought is its beginning and ending. Since drought is a creeping phenomenon, making an accurate prediction of either its onset or end is a difficult task. To most observers, drought seems to start with the delay in the timing (or failure) of the rains. The commencement of hydrological drought can be delayed because of the damping effect of groundwater reserves which continue to support water flows, at least for a while after the cessation of the rainfall. It is easier to determine the end of drought, particularly when abundant rainfall saturates the soil mass, raises the flows, reservoir levels and groundwater tables.

India has witnessed consecutive droughts in the year 1985-86 and 1986-87, during which country has suffered heavily. In the drought of the year 1985-86, about 260 districts, 1,490 lakh population, and 435 lakh ha cropped area were affected; the situation was similar in 1986-87. The increasing rate of the annual expenditure on natural relief in the country is indicative of the increased incidence and recurrence of the natural disasters. The extent of damages caused by drought can be assessed from the shortage of water for domestic and livestock demands, scarcity of fodder, reduced agricultural production and the assistance sanctioned by the center or state governments for drought relief. During the years 1985-86 and 1986-87 alone, over Rs. 10,000 crores were provided as central assistance as against much smaller amount provided during early plan periods; this indicates the impact

of droughts of 1985-86 and 1986-87 on the economy of the country.

Studies of Drought

A major problem involved in studies of drought and its management is that data required for drought studies are collected by different agencies. Generally, the coordination among these agencies is not to the desired extent, and as a result the information needed for planning effective strategies is not available at one place. It is necessary, therefore, to have integrated country-wide hydrological monitoring system. Such an integrated system will need to monitor all data concerning hydrological variables, water use statistics, catchment details, and socioeconomic data.

A difficulty arises in analyzing drought is due to the fact that drought occurrence depends on the interaction between the natural occurrence of hydro-meteorologic factors and the intended use of water. Different perceptions of drought from the view-points of meteorologist, agriculturist, and hydrologist is an example of this difficulty. There is a need to develop drought indices integrating the different perception of drought.

Remote sensing plays important roles in the study of drought, particularly for prediction of drought to estimate soil moisture status, evaporation rates, and biomass levels. Studies involving remote sensing techniques can be carried out and, accordingly, drought management strategies planned.

In view of frequent occurrences of drought in recent years, and considerable damages incurred as a result, attention has been directed to more careful planning for future droughts. It is in this direction that comprehensive drought response plans have been prepared in various countries throughout the world to reflect the water supply characteristics, problems of the states and potential impacts; there is a need to formulate such plans in India also. In developing such plans, it is important to identify the activities, which have relatively more importance from water availability point of view.

A number of measures based on increasing available water supplies and reducing demands, or to minimize impacts must be taken to mitigate drought consequences. All of these measures have varying degrees of effectiveness relative to the circumstances of each drought. Experiences gained from the occurrences of drought in the past might be utilized to form a judicious combination of measures, which can be helpful for mitigating the future drought and their consequences.

Water conservation needs more emphasis so as to augment existing water supply and avert critical water short-

age. Water conservation campaigns through education and information dissemination are necessary to create awareness in the users, and make adoption of water conservation measures a success by inducing social acceptability; this is by far the most vital of all the means to alleviate drought problem.

Policies to Deal with Drought

During the early part of post-independence era, emphasis was placed on relief works for minimisation of impact of droughts. These programs include remission of land revenue, streamlining, communication, and providing employment through relief works and irrigation facilities. The Irrigation Commission (1972) accorded high priority to the development of irrigation facilities in drought-prone areas. The Drought-Prone Area Program was launched by the GOI in 1973 to reduce the impact of severity of drought, and to provide employment in drought-prone areas. A program for Minor Irrigation Works has been underway since 1983-84 under centrally sponsored small and Marginal Farmers Assistance Program.

For inter-basin water transfer, the idea of National Water Grid, was mooted by Rao and Kathuria (1992), who proposed to provide a Ganga-Cauvery link. This proposal involved net power requirements of 5 kw, which the country could not afford; the proposal, therefore, was not considered. Captain Dinshah Dastur presented a proposal for Garland Canal Scheme. Although in concept it was interesting, it was technically unsound and economically prohibitive. Hence, this proposal was also dropped. The Ministry of Irrigation, presently the Ministry of Water Resources, evolved a National Perspective Plan in 1980 for creation of optimum storages linking various river systems to provide multi-purpose benefits.

The National Perspective Plan envisages a broad approach to the existing uses, to allow normal water development under existing legal and constitutional framework to meet reasonable needs of the basins and the states for the foreseeable future; this would help achieve the most efficient use of land and water to plan optimum development of available storage sites, and to transfer over long distance by linking various systems so that drought affected and backward areas are assured a minimum supply of water. As a first step towards taking up the National Perspective Plan, a center has set up a National Water Development Agency to undertake detailed surveys and investigations to determine the feasibility of the proposal of Peninsular River Development, and prepare reports of various components of the scheme.

Commenting on the National Perspective Plan, Rao (1981) observed that the cost of Rs. 500 billion for the

project, though a great under estimate is too astronomical and astounding for the country; the expenditure involved is too high in relation to the benefits of irrigation, power generation, etc. He suggested various water management measures such as increasing irrigation efficiency, implementing water harvesting, installation of pump canals, changes in cropping patterns, and adoption of dryland technologies to bring more benefits that envisaged in the perspective plan without legal, constitutional or social problems.

It has been proposed that a Drought Mitigation Program should be launched to mitigate the impact of drought over a period of time, to optimize the utilization of all resources for crop production in the areas, and to improve the living standards of the rural poor suffering the catastrophe. Development strategies should be aimed at removing regional imbalances in the country by improving the overall productivity and restoring a proper ecological balance to the drought-prone areas through development and management of irrigation sources; initiating soil and water conservation and afforestation programs; modifying the cropping pattern and pasture development, livestock development; and development of small and marginal farmers. A critical assessment of prevailing water use policies and practices at various levels and for various purposes is needed for developing guidelines for better use as part of the overall development strategy. The roles of information and communication technology need to be acknowledged for disseminating information and knowledge regarding the existing status, problems, and opportunities for improving the management of India's scarce water resources. The GOI should examine various alternative plans for inter-basin water transfer in close co-ordination with state governments to finalize most feasible plan considering economical, social, environmental, technical and other factors.

Socioeconomic Development Programs

Activities presently undertaken in watershed management projects for the poor and women do not empower them to be equal partners with men. Unless we progress from the attitude that the poor and women are to be treated as disadvantaged to the point where they are treated as integral members of the community, and involve them in decisionmaking, watershed management projects will continue to remain welfare-oriented as far as the poor and women are concerned.

Women are disadvantaged because their contribution to the rural economy is not recognized. Consequently,

they do not receive their rightful compensation in terms of wages, or in terms of ownership of productive assets and benefits accrued from them. The importance of increasing women's participation in watershed management projects has been recognized, and efforts are being made in this direction. However, there is still a need to sensitize policy-makers and the staffs of project implementing agencies (PIAs) to understand the core issues related to ensuring benefits to poor and women from watershed management projects.

Main Issues

Programs for agriculture development have always targeted men rather than women, since women are rarely looked upon as farmers. In watershed management, too, it is the farmers who first come forward to participate in the programs. Women perform more tasks and spend more hours than men in agricultural production; we need to recognize that they are farmers, too. Since women rarely own or control productive assets, they are not looked upon as decisionmakers in the management of natural resources. Common-property resources provide women with livelihood options that are not always visible. Restrictions on access to common-property resources increases drudgery in fuel and fodder collection, and reduces the livelihood options available to women. An assessment of the interface between livelihoods and the resource base would help to keep in focus issues related to the economic survival of women resource users, through both the planning and implementation stages of the project.

The number of women appointed to Watershed Committees has been largely token, since one or two women on male dominated committees are unable to effectively contribute to the decisionmaking process. Besides, one or two women from the community usually do not represent the interests of all the women in the community. Women-area heterogeneous group, and women from different sectors of the community have different needs. Women are often unable to participate in community activities without the support of their families. It is the responsibility of the PIAs to facilitate the participation of women in community activities by setting up support systems. It is also important, therefore, for the PIAs to have specially trained staff.

Since watershed management has a central technical component, it is important that women are also given technical training, so that they have the option to move up in the decisionmaking hierarchy set up for the implementation of projects. Another important area that needs to be looked into is that of equity issues in wage employment in watershed management programs. Disparities are found in wages paid to men and women for agricultural labor and physical works undertaken in the project. Gender

disparities also arise from the unequal distribution of ownership and control of productive assets between men and women. If decisions related to access and sharing of resources remain in the hands of men, it is likely that women will never receive their share of benefits from these resources. It is difficult to address issues related to inter-household benefit sharing, but attempts can certainly be made to improve intra-household benefit sharing for women through community projects.

Recommendations

Watershed management projects should be implemented in two stages. During the first stage, the PIAs should understand the community, conduct a livelihood-resource survey, and build women's organizations. The budget provided for entry-point activities could be used for this. In addition, some extra budget could be provided for capacity-building for PIAs' staffs. The second stage should consist of the implementation of project activities. The implementation should be performance- and target-oriented, with monitoring and evaluation being an integral part.

Proposals submitted by the PIAs should indicate how under-privileged and women's issues will be addressed, and what should be the indicators of success for the integration of gender in the program. The budget available for activities for women is normally only a small percentage of the total budget. Therefore, funds should be available for strengthening women's groups. Livelihood options should be provided to women through appropriate income generating activities. To create an environment for, and facilitate the participation of the poor and women in village-level committees, the representation of women should be made 50%. Capacity-building for PIA staff, village leaders, motivators, and committee members should be emphasized.

Opportunities For Future Programs

Since the end of the 1970s, important changes of a positive nature have taken place in India regarding soil and water conservation policies. These changes came as a result of an increase in the awareness at the high decisionmaking level towards the seriousness of the country's erosion problems and the urgency to solve them. However, a greater effort is needed in terms of improving the institutional weaknesses and capacity-building; spe-

cial emphasis has been placed on building the capacity for effective watershed management programs.

Capacity Building

Human resources development (HRD) is one of the important approaches in watershed management. It is essential for effective and sensitive implementation of the watershed management; more successful experiences in India illustrate that HRD and institutional capacity-building is a critical factor for peoples' participation and sustainable development. In the last 50 years experience of soil and water conservation in India, capacity-building means that the competence of individuals and organizations are augmented to enable those implementing watershed management projects to work together responsibility. Similarly, capacity-building means that individuals and institutions supporting the watershed project are enabled to facilitate project implementation sensitively and become more responsive and flexible in delivering services.

Capacity-building can be considered in three categories. *Individual capacity-building* deals with knowledge, attitude, technical, managerial, and participatory skills, and job-related, field-oriented operational skills which are crucial for all implementors and individuals at whatever level they work; these cut across all types of organizations. Organizational capacity-building is necessary whether it is a government department, NGO, or any other organization. For an organization to become more effective and have better capabilities, all individuals should go through individual capacity-building within the organization. Internal management procedures should be revamped and improved as necessary to make them more flexible and responsive in the light of the aim of capacity-building in watershed management; this includes the whole gamut of human-resource management policies starting with recruitment, placement, promotions, and incentives, and organizational restructuring of the organizations. Institutional capacity-building is also important, since institutional arrangements need to be improved to support both individuals and organizations to deliver whatever needed services. These improvements can be done through linkages and coordination mechanisms, setting up new institutions, technical and financial support and enabling policy environment.

Key Issues

The key issues (questions) in capacity-building are whether the present balance between "hardware" and "software" of watershed management projects is appropriate in terms of allocation of time, funds, manpower and attention; and whether everyone agrees on what

needs to be done for improving the quality of watershed management. It should be kept in mind that scaling-up involves massive reorientations of the government and other development agencies, considering that the strategies should be adopted to make the best use of training infrastructures, facilities, and training materials and methodologies; and that the roles played by the GOI, state governments, NGOs, and donors in this strategy be known.

Future Directions

Future directions of capacity-building can be viewed at watershed, district, state, and national levels. At the *watershed level*, PIAs should focus on the capacity-building needs of the watershed communities and follow a bottom-up, demand-based, step-by-step approach. PIAs should also expand the scope of capacity-building for watershed communities to cover integrated water-use management, animal husbandry, horticulture and other production systems, and land-use systems to improve livelihood sustainability. PIAs should use progressive farmers-villagers as resource persons and pay for their opportunity cost to develop them as a sustainable alternative.

Need-based exposure visits to successful watershed management projects should also be organized. PIAs might draw upon other project staffs or district-level training centers for resource persons. Specialized need-based packages should be developed for local Water Associations and Watershed Committees. And, importantly, the village watershed communities should be involved in developing and monitoring their own monitoring and evaluation indicators.

Attempts should be made to use progressive PIAs as exposure centers and resource persons for the sustainability of capacity-building at the district level. Orientation programs should be run for the Panchyat Raj institution functionaries to enlist their cooperation. District authorities should act as a clearing house for information, support and coordination of training centers, resource persons, and materials and methods within the district, and coordinate all activities at the district level.

State governments should play a lead role in coordinating the efforts of state training institutions, support NGOs in identification of training needs at the *state level*, upgrade and equip training infrastructures, develop faculty skills, and ensure synergy and optimum capacity utilization. State governments need to make sure that all key functionaries at the state and district levels are fully sensitized and trained. State training institutions should run only orientation and sensitization programs for senior officials at their headquarters.

Guidelines at the *national level* need to be amended to incorporate more comprehensive watershed-based development, which is likely to lead to more sustainable

rural livelihood. Attempts should be made to amend these guidelines to provide for a discrete second stage of capacity-building for the PIAs in the project approval cycle; this might slow down the program but would ensure quality and more sustainable development. Participatory mechanisms should be set up for thorough reviews of the guidelines to incorporate earlier experiences. Capacity-building coordination units need to be strengthened to enable them to play the critical role of clearing house in the capacity-building sector.

Education and Training

Watershed management is not presently included as a separate specialization in formal courses in India. It is, however, being increasingly covered in undergraduate and post-graduate courses. Opportunities are generally offered at agricultural universities, with courses offered on soil conservation and watershed management by faculties of agricultural engineering, agronomy, and soil science; at IIT, Kharagpur, through the Departments of Agricultural Engineering and WTC of IARI; at engineering universities, like Roorkee through the Department of Hydrology and Water Resources Development Center; and at IARI, Delhi, IIT Kharagpur, University Roorkee, IIM, Ahmedabad, Anna University, Guindy, and agricultural universities.

In the absence of facilities with formal educational institutes, SCB created facilities and offered foundation courses in watershed management in the early 1950s. These courses were designed to inculcate multidisciplinary perception and on-the-job competence to the officials of the Departments of Soil Conservation, Agriculture, Forests, Agricultural Engineering, and Land Development Corporations. The courses covered elements of watershed management from the broad-subject matter areas of soil and water conservation including agro-meteorology, watershed hydrology, and sedimentation; to soil science and land-use survey, including aerial photo interpretation, land evaluation, and amendments for reclamation conservation cropping; to conservation techniques involving agroforestry, agrostology, and horticulture; and to conservation forestry, farm forestry, fuel and fodder production, and pasture development.

These courses, for durations of 3 months to one year, include classroom discourses; field practicals; project-oriented work covering investigation, surveying, and

planning; and study tours to acquaint the participants with diverse problems in different soil and water conservation regions and with indigenous variations in remedial measures.

Summary

The major objectives of watershed management programs in India are to retard environmental degradation to permissible limits, and to increase biomass production to optimum levels. Meeting these two objectives help in achieving sustainable overall production on watershed lands. However, there is large variability in the types of biomass, degradation and biological factors, and their interactions. For a successful management strategy, it is necessary to understand and quantify these interactions in space and time. Experiences over last five decades in watershed development, water management, and biomass production are exhaustive. But, most of these experiences are the outcome of sectoral and short-term goal-oriented programs, which are incompatible to the sustainability concept; or, are not pursued enough to result in their acceptance and adoption by people. There are a few field-level successes which hint at the need for a change towards people-oriented programs in watershed management for achieving sustainability of these programs; however, this calls for reorienting our research approach to fulfil this gap.

Major research issues to be addressed in developing appropriate implementation procedures and activity schedules for watershed-based development and management include tools for measuring the overall degradation of natural resources; methodologies for assessing biomass production through a single index; models for determining temporal-water availability on watersheds; tools and models for assessing water requirements of plants on watershed lands; detailed analyses of farming systems and their development in relation to environmental sustainability; analyses of irrigation systems in relation to water availability potentials and management; prescribing energy management practices through systems analysis approaches and mechanization; evaluating the impacts of use of inorganic fertilizer, insecticide, pesticide and imported water on natural resources and environment; and developing measures of the socioeconomic status of the inhabitants of watershed lands.

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Literature Cited

- Irrigation Commission. 1972. Report of the Irrigation Commission. Volume I.
- Rao, A. N., and K. K. Kathuria. 1992. National water resources policy - future development Needs. In: Proceedings of the Seminar on Irrigation Water Management, Delhi, March 1993. Volume I, pp. 52-64.
- Rao, K. L. 1981. Water world. Volume III.