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GLOBAL WARMING, VULNERABILITY OF WATER RESOURCES & COMMUNITY LEVEL ADAPTATION PRACTICES IN INDIA

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INTRODUCTION

The IPCC Second Assessment Report (1995)[1] brings out Sensitivity, Adaptability and Vulnerability of ecological and socio-economic systems - including hydrology and water resources management etc. to climate change. Human induced climate change represents an important additional stress on many ecological and socio-economic systems, already affected by pollution, increasing resource demands, and non-sustainable management practices. Article 2 of the UNFCCC explicitly acknowledges the importance of natural ecosystem, food production, and sustainable development.

The most vulnerable systems are those with the greatest sensitivity to climate changes and the least adaptability.

Sensitivity is the degree to which a system will respond to a change in climatic conditions e.g., the extent of change in ecosystem composition, structure and functioning including primary productivity, resulting from a given change in temperature and pptn.

Adaptability refers to the degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of change in conditions.

Vulnerability defines the extent to which climate change may damage or harm a system. It depends not only on a system's sensitivity but also on its ability to adapt to new climatic conditions.

Both the magnitude and the rate of climate change are important in determining the sensitivity, adaptability, and vulnerability of a system.

Vulnerability increases as adaptive capacity decreases

The vulnerability of human health, socio economic system and to a lesser extent, ecological systems - depends upon **economic circumstances** and institutional infrastructure. This implies that systems typically are more vulnerable in developing countries where economic and institutional circumstances are less favourable. People who live on arid or semi-arid lands, in low-lying coastal areas, in water limited or flood prone areas, or on small islands are particularly vulnerable to climate change. Some regions have become more vulnerable to hazards such as storms, floods, droughts as a result of increased population density in sensitive areas such as river basins and coastal plains.

Models explore potential global impacts. However, assessing the regional impacts is very difficult, in particular it is expected that climate change will not be a gradual process, but will come through extreme weather events and their impacts. Such human induced activities mean that a phenomena like desertification is more likely to become irreversible, especially with a drier environment and further soil degradation through compaction and erosion. Nonetheless, vulnerability to climate change is not simply a question of potential physical impacts; **it is a question of the ability of the country, its institutions and community to anticipate and respond effectively to the adverse impacts.**

State of Economy and Vulnerability

The stronger the economy and institutional capacity, the greater the resilience and adaptability to climate variability. It is important to evaluate. It is well admitted that wealthy and industrialised countries will be better situated to cope with climate change, as they have already demonstrated with extreme climate events.

Poverty increases vulnerability

A very large percentage of population in the developing countries like India lives below the poverty line. Poverty automatically makes such countries and people vulnerable to the adverse impacts of climate change. In addition lack of resources - both finances and technologies and capacity in addressing to the adverse impacts of climate change make the developing countries like India much more vulnerable as well as to adaptation to climate change. The situation is much worse in regions in India where such resources are already under stress even without the climate change - be it be water, agriculture, forestry **or human health.**

[1] *Intergovernmental Panel on Climate Change (IPCC), Second Assessment Report on the Impacts, Adaptation and Mitigation of Climate Change, WMO / UNEP, 1995*

[2] *Climate Change Science : An Analysis of Some Key Question, National Research Council, National Academy of Science, Washington, D.C,2001*

Even if vulnerability is delineated and impacts are assessed in specific regions of the country, but adaptation to such changes is not an easy process in poor countries. The main barrier is availability of financial resources to meet high costs of adaptation. However in affluent countries, the situation is quite different. In a recent report released by the US National Academy of Sciences on "Climate Change Science : An analysis of some Key Questions",[2] the key conclusion is that US society is likely to be able to adapt to most of the climate change impacts on human systems, but these adaptation may come with substantial cost.

INDIA'S VULNERABILITY TO GREENHOUSE GAS INDUCED GLOBAL WARMING

The vulnerability of the Indian sub-continent to the impact of climate change is most relevant in the tropics, for the majority of people in India and its neighbouring countries depend on agriculture for their livelihoods and the agricultural production depends a great deal on the Asian Summer monsoon and its variability on a variety of time scales.

A study of the rainfall data from 25 meteorological sub-divisions of India for 81 years (1875-1955) did not reveal any major changes in rainfall, except the bulk of the rainfall over India shows a pattern similar to that of the annual rainfall. However analysis has revealed an increase in the mean annual surface temperature over India. The relative dominance of the increased concentrations of greenhouse gas, as a result emissions of ghgs from fossil fuel burning, deforestation and land use change in India, as in the rest of the world, may have contributed to the observed temperature trend. Based on atmospheric General Circulation Model projection, the best estimate of surface warming for the IPCC's B-a-U scenario is warming of 1 to 2^0C over the Southern Asian Region by the year 2030. The precipitation changes over South Asia are likely to increase throughout the region by 5 to 10% in Summer, while marginal changes are expected during winter. The projected largest warming of > 3.5^0C occurs over the north west particularly over Rajasthan and adjoining areas. Relatively uniform warming of approximately 2.5^0C occurs over both the Arabian Sea and the Bay of Bengal. The most pronounced greenhouse gas induced warming over the land mass of the Indian sub-continent is expected to be during the pre-monsoon season. The simulated changes in annual as well as seasonal surface temperature over the entire study area are found to be statistically significant at 95% confidence level.[1]

Vulnerability of Indian Coasts to Sea Level Rise (SLR) due to Greenhouse Gas induced Global Warming

Global Warming is expected to melt the polar ice caps, and land ice and glaciers and increase water-level in the oceans. In addition warming of the sea water due to global warming will also add to the sea level rise due to thermal expansion.

India has a long coastline - the total length of the coastline of the India maintained is 5700 km (from the Sunderbans in West Bengal to Rann of Kutch in Gujarat) - however with the coastlines of Lakshadweep and Minicoy and the Andaman and Nicobar Group of Islands are taken into account, the total Indian coastline comes to over 7510 km.

Some studies conducted recently,[2,3] reveals that most of the coasts in India are vulnerable to sea level rise due to climate change - the very high risk coastal zones are along the deltaic areas of West Bengal, Orissa coasts, and Gujarat coasts. The coasts along the eastern and western ghats near Vishakapatnam and Bombay respectively are projected to be least vulnerable to sea level rise. The population density along the coasts is very high (Table 1). This will mean that a large population will be vulnerable to SLR due to global warming, requiring rehabilitation and resettlement (R & R).

The projected vulnerability of the Indian coasts to SLR is considerable causing inundation of low lying coastal areas, accentuated by storm surges, intrusion of saline water into the **coastal groundwater aquifers** and loss of ecologically fragile and important mangroves and wet lands. Sea Level Rise will not only displace people, disrupt the coastal economy and demolish coastal eco systems but also make the entire area vulnerable to water resources particularly for drinking and agricultural purposes. Adaptation to sea level rise by constructing dikes to prevent sea to inundate coastal areas is beyond the means of the poor communities. In the Indian situation, the communities are to be provided with facilities for increasing their resilience to cope with such disasters : Some of the ways to increase coping capacity of the community through sustainable livelihood practices such as "Grameen Banks" and "Entrepreneurship" that increase community resilience to adverse impacts like floods, droughts, cyclones and other natural calamities.

[1] *Actual And Anticipated Changes In India's Climate : M.Lal Et Al In The Book Global Warming Ed. M. Lal, P117, Tata Mcgraw Hill, 1993.*
[2] *Impact of Rising Sea Level along the Indian Coastline : M Bandyopadhyay in the book "Global Warming" Ed. M. Lal, p 153, Tata Mcgraw Hill, 1993.*
[3] *Sea Level and Climate Fluctuation during the Quaternary Period : V. Asthana & Pawan k. Srivastava in the book "Global Warming" E. M. Lal, p 136, Tata Mcgraw Hill, 1993.*

Table 1 : Population density in the different coastal belts in India

State	No. of Population / km^2
West Bengal	616
Orissa	165
Andhra Pradesh	196
Tamil Pradesh	372
A & N Islands	23
Kerala	655
Karnataka	194
Maharashtra	2040
Gujarat	174
Lakshadweep	1258
Pondicherry	1229

ADAPTATION

Adaptation to Greenhouse Gas Induced Global Warming

What are the adaptation measures ?

There are potentially many adaptation measures that may be adopted in response to climate change.

The adaptation measures can be broadly grouped under the following categories.[1, 2]

(1) **Bear Losses :** All other adaptation measures may be compared with the baseline response of "doing nothing" except bearing or accepting losses. In theory, bearing loss occurs when those affected have no capacity to respond in any other ways (for example extremely poor communities) or whose the costs of adaptation measures are considered to high in relation to the risk or the expected damage.

(2) **Share Losses :** Among wider community.

(3) **Modify the threat :** For some risks, it is possible to exercise a degree of control over the environmental threat itself.

(4) **Prevent effects :** An example would be for agriculture, changes in crop management practices such as increased irrigation water, additional fertiliser and pest and disease control.

(5) **Research :** The process of adaptation can also be advanced by research into new technologies and new methods of adaptation.

(6) **Educate, inform and encourage** behavioural changes.

3.1 Tools for Adaptation

The sustainable livelihoods approach seeks to reduce a community's vulnerability to shocks by enhancing its portfolio of social capital including access to natural, physical, financial, technical and human capital - and thus enhancing its ability to cope with such shock. Where this approach have been applied, communities were assisted by organisations in achieving greater stability and resilience.

Extreme climate events have evoked precautionary and reactive responses by governments. Long term government efforts to enhance adaptive capacity, however, are broadly lacking. The recent growth of fostering of community level strategies for coping with and adapting to shocks can fill this void. The assessment, integration and catalysing of community level responses, can make subsequent government efforts (often under fiscal strain) more effective and relevant. Most importantly, this endeavour can also **enhance community resilience,** thereby reducing the loss of human life and livelihoods with which climate change threatens South Asia and particularly India.

There is a great potential for synergy between the efforts of sustainable livelihoods organisation and existing efforts to address climate change adaptation in South Asia.

COMMUNITY LEVEL CASE STUDIES ON VULNERABILITY AND ADAPTATION TO GLOBAL WARMING

Community level case studies on Water Harvesting to cope with extreme climate events like drought in various drought prone areas in India

In India community level water harvesting efforts in regions vulnerable to droughts / severe droughts due to lack of adequate rainfall and infrastructure for storage of rainwater during the rainy season has made the water harvesting process a very powerful technology for an effective adaptation at the community level to cope with such natural disaster which may be exacerbated due to human induced climate change. Though adequacy of rainfall is a very important factor to consider in discussing impacts of droughts, but it is important to remember that it does not matter how much rain a place gets, if there is no infrastructure to capture rain water, the place will still to short of water. It

is unbelievable that Cherrapunji which gets 11,000 mm annual rainfalls still have serious drinking water shortages. The CSE Report titled "Making Water Everybody's Business" assert that every village in India that can meet the basic drinking and cooking needs through community level activities including rain water harvesting. The community-based case studies that have been reported in this chapter are primarily based on material taken from the published literature (Making Water Everybody's Business - edited by Anil Agarwal etal) and media reports.

5.1 Community Level Case Studies : Western Coastal Plains

Out of the total of about 18,500 villages in Gujarat, at least 12,000 - 18,000 villages can be categorised as 'no source' villages. 'No source' villages ate those who do not have dependable source of drinking water. A number of problems like salinity, sea water incursion, high fluoride content and depletion of ground water sources lead to severe drinking water shortage. The State Government response has been to introduce usual solutions such as utilising groundwater sources, constructing large irrigation dams, and introducing piped water supply and tanker services during the dry season when water availability is under stress. These solutions however did not take into account specific problems of individual areas, and were not therefore very successful.

Large areas along the **coastal parts of Dhandhuka block** (in Ahmedabad district) used to be thickly covered with mangroves and piloo trees till about 30 - 40 years ago. But with increasing water scarcity and environmental degradation local people have been forced to migrate. Introduction of piped water supply raised hopes about quality water becoming easily available and in sufficient quantity. But both the quality and the quantity of water fell short of the expectations of the community.

Local communities took initiatives to find better solution to the chronic drinking water shortages. Local communities in villages Rajpur, Mingalpur, Mahadevpura and Khun villages of Dhandhulka block were quite divided among men and women on the foremost reason for migration of people from the area - men cited the 'unproductive saline wasteland' as the main reasons, on the other hand women insisted that the severe drinking water problem as the foremost reason for all difficulties in the area. The local communities were of the view that the water resources must be augmented as common property by desilting existing ponds and building new ones for drinking purposes to benefit the whole village. Villagers suggested the use of some sort of lining material on the bed and inner walls of new ponds to prevent salinity seepage from below and of the harvested rainwater in the pond.

Villagers contributed both in terms of labour and other resources. Success of the project inspired villagers to putforth new proposals to Gujarat Water Supply and Sewerage Board (GWSSB) for obtaining support for such ponds, sowing the seeds of a long-battle. The demonstration of lined ponds in these villages has resulted in the setting up of a Samiti, a people's organisation comprising villagers from various village organisations who help in promoting such ponds. Some 50 percent of the 94 members were women.

5.2 Community Level Case Study : In Alwar district of Rajasthan

Communities from 650 villages took the initiatives to rejuvenate about 3000 traditional water harvesting structures (TWHS) called 'Johads'. Johads are small earthen check dams that capture and conserve rainwater, improving percolation and groundwater recharge. The results have been spectacular - rising groundwater level by six meters and increasing forest cover by 33 percent. The most spectacular effect has been on the five rivers that used to go dry immediately following the monsoon - have now become perennial.

For every Rs. 100 invested in Johads, the agricultural production has risen by Rs. 400 per capita per annum. This has slowed down the annual migration of the male population to cities in search of livelihood, and the people are in a position to address issues like health and education. At the core of this success lies the emergence and proper functioning of popular and local institutions like the **gram sabha at village levels**.

This is another example how a community level effort can tackle problem like water scarcity / drought and ecological degradation, to bring back water in their rivers, forests cover that had completely disappeared.

These community level activities was inspired by an Alwar based organisation called Tarun Bharat Sangh (TBS).

In rejuvenating about 8000 traditional water harvesting structures no qualified engineers were involved.

All the construction work-right from planning, site selection, design and execution of about 3000 Johads was undertaken **by the villagers themselves**, and most assuring fact is that all the structures are working fine, and none collapsed.

5.3 Community Level Case Study : In the Central Highlands of Bundelkhand Region

Bundelkhand region comprising seven districts of Lalitpur, Jhansi, Jalaun, Hamirpur, Mahoba, Banda, Shahiinagar in Uttar Pradesh and six districts of Datiya, Tikamgarh, Chattarpur, Panna, Sagar and Damoh in Madhya Pradesh. Poverty, illiteracy, unproductive agriculture and an acute lack of infrastructure are the main issues that the development processes in the region must address on a priority basis. Environment degradation is increasing with soil erosion and widespread deforestation.

This region receives an average rainfall of only 750 mm annually. Traditionally, groundwater resources in Bundelkhand are meager due to the presence of hardrocks like gnesis and granite. Availability of water in the Bundelkhand region varies from season to season. In this region agriculture is highly dependent on rainfall and only 20% of the total area under agricultural activity is irrigated.

Against this backdrop, Development Alternatives (DA) with the active participation of the local communities, and in close consultation with the district administration of Tikamgarh **has surveyed villages of Niwari Block which were facing acute drinking water problems**. Five villages were selected for interventions. The main objectives of the intervention were[3,4] :

- to provide adequate quantity of drinking water for these villages
- to increase availability of ground and surface irrigation in the area by constructing innovative water harvesting structures by constructing Check Dams

[**Check Dams.** There are small barriers built across the direction of water flow on shallow rivers and streams for the purpose of water harvesting. The small dams retain excess water flow during monsoon rains].

- upgradation of wells and handpumps to minimise / eliminate stagnant water in close proximity of wells and hand pumps
- to increase drinking water availability in these villages

With these objective two check dams were constructed across the Gurari river in the area. These water harvesting structures created opportunities for the community to raise their income by increased agricultural outputs, and the awareness of the community on the benefits of safe drinking water and sanitation around the wells and handpumps.

The project resulted in improving the quality of life of the villagers by providing them with the scarce resource - water. The check dams on the Gurari river have resulted in recharging the groundwater supply within a radius of 2-3 km around the structures with the result that farmers can now take up at least two crops a year from only one crop earlier. The water reservoir also made available adequate water for lift irrigation to cater for 300-400 ha of crop land.

5.4 Community Level Case Study in Decan Plateau : Anantapur District, Rayala Seema Region, Andhra Pradesh[5]

Out of the eight districts declared as drought - prone in Andhra Pradesh, the four districts of Kurnool, Ananthapur, Cuddapah and Chittor with a population 110 lakh, comprise the Rayalseema region. Located in the rain shadowzone, Rayalseema has been facing droughts almost every alternate year for nearly a century. About 50 per cent of the average rainfall 550 mm are received over only 5-7 days and the number of rainy days with 25mm and above are less than 10. Nearly 75 per cent of the population is engaged in agriculture despite inadequacy of rainfall coupled with infertile land and poor moisture retention capacity of the soil. The only rivers are Pennar, originating in the Nandi Hills of Karnataka, and Chitravathi. The rainfall in the district is meagre, untimely and erratic and the entire area is drought prone.

To deal with the situation, local communities in the district had devised traditional water harvesting systems to meet drinking water needs, and to a certain extent irrigation needs. These include water harvesting systems in the district community tanks (1091), spring channels (1221), river channels (243) and wells (58,483) in the district as **collective property**. This community activities have greatly improved the water availability in the region and improved their economic level.

5.5 Community Level Case Study in the Eastern Ghat Region : Saora Hills of Orissa

Saoras one of the oldest tribes in India, harvest rainwater to turn stream beds into paddy fields and thus an inhospitable environment into a habitable one. The Saoras who live in the Saora hills of Orissa practice terraced paddy cultivation. Conservation of rainwater and improvement of water regime in hill slopes are the main objectives of terracing. Using stone-packed contour bunding, saoras layout small terraced fields on the hilly slopes and grows paddy. By means of water channels they regulate water flow from natural hill streams and irrigate the terraced fields. As flow irrigation is not possible in an undulating topography, the runoff water is stopped at different levels and allowed to soak deep into the soil. This results in availability of adequate moisture at root levels, which helps in better crop production.

5.6 Community Level Case Studies in the Central Highlands : Jhabua District, Madhya Pradesh

Jhabua is an upland region of western Madhya Pradesh. Once a heavily forested area, Jhabua lost its natural wealth over the last 45-50 years. Almost 80 percent of its forest is severely degraded. The reasons are all man made - unauthorised clearing of forests by contractors for agricultural activities and population pressure. As the uplands were used for cultivation without terracing, the humus and fertile layer of soil was lost and soil erosion accelerated. Free grazing further accelerated the vegetative cover. The district was dotted with rock exposed hillocks. The intensive cultivation on uplands led to an ecological disaster, resulting in loss of land productivity, decline in employment opportunities and distress out migration of people.

The situation changed in the mid - 1990s, when the Madhya Pradesh government launched the Rajiv Gandhi water shed Development project (RGMWD) in October 1994. A decentralised and time bound mission, it started with the objective of improving 1.2 million hectares (mha) of land and several watersheds by the year 2000. It envisaged greening more than 2.9 mha - approximately one percent of the country's total land area - spanning 6,691 villages through 5024 watersheds.

The Madhya Pradesh government is now looking a mid-course strategy shift. The strategy is to build a community based **water security system** that would be controlled and monitored by the village level Paani Roko Samities. Under the system it is envisaged to create 8-10 lakh water harvesting structures and at least 25,000 water tanks in the villages. In the Kallipara Panchayat of Jhabua block the village community through its initiative constructed 613 check dams. They have also completed the task of recharging a large number of handpumps by constructing the recharging pits. The villages in most of the villages are now very happy that hand-pumps installed in their villages after March 2001 are in working condition. In most of the villages water table has gone up.[6]

Combining the principles of Joint Forest Management (JFM) and watershed treatment was a new approach that was adopted in Jhabua and helped in the formation of 20 village forest committees, the executive body used JFM that protects forests with the help of the forest department. Of Jhabua's total forest area, 60 percent (100,950 ha) is now under JFM and the 344 village committees cover 420 villages.

Management of watershed development finances in Jhabua District

The total government expenditure till min 1998 for watershed development was 16.48 crore. Of the Rs. 16.48 crore, Rs. 4.53 crore (about 30 percent) was spent by the project implementation agencies, out of which a substantial amount was spent (about 60 percent) to build up the credibility particularly of the community organisations, for their training and capacity building to build institutions and social mobilisation at the village level.

A **saving scheme** programme encourages villagers to save a part of their wages as a Watershed Development Fund (WDF), for future use for the management of the watershed. This is a mandatory fund developed through contribution from all the users groups who are land owning people. Self-help groups (groups of landless people) do not normally contribute to this fund. The fund is entirely controlled by the community, and neither the panchayat not the officials of the rural development have any control over it. Savings are also encouraged through a village fund for use by the villages for collective activities of the communities and a women's thrifts and credit fund which women can use to help each other with soft loans. The watershed management programme, thus not only helped in improving the local ecology, but also in an improvement of the collective and individual financial security of the local communities and improved their coping capacity with drought and other natural calamities.

[1] Vulnerability and Adaptation Assessments : An International Handbook : Ed. by Ron Benioff, Sandra Gull and Jeffrey Lee, Kluwer Academic Publishers, April 1996

[2] Vulnerability and Adaptation to Climate Change in Latin America, Ed. Cecilia Rams Mane, C.R. Special, Vol. 9, Nos. 15211992

[3] Water Management Practices for Bundelkhand : Water for life : Air Vice Marshal S. Sahni (Retd.), DA N.L. March 1997.

5.7 Community Level Case Study in Western Coastal Plains : Saurastra

Gujarat faces severe water shortage every year. The potential for surface irrigation being particularly low in the Saurastra region of Gujarat, harvesting rainwater through recharge wells is providing welcome relief. Over the years, ground water has been excessively extracted leading to large scale salinisation of coastline due to the incursion of sea water. Drop in groundwater in North Gujarat is also increasing fluoride concentrations, a serious health hazard. About 78 percent of the total irrigated area in Gujarat is served by wells alone which has caused severe groundwater depletion. In view of this harvesting of rainwater becomes a necessity.

The farmers in the region felt the need for more check dams to store river water during rainfall, and the existing but unused / failed wells may be utilised for storing rainwater. Further the farmers suggested that village level committees be formed to develop programmes for recharging both private and public wells and handpumps and construct check dams and percolation wells on river beds. An effective information centre to assist farmers in water harvesting and management techniques in co-odination with government and non-governmental organisation were also envisaged.

The case study made it clear that well recharging activity is becoming popular in Saurastra, per capita and household water consumption are increasing with better availability of water resources.

Farmers are already optimising yields by using stored water during poor monsoon or failure of monsoon. This has increased their per capita income as evinced by increased use of fertilisers and pesticides.

CONCLUSION

1. The present study and analysis have clearly brought out that developing countries like India are most vulnerable to the impacts of climate change due to resource constraints, lack of capacity and adequate funds. This vulnerability is further exacerbated due to large-scale poverty in these countries.
2. The case studies bring out the efficacy of community level responses to address to acute water scarcity. The community level responses can be channelised and further strengthened, by creating an enabling environment in the country / society by developing sustainable livelihood practices and entrepreneurships among the people and society. Such practices will not only increase the capacity of community to cope up and increase their resilience to such natural calamities like droughts, floods, cyclones etc., but will check migration of people to other states / regions.
3. The traditional community level practices to cope with situation like droughts in water scarcity / drought prone areas / region can be integrated into Government Policies and Responses to cope with such calamities and for adaptation to hydrological resources in India.
4. Such community level efforts must be encouraged by governments to start activities like Grameen Bank / Co-operative Banks on a co-operative basis by all the stakeholders. Such a mechanisms can provide small loans to the affected communities to enable them to cope with adverse situations. Such a mechanism will also help in community based adaptations to water resources in water scarcity areas. The Co-operative Banks initiated from small contributions from communities increases the community resilience to face such climatic vagaries and extreme weather events.
5. Technological responses to adapt to climate change is most suitable for rich countries. Such adaptations in developing countries however may face technology, transfer barrier, financial barrier, and capacity building barrier. Solutions to such barriers must be put in place in developing countries before adopting technological options to adapt to climate change. Such solutions must be found from a participatory process among the communities and not transplanted from other countries / regions.

BIBLIOGRAPHY

1. Intergovernmental Panel on Climate Change (IPCC), Second Assessment Report on the Impacts, Adaptation and Mitigation of Climate Change, WMO / UNEP, 1995
2. Climate Change Science : An Analysis of Some Key Question, National Research Council, National Academy of Science, Washington, D.C,2001
3. Actual And Anticipated Changes In India's Climate : M.Lal Et Al In The Book Global Warming Ed. M. Lal, P117, Tata Mcgraw Hill, 1993.

[4] Check Dam - A Tool for Sustainable Development : Sanjay Vashist, DA N.L. April 2001.

[5] In Harmony with Nature : Koda Ramakrishna Reddy, Srikrishnadeva Ray University, Ananthapur in "Making Water Everybody's Business", Eds : Anil Agarwal, Sunita Narain and Indira Khurana, March 2001.

[6] M.P. Focus on Water Conservation : Lalit Shastri, The Hindu, June 19, 2001

4. Impact of Rising Sea Level along the Indian Coastline : M Bandyopadhyay in the book “Global Warming” Ed. M. Lal, p 153, Tata Mcgraw Hill, 1993.
5. Sea Level and Climate Fluctuation during the Quaternary Period : V. Asthana & Pawan k. Srivastava in the book “Global Warming” E. M. Lal, p 136, Tata Mcgraw Hill, 1993.
6. Vulnerability and Adaptation Assessments : An International Handbook : Ed. by Ron Benioff, Sandra Gull and Jeffrey Lee, Kluwer Academic Publishers, April 1996
7. Vulnerability and Adaptation to Climate Change in Latin America, Ed. Cecilia Rams Mane, C.R. Special, Vol. 9, Nos. 15211992
8. Water Management Practices for Bundelkhand : Water for life : Air Vice Marshal S. Sahni (Retd.), DA N.L. March 1997.
9. Check Dam - A Tool for Sustainable Development : Sanjay Vashist, DA N.L. April 2001.
10. In Harmony with Nature : Koda Ramakrishna Reddy, Srikrishnadeva Ray University, Ananthapur in “Making Water Everybody’s Business”, Eds : Anil Agarwal, Sunita Narain and Indira Khurana, March 2001.
11. M.P. Focus on Water Conservation : Lalit Shastri, The Hindu, June 19, 2001