Climate change adaptation implications for drought risk mitigation: a perspective for India

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Abstract

There is growing evidence that the climate change do has implications for drought vulnerable India with studies projecting future possible reductions in monsoon related rainfall in the country. The existing drought risk mitigation and response mechanisms were looked into and gaps were identified by drawing lessons from previous disasters and response mechanisms. In absence of reliable climate predictions at the scales that make them useful for policy level planning, the emphasis was on identifying no-regret adaptation options those would reduce current vulnerabilities while mainstreaming the adaptation in the long run. The most notable climate change implications for the drought vulnerable India are the enhanced preparedness with due emphasis to the community based preparedness planning, reviewing the existing monsoon and drought prediction methodol-ogies, and establishing drought monitoring and early warning systems in association with a matching preparedness at the input level.

Introduction

Since the First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) was made available in 1990, the global climate change has been drawing attention of many to this very important topic of climate change, though it was a difficult proposition for many to accept in the beginning that the climate change is real. As the understanding on global climate and its change, mostly human induced, increased over the time, one could see an increasing number of scientists and administrators accepting it as happening. It has also been agreed that the climate change vulnerabilities are related to the developmental state of a country, as indicated by the differential impacts of climate change on countries at different developmental levels (Richards 2003; Smit and Pilifosova 2001; Tol et al. 2003). Also, a country's vulnerability to climate change is decided by the presence of appropriate mitigation and adaptation options. Climate change also demands that the current

Vulnerabilities need to be looked from a different perspective. Within climate change adaptation community, there is a common assertion that if we could cope better with the present climate risks, possibly we could significantly reduce the impacts of future climate change (Thomalla et al. 2006). There are also views that the adaptation to short-term climate variability and extreme events serves as a starting point for reducing vulnerability to longer-term climate change (Spanger-Siegfried and Dougherty 2005).

India, being the second largest developing and populous country in the world, has significant role to play both as a source for the climate change and as a sink for its consequences. Hence, in this paper, we intend to present the drought vulnerability of India in view of the climate change, analyze the existing management structure for dealing with these vulnerabilities, and identify suitable adaptation options to reduce the drought vulnerability. We suggested no-regret adaptation options as they are not only aimed at bridging the gaps in

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the existing drought vulnerability reduction initiatives but also serve as a beginning point for mainstreaming adaptation to climate change in a long run. While doing so, we also consider dealing with the local vulnerabilities as most important in addition to the appropriate support from the above in terms of timely forecasts, drought monitoring and quick response through solving the inter and intra governmental bottlenecks.

Drought and climate change vulnerability of India

India has been vulnerable to vagaries such as droughts, floods, heat waves and cyclones since time immemorial (BMTPC 1997; High Powered Committee 2002). These vagaries have left behind death and destruction with huge impact on the developing economy of the country. India receives an annual average rainfall of around 975 mm more than 75% of which is received in a span of four months from June to September. The performance of the Indian agrarian economy is very much dependant on these four months (Department of Agriculture and Cooperation 2004). The pattern of onset and withdrawal of the monsoon leaves the northwest India with little rainy period while the southwest and northeast parts of the country receive higher rainfall and longer rainy season. Coupled to this, the short and intense rainfall spells make the dry land areas more vulnerable to runoff losses and further drought proneness. The 68% of India's cropped area receives rainfall between 750-2,000 mm per annum. These areas are highly prone to irregularities in monsoons such as late onset, long breaks and early withdrawal etc and hence are vulnerable to droughts of different durations and magnitudes (Shaw et al. 2005).

India has a long drought history. India faced 22 major drought years (years with rainfall less than one standard deviation below mean) during the period 1871-2002. The Emergency Database (EM-DAT) of Centre for Research on the Epidemiology of Disasters (CRED) reports the impact of drought in India. According to this database, droughts have affected nearly 1,061 million people and killed 4.25 million people in India during 1900-2006 (Center for Research on Epidemiology of Disasters 2006). One of the major reasons for thee droughts has been a strong link with the El Nino-Southern Oscillation (ENSO) patterns (Gadgil et al. 2003). For example, the country faced 10 drought years out of 22 during the ENSO period of 1965-87 while only 3 drought years during 1921-64 (Department of Agriculture and Cooperation 2004). In recent decades, a weakening relationship between Indian monsoon and ENSO phenomenon was also suggested due to Eurasian warming (Kumar et al. 1999). However, the recent droughts of 2002 and 2004 suggest the inherent vulnerability of the Indian monsoon system due to the El Nino phenomenon (Saith and Slingo 2006). Selvaraju (2003) has clearly demonstrated the

linkage between ENSO and Indian foodgrain production. Hence, it is clear that the Indian monsoon system, the dependant agricultural sector and droughts are very much linked to the regional and global climate system and hence are very much vulnerable to the changes in climate both at regional and global scales.The global climate change is characterized by increase in surface temperatures to the tune of 0.6±0.2°C over the twentieth century and with a projected rise in the range of 1 3.5°C by 2100 (Houghton et al. 2001). Among the observed impacts, the number of people living in water stressed regions is expected to grow from present level of 1.7 billion to 5 billion by 2025 depending on the rate of population growth and these impacts are projected to be more severe in central Asia, Southern Africa and countries around Mediterranean Sea (Vörösmarty et al. 2000).

This is expected to threaten the food security and sustainability in these countries. There has been agreement that the global climate change would modify the hydrological cycle hence increasing the possibility of droughts and floods globally (e.g. Allen and Ingram 2002), though with uneven distribution of impacts over the continents (McCarthy et al. 2001). Evidences also suggest that the human induced global climate change is leading to El-Nino kind of environments in the Eastern Pacific (Timmermann et al. 1999), though it is difficult to quantitatively associate the present changes to the climate change phenomenon. However, cautious approach is required in relating the vari-ability in the extreme events entirely to the climate change while recognizing that the data are weak and that there is a dearth of analysis (Burton 2004). Climate change is expected to change the existing vulnerability profile of India (O'Brien et al. 2004).

The country level studies on the past climate indicated an increase in the temperatures to the tune of 0.57°C per 100 years (Kumar et al. 1994; Singh et al. 2001). While some studies identified no national level trend in rainfall (Pant et al. 1999), there have been decadal departures above and below the long time average alternatively for three consecutive decades (Kothyari and Singh 1996). At the regional scale, extreme summer rainfall events were observed in northwest India during the recent decades (Singh and Sontakke 2002). In addition, the number of rainy days during monsoons along the east coast has gone down during the last decade indicating more intense rainfall events. Roy and Balling (2004) have computed the extreme daily precipitation indices in India and found an upward trend in rainfall in 114 weather stations and downward trend in 61 weather stations out of 130 stations across India. The extreme rainfall was significantly reducing in the Eastern part of the Gangetic Plains and part of Uttaranchal while the upward trend was observed from the Himalayas in Kashmir to most of the Deccan Plateau.

There are few studies available on the possible future climate over Indian sub-continent. The climate projection studies indicated a general increase in temperatures in the order of 3-6°C over the base-period average, depending on the scenario, with more warming in the northern parts than the southern parts of the country (Lal et al. 1995; Lonergan 1998; The Energy Resources Institute 2001). Increased rainfall with increasing CO2 concentration was observed in experiments involving GCMs (Bhaskaran et al. 1995). The climate models predicted a change in precipitation by 5-25% over India by the end of the century with more reductions in the wintertime-rainfall than the summer monsoon leading to droughts during summer months (Lal et al. 2001b). Studies by Lal et al. also suggested increased variability in the onset of monsoons with implications for sowing time for the farmers in future. Obtaining more specific regional projections has been difficult owing to lack of sufficient reliable regional models. Regional model studies involving HadRM2/HadCM2 indicated no substantial change in monsoon rainfall (Kumar 2002). Climate projections developed for India for the 2050s using the regional model HadRM2 run on the IS92a emission scenario indicated an increase in average temperature by2°C during that period, an overall decrease in the number of rainy days by more than 15 days in western and central India and an increase by 5-10 days near foothills of Himalayas and in northeast India.

The projections also indicated an overall increase in the rainy day intensity by 1— 4 mm/day except for small areas in northwest India where the rainfall intensities may decrease by 1 mm/day (Bhattacharya et al. 2006). The high resolution (50x50 km) climate prediction experiments involving state-of-art regional climate modeling system called PRECIS (Providing regional climates for impacts studies) developed by the Hadley Center for Climate Prediction and Research revealed possibilities of increased rainfall and temperatures in global warming scenarios (Kumar et al. 2006). In these experiments, the west central India showed maximum increase in rainfall with possibilities of extreme precipitations in Western Ghats and northwestern peninsular India. Projections using Soil and Water Assessment Tool (SWAT) water balance model and HadRM2 indicated droughts and floods in climate change scenario (Gosain et al. 2006). The studies indicated acute water scarcity conditions in the river basins of Luni, Mahi, Pennar Sabarmati and Tapi and sever flood conditions in the river basins of Godavari, Brahmani and Mahanadi.

While considerable progress has been made in achieving the high-resolution climate predictions, the quantitative estimates still have large uncertainties associated with them (Kumar et al. 2006). Due to being far from conclusive and lack of dependable regional scenarios, it suffices to discern that the governments at all the levels need to be on watch for dealing with any surprises. Under these circumstances, identification of appropriate adaptation options seems to be a right policy. The right adaptation policy will be to look at the existing vulnerability reduction mechanisms and improve upon them by plugging the gaps. Keeping this in mind, in the following sections, we emphasized the need for adaptation and looked at the existing drought vulnerability reduction mechanisms in India, both on response and mitigation fronts, and identified suitable no-regret adaptation options.

Need for adaptation

The global community has called for a number of initiatives to combat the global climate change. Some of these measures include policy responses such as planned adaptation to impacts and mitigation (Kane and Shogren 2000). While the mitigation aims at reduction of greenhouse gas emissions through managing their sources and sinks, the adaptation works with the process of increasing the capacities of communities and governments such that the possible negative impacts are reduced. Adaptation refers to change in a system in response to some force or perturbation such as climate change (Smithers and Smit 1997; Smit et al. 2000).

Adaptation is not new. Throughout history, people have been adapting to the changing conditions. What is needed is to incorporate future climate risks into policy making (Lim and Spanger-Siegfried 2005). Adaptation also gives us an opportunity to revisit some of the unresolved disaster reduction and sustainable development issues (Subbiah 2002). Adaptation is important in climate change in two ways - in reducing the impacts of the future climate change and in understanding the options for such adaptations to climate changes. There is a need for accelerating the planning and adaptation due to the fact that the accelerated human induced changes in the climate may outpace the natural adaptation capabilities built in the existing systems (Bruce et al. 1996). Two policy-relevant research reports that were recently released, the US National Assessment of Climate Change Impacts on the United States and the Working Group II Report (Impacts, Adaptation, and Vulnerability) of the Third Assessment of the IPCC also stressed the need for adaptation. According to these reports, adaptation can ameliorate many adverse economic impacts of climate change in developed countries, barring abrupt climate change; however, developing countries and natural ecosystems are at particular risk because they have less ability to adapt. Even in industrialized countries, government programs to promote collective adaptation efforts likely will be needed. The IPCC Third Assessment Report particularly identified the Asian region as most vulnerable to climate change related impacts due to its poor adaptive human systems (Lal et al. 2001a). India being one of the developing countries in the Asian region, the report is of high significance in framing India's future adaptation policy.

After India ratified the UNFCCC in November 1993 and became a non-Annex 1 country, it has the responsibility of making efforts towards identification of possible climate change impacts on the country and work towards reducing these impacts through suitable adaptation strategies since large populations in India are directly dependent on the climate sensitive sectors. In its Initial National Communication to the UNFCCC, India identified the possibilities of water stress due to reduction in fresh water systems leading to threat to agriculture and food security of the nation (The Energy Resources Institute 2001). The Initial Communication has also identified important strategies specific to drought vulnerability reduction such as changes in land-use pattern, water conservation, flood warning systems, and crop insurance. While identifying the existing programmes in India that aim at combating water scarcity, the Initial Communication proposes that the same programmes hold good even in climate-change scenario such as extreme events of droughts and floods. Some such programs identified in the Initial Communication are watershed development programs, command area development programs, crop diversification and extension of irrigation facilities to larger areas in addition to various flood control measures in some of the flood prone areas in the country. However, we will see in the following section that there is a need for improvement in these programs. The Initial Communication identified that there is a need for common nationwide adaptation strategy such as integrated watershed management starting from the local level water conservation practices to integrating impacts of these practices to a basin level such that the combined effect of water conservation at small levels reflect well at the larger basin level water resources.

Drought risk management in India

Drought monitoring, response and relief mechanisms

Drought management in India is a state subject and the role of the central government is confined to being a facilitator. Generally, the central government assists the State governments in dealing with disasters upon the latter's request. Similar is the case with the slow onset disasters like drought. The Ministry of Agriculture and Cooperation is responsible for drought management in India.

At the national level, the responsibility of weather forecasting and drought monitoring is rested with the India Meteorological Department (IMD) and National Center for Medium Range Weather Forecasting (NCMRWF) under the Ministry of Science and Technology. IMD provides current meteorological observations and short-range (1-2 days ahead) and long-range (monthly and seasonal scales) forecasts and NCMRWF provides forecasts for the medium-range (3-10 days). In order to internalize this information into tangible actions, an

Table 1-1 Composition of CWWG and its role (Samra 2004)

Composition	Role
Central Relief Commissioner	Chairman of the group; promote overall coordination
Economic and statistical advisor	Reporting on behavior of agro-climatic and market indicators
India Meteorological Department	Monsoon forecast and progress of monsoon
Central Water Commission	Water level situation in major reservoirs
Crop specialists	Crop conditions and prospects
Agricultural input supply divisions	Supply and demand of all agricultural inputs
Agricultural extension specialists	Reporting on field level farm operations
Ministry of power	Managing electrical power for ground water use
Ministry of petroleum	Diesel supply for ground water use
Indian Council of Agricultural Research	Information for technology transfer

institutional mechanism called Crop Weather Watch Group (CWWG) was established under the Ministry of Agriculture in 1979 (Samra 2004). The Table 1-1 enlists the composition of CWWG and its role. Being an inter-ministerial group, the CWWG is responsible for assessing the drought condition from time to time and serves as a 'trigger mechanism' to activate drought response systems in coordination with the similar groups at the state level. The CWWG meets once every week during monsoon season (June to September) and assesses the monsoon situation and other parameters of drought such as water levels in various reservoirs and ground water situation.

At the state level, the drought management system follows a uniform approach throughout India, though few exceptions exist. The states have established a drought early warning system, similar to that of CWWG at the central level, under the chairmanship of Principal Secretary, Revenue named as Weather Watch Group (WWG; Rathore 2004). The working of WWG resembles very much to that of the CWWG formed by the Ministry of Agriculture and Cooperation (see the previous Section). This group meets once in every week and assesses the drought situation by monitoring parameters such as rainfall, irrigation facilities, water in reservoirs and electricity supply etc. The state Cabinet Committee, which is a standing committee, gets activated in the wake of declaring drought in the state. The Cabinet Sub Committee is responsible for policy decision-making, monitoring and implementation of the drought relief work. There are separate groups for policy making and monitoring and implementation purposes. The Chief Secretary is the head of the Group that is responsible for Policy making while the Relief Commissioner is the head for the implementation group.

The State Relief Manual mainly facilitates the relief work and outlines clear guidelines for implementing the drought relief. Appropriate institutional mechanisms are in place to check the quality aspects in implementation of drought relief work. In general, the drought relief interventions of the state comprise of providing monetary relief (loans, grants etc); food, water, and fodder supply. Crop contingency relief measures such as supply of seeds and fertilizers are also being taken up depending on the drought situation. The affected population is engaged in works such as deepening of village ponds, agricultural ponds, construction or repairing of check dams, construction or repair of roads etc. Cattle camps are established to provide centralized facilities for arranging feed and water facilities for farm animals. Though widely debated and controversial, giving away cash doles has been a common practice in some of the states. However, such 'grants' are made to only aged, infirm, children and pregnant women who are categorized as most vulnerable sections of the society. Supply of drinking water is another important aspect of drought management in many states in India. The transportation of water through rail and road transport facilities to reach the doorsteps of affected communities is both cost intensive and well establishes the fact that many states in India don't have longer term policies for securing drinking water supply especially during stress conditions.

Figure 1-1 shows the information flow after the CWWG identifies the drought. The Fig. 1-2 indicates the path of drought response at national level in 2002 drought and Fig. 1-3 indicates the path of drought response in the state of Rajasthan. The case study of 2002 drought, conducted by Someshwar and Subbiah (2002), indicated that the state government assesses the situation and sends a request for the central assistance in the 6th week after identification of drought situation in the state. It can be seen from the Fig. 1-2 that it took 3 weeks time for the Central Government to send Central Assessment Teams for assessing the drought situation in the affected state and to respond to the assessment request by the state government. This shows the lack of capacity with the state government to deal with the debilitating disasters like droughts and lack of clarity in decision making both at central and state governments leading to loss of valuable time in response.

The case study also identified crucial gap in dissemination of climate information to the end users as the end-to-end climate applications system for drought mitigation doesn't exist in India (Someshwar and Subbiah 2003). It shows that India has developed a fine institutional mechanism that has been perfected to initiate drought relief measures rather than to forecast in advance that helps in mitigating the impacts of the impending drought.

Drought mitigation mechanisms

Watershed development programs and other social developmental programs mainly drive the drought risk mitigation in India with an aim at overall development of stressed environments. The list of various government programmes is given in Table 1-2 (Swami2001). The Drought Prone Areas Programme (DPAP), Desert

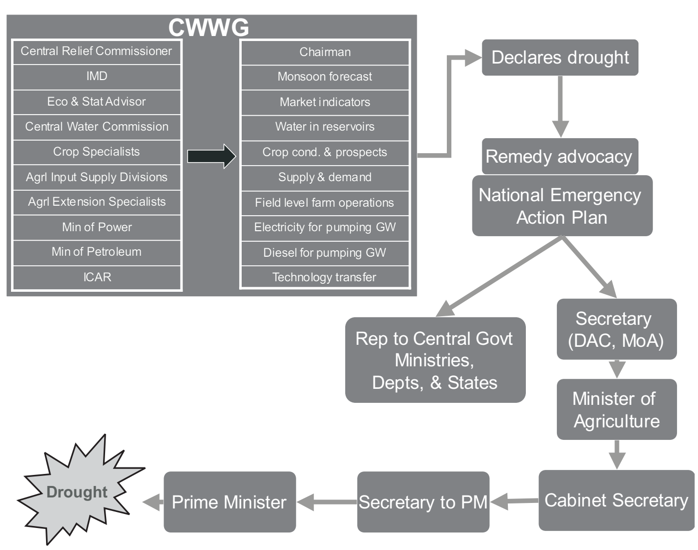

Fig. 1-1 Information flow for declaration of national drought in India (constructed from Someshwar and Subbiah2003)

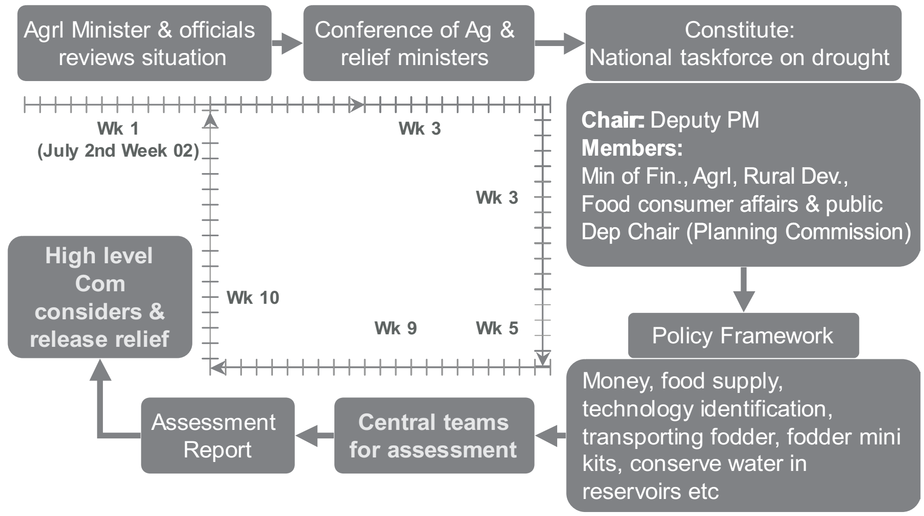

Fig 1-2 The response path at national level after a drought has been declared (constructed from Someshwar and Subbiah 2003)

Development Programme (DDP) and Integrated Wasteland Development Projects are run by the Ministry of Rural Development and National Watershed Development Programme in Rain fed Areas (NWDPRA) is by the Ministry of Agriculture. There are also many independent watershed programs managed by NGOs (Sikka and Sharda 2002). Some of the major drawbacks identified in the government planned and managed watersheds are the top down approach leading to less fulfillment of local felt needs, poor community participation, least development of community based assets, lack of sustainability, monitoring of projects in terms of financial management rather than on outputs such as natural resource managementand on how such interventions could lower the drought vulnerability of the program villages or regions (Kerr et al. 2002). This indicates that

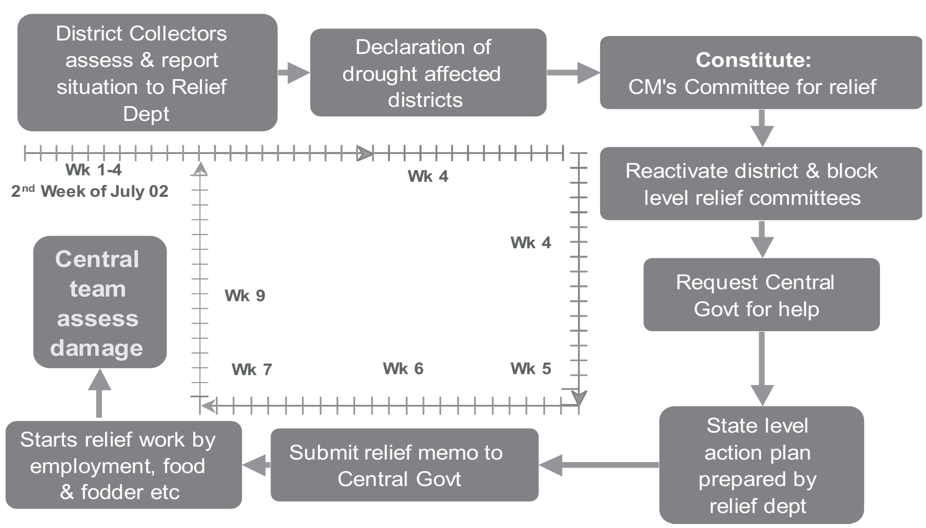

Fig. 1-3 State level drought response mechanism of Rajasthan during 2002 drought (constructed from Someshwar and Subbiah2003)

Table 1- 2 Drought proofing and developmental programmes in India (Swami 2001)

Programme	Coverage/expenditure (INR)
Drought Prone Areas Programme (DPAP)	180 districts of 16 States, Rs 19.0 billion
Desert Development Programme (DDP)	40 districts of 7 States, Rs 8.5 billion
Watershed approach: A geo-hydrological approach for in situ soil and water conservation	Rs 22.6 billion
Others including developmental programs	
Food for work Programme, Employment Assurance Scheme (EAS)	Rs 16.0 billion
Jawahar Gram Samridhi Yojana (JGSY)	Rs 16.5 billion
Pradhan Mantri Gram Sadak Yojana (PMGSY)	Rs 25.0 billion
Swaranjayanti Gram Swarozgar Yojana (SGSY)	Rs 5. billion
Annapurna Scheme	Rs 3.0 billion

the government projects are often a failure due to lack of participatory approaches and NGO or NGO-Government projects succeeded mainly because they provided opportunity for people's participation. Such an approach could facilitate better maintenance of assets even after the project period, better than the government projects that provided lots of subsidies to the communities while implementing waster conservation measures.

Till more recently, the above mentioned area development programmes have laid down their own guidelines depending on the main objective of these programmes. However, a national committee under the Chairmanship of Prof Hanumantha Rao reviewed these programmes and gave a recommendation for common guidelines for implementation of watershed based projects in India and emphasized the need for community based watershed management (Saravanan 2003). The committee observed that these programmes failed to meet the targets, both financial as well as those related to outputs, mainly due to the inappropriate administrative arrangements as well as lack of public participation. The Committee gave a new set of common guidelines for governing the watershed programmes (Government of India 1994). These guidelines were later revised with a name 'Hariyali' which suggested involving the local level governments more meaningfully in planning and management of economic development activities (Government of India 2006). It is yet to be seen how the newly evolved guidelines makes the watershed management deliver better results, especially under the climate change scenario.

No-regret adaptation options for India

Local capacity for drought preparedness and mitigation

The literature suggests that the local governments and communities often lack capacity to deal with the catastrophic disasters and hence there is a need to enhance their capacity (Ivey et al. 2004; Christoplos et al. 2001; Rocha and Christoplos 2001). This signifies two aspects. Firstly to improve the capacities of local communities and secondly to improve the capacities of local governments including the states which are chronically drought prone. In this section, we elicited the ways of improving the local capacities.

Capacities of communities

The vulnerability to natural disasters is directly related to the developmental level of the communities (Bolin and Stanford 1998). Involvement of communities in disaster management planning enables local governments and disaster management personnel to gain better understanding on the vulnerabilities of the communities (Mileti 1999; Pearce 2003). Communities can be involved at the local level preparedness planning, vulnerability mapping while preparing the community level drought management plans (Hayes et al. 2004). Drought preparedness planning will increase the society's capacity to cope more effectively with the extremes of climate and water scarcity and provide substantial benefit in preparing for the potential changes in climate (Wilhite 2002; Wilhite and Svoboda 2000). Currently, India lacks such community based drought preparedness planning at village, district, and prefecture levels. The disaster risk mitigation (DRM) program, a recent collaborative initiative between Government of India and United Nations Development Program (UNDP), can serve as a starting point for the country (National Institute of Disaster Management 2006). The Program envisages preparing disaster management plans for effective preparedness against all sudden onset disasters at community, village, block, district, and provincial levels. Subsequently, the Parliament of India has passed The Disaster Management Act (2005) enabling the local authorities such as Panchayat Raj institutions, municipalities, town and district planning authorities to prepare community based disaster management plans for effective disaster risk mitigation (National Disaster Management Act 2005). While the act doesn't differentiate between the slow onset disasters such as droughts and sudden onset disasters such as earthquakes, the current focus of the DRM program is on the sudden onset disasters. The strategy adapted for the local level risk management is depicted in Fig. 1-4 (Ministry of Home Affairs 2004).

It appears that providing drought relief to the effected populations constitutes one of the major drought management strategies for the local and state level governments in India. It could be seen that the entire

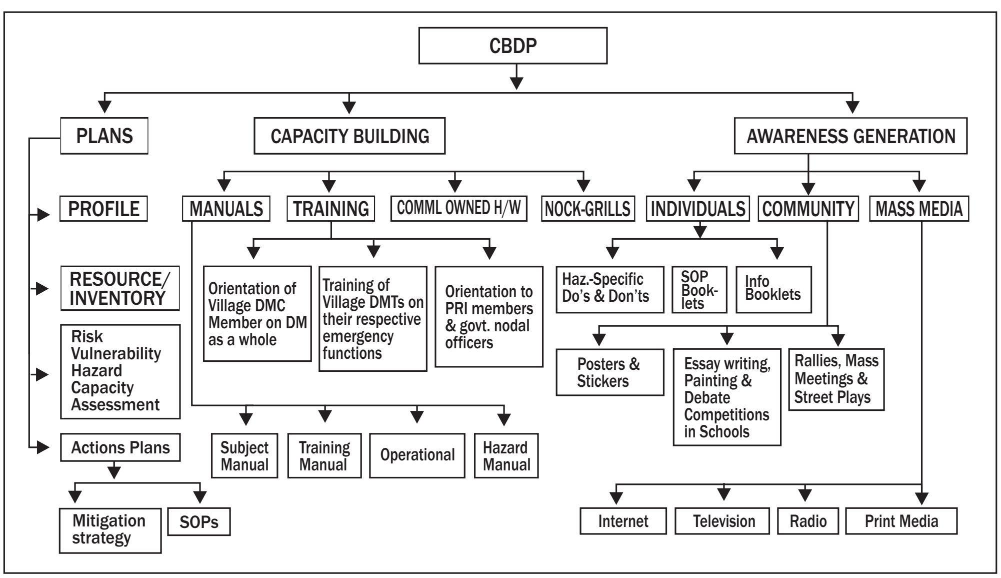

Fig.1-4 Community based disaster management planning adapted in India (Ministry of Home Affairs 2004)

response mechanism is top-down in nature and there is little or no focus on the communities in enhancing their capacities that enable them to plan ahead and respond to the drought situations. Though the main aim of the relief measures is to alleviate the immediate impact of the drought, this reactive crisis management approach has been criticized by scientists, government officials, and many relief recipients as inefficient, ineffective and untimely and that there exist an opportunity for governments to build sustainable livelihoods by combining drought relief measures with that of sustainable use of natural resources and development of more tangible assets (Bruwer 1993; Wilhite 1993; Sainath 1996). For example, a shift from ad-hoc measures to planned relief interventions that aims at creating longer-term livelihood options is an important thing to be considered (National Institute of Disaster Management 2005). This could be achieved through identification of vulnerable livelihoods and making specific corrective interventions during drought relief, development of local market facilities and non-farm employment opportunities (livelihood diversification) that reduces the vulnerability to drought related events, identification of local needs and using the drought relief resources to fulfill these needs, and emphasizing more on the mitigation measures that take care of future vulnerabilities.

Identifying the coping range of the communities and enhancing their capacity through appropriate adaptation measures seems to be a boon for vulnerability reduction (Moench and Dixit 2004; ZENEB and UNDP 2001). Identification of community coping mechanisms, changes in these coping mechanisms over the time and mapping these trends with the past climate trends such as increasing or decreasing frequency of scarcity events in that location seems to be very much lacking in the existing strategies for drought vulnerability reduction. While doing so, there is also a need to differentiate between planned adaptation and autonomous adaptations which would serve as an indicator of the community's capacities. Similarly, investigations are also necessary to know whether the adaptations were anticipatory or reactive, whether these adaptation mechanisms have alternative costs or not and if so what made the communities to take such decisions (Carter and Kankaanpaa 2003).

On the mitigation front, there are number of success stories involving the communities in effective planning and management of watershed management and natural resource management programs (Kerr et al. 2002; Farrington and Lobo 1997; Turton and Bottrall 1997). Many of these community based watershed management interventions are localized and are small scale operations by local and regional NGOs. Hence, doubts were raised on the technical and administrative feasibility of replicating these success stories in a large scale by the government (Turton and Bottrall 1997). However, preconditions such as close engagement of stakeholders, promotion of local level watershed planning methodologies, and provision of local level framework for involving various stakeholders and channeling of funds have been suggested for a sustainable scaling up of the community based watershed management programs (Farrington and Lobo 1997). There are expectations from the initiatives such as Hariyali guidelines, discussed earlier, which emphasize the participation of local communities in drought risk mitigation and integrate different watershed development programmes into a single common umbrella. However, these initiatives are yet to show significant impact on the ground. Hence, a combination of mitigation programs guided by the guidelines such as Hariyali and preparedness planning guided by various community based drought management plans is highly necessary for the country.

Capacities of local governments

Globally, lack of coordination of policies and programs within and between levels of government has been identified as one of the deficiencies in dealing with the disasters such as drought (Wilhite 1996). In India, local governments often lack the capacity to deal with the debilitating disasters such as droughts. It has been a common practice for the state governments to demand additional funds from the national government ever time the statesare affected by the drought or drought like situations (Sainath 1996). For example, during drought 2002, the central government released funds to the tune of Rs 129.15 billions to assist states in drought relief. This signifies the lack of local capacity to deal with the scarcity situations. States governments also often require time in preparing memorandum requesting central assistance. In some cases it could extend to months as in the case of Gujarat state; partly, the delays are due to tedious means of assessing the drought impacts through crop cutting experiments (Samra 2004). It took nearly nine weeks to send central teams for assessing the drought situation and an additional one more week to consider the state requests for relief assistance (Fig. 2). Such administrative delays could be effectively avoided if specific standard operational procedures are established, in addition to the effective drought monitoring, as discussed in the later sections, for taking quick decisions on the requests made by the states in the wake of a drought.

There is also a need for a long-term strategy to build the capacities of local governments such that their dependency on the central government is reduced significantly. There are suggestions for a greater governments and NGOs collaboration in risk reduction (Rocha and Christoplos 2001). The state-NGO relationships in India are not uniform across the country while certain NGOs collaborate with the governments and others do not (Sen 1999). Krishna (2003) suggests that a partnership between local governments and community based organizations will help build the capacities of the both. He argues that it would help local governments in gaining collective support to its developmental programs making them more participatory and sustainable. The advantage of community based organizations is that they work closely with the communities and hence have much idea on the local problems than the governments do (Ebrahim 2001). Hence, it is necessary that the governments and NGO identify areas where they can collaborate within the broad spectrum of drought risk mitigation. Such a clear identification of roles and responsibilities would certainly enhance the local capacities to deal with the future risks.

Drought prediction and communication

India has a well established agromet advisory service in the form of agricultural advisory service units. Established in 1977 in coordination with the state agricultural departments, these units issue weekly and bi-weekly agromet advisories for the farmers to take up appropriate agricultural practices. However, these being far from useful for advanced planning, as these advisories help farmers in taking up day-to-day farming operations, what is necessary is forecasts extending the medium range (Ray 2000).

The long-range weather forecast of summer monsoon across India is among the toughest because of the complex atmospheric conditions in the tropics, the reason why IMD predicted a normal monsoon during 2002 which eventually turned out to be a severe drought year (Bagla 2002). The bottom-line here seems to be lack of ability both at IMD and NCMRWF to provide reliable medium and long-range forecasts due to the methodological problems associated with the weather forecasting (Gadgil et al. 2002). Part of the problem lies in the 16 parameter model that IMD employs in predicting the monsoon. However, predicting monsoons has not been a well crafted art because of the inherent problems in understanding the climate system as such.

Therefore, India needs to continue to look at its monsoon prediction methodology and develop method that is validated for its special needs. The available literature suggests many approaches. For example, the benefits of using neural networks that combines deterministic and stochastic models in producing a better forecast than the best standard method has been demonstrated (Navone and Ceccatto 1994). Similarly, predicting themonsoons using models that couples constantly changing ocean and atmospheric conditions with that of the terrestrial conditions has also been advocated (Kumar et al. 2005). However, these models are known to fail to predict the extreme evens such as droughts and floods. Hence, a shift from empirical to dynamic models has been suggested in order to enhance the forecasting skill (Gadgil et al. 2005). The country also needs to enhance the data processing facilities that utilize the large data collected by INSAT satellites that is lying unused.

Another area that needs significant improvement is making available the relevant forecasts that help the end-users to take decisions with more confidence. One of the ways of doing it is by improving the consistency, quality and value of the forecasts (Murphy 1993). Currently, the operational forecast of the monsoon in India is a gross prediction on whether the monsoon is going to be normal or deficit. Providing the information specific to the spatial and temporal scales is important for the prediction to be useful for the local level planning, which is not within the means of prediction at present, given the extreme complexity of the monsoon system (Ramachandran 2003). Such value-added climate information with sufficient lead-time to plan appropriate management options would certainly enhance the adaptive capacity of the communities to the extremes. There is also a need to integrate the climate forecasts with other aspects of infrastructure and input supply such as seeds and fertilizers (Blench 1999). Taking into consideration the complex nature of seasonal and inter-annual climate forecasting, Meinke and Stone (2005) suggested a participatory and cross-disciplinary approach by bringing together institutions (partner-ships), disciplines (e.g., climate science, agricultural and rural sociology) and people (scientists, policy makers and direct beneficiaries) as equal partners so that appropriate management decisions could be made from the available forecasts. A similar approach is needed for reliable drought preparedness in India.

Drought monitoring

The quality of decisions made by the decision makers is directly affected by the availability of right information at the right time (Redmond 1991). The drought monitoring system in India in the form of CWWG and its state level counterparts needs to be supported with a more reliable and near-real-time or real-time drought monitoring system that enables them to reduce the delays in decision making. India has a good network of weather stations that monitor various parameters of weather that could be effectively integrated into a Geographical Information System showing the drought conditions in the country. Such a monitoring system has been developed in the USA. The goal of the US drought monitor is to track and display the magnitude and spatial extent of drought and its impacts (Svoboda et al. 2002). It presents the current drought conditions in an easy to read format and can be readily used by the local level administrators, scientists and media personnel. In the Indian context, such a monitoring tool should also help the decision makers to quickly estimate the crop losses due to drought (Samra 2004).

The Southeast Asia Drought Monitor developed by the International Water Management Institute (IWMI), which currently covers only the western India, Afghanistan and Pakistan, can be a good beginning (Thenkabail et al. 2004). This monitor provides drought information at the regional, district/provincial and pixel level (currently 0.5x0.5 m) and helps local administrators to monitor and mitigate the drought impacts. Still under development, this tool heavily depends on the remote sensing data and needs to consider the ground information such as meteorological and agricultural data to make this tool more dependable.

The Karnataka state in India deserves a special mention here. The state has established a special Drought Monitoring Center, an innovation in itself in the country, for monitoring state level drought onset conditions in order that the state administration plans in advance of the crisis. The center monitors rainfall, water-reservoir levels and other relevant parameters on daily basis in the rainy season (Samra 2004). This innovation would have to be looked into more closely on its effectiveness and be replicated to other states as well. This improves the capacity of states in terms of analyzing the weather information and put to use for practical purposes, as the states have been heavily depending on the national level institutions such as IMD for this purpose.

Enhanced operational preparedness

The above drought monitoring system would be effective if it is supported by an enhanced operational preparedness for initiating quick response. Success stories are available on use of climate information in decision making and avoiding the possible risks (Glantz 2003). The drought of 2002 also provides us a good lesson in this regard. During 2002, after a good start in June, the monsoon failed to progress in the crucial month of July, the wettest month in India's monsoon (Bagla 2002). The monsoon revived effectively by August and continued till the end of September. Though the July failure has caused major crop loss, there was no means for the government and market system to respond to the revived monsoon and make available necessary short duration alternative crop seeds those could have been sown and satisfactory crop could have been obtained in many parts of the country (Department of Agriculture and Cooperation 2004). This is despite the fact that there exists sufficient knowledge on the mid-course corrections with the local agricultural departments (Venkateswarlu 1987). It shows that the agricultural input supply mechanisms need to be revived such that they respond quickly to the monsoon.

Conclusion

In this paper we considered the available evidences for the climate change over Indian sub-continent and assessed the existing preparedness and mitigation mechanisms for drought risk reduction in the country. We understand that the absence of region specific climate change scenarios would certainly hamper the utility of existing information for use at the policy level and there is a greater need to address the uncertainty of future climate change in order to identify appropriate adaptation options (Pittock and Jones 2000). It has been suggested that the existing limitations in dealing with uncertainties can be effectively dealt with if an integrated assessment of climate change impacts on biophysical, environmental and socioeconomic aspects be carried out by downscaling the outputs from the global and regional simulation models, which would enhance the utility of climate change prediction research for regional policy planning (Mall et al. 2006).

In absence of confidence about future changes in risk and lack of familiarity with the problem, the policy makers are advised to be on watch and be more prepared (Fussel 2007). The no regret options, options which do not depend on the impact projections, should be identified and implemented. What we tried to do in this paper was to identify such no-regret options that would improve upon the existing interventions, hence reducing the vulnerabilities to a greater extent. Among all the adaptation measures identified and elaborated, the community based preparedness and mitigation planning is the key as it would greatly enhance the capacities of communities by broadening their coping range. The

community based adaptation mechanisms over the length and breadth of the country should be identified, improved upon them and scaled up to larger areas with similar socio-economic backgrounds. Similarly, there is a greater need for clarity in center-state relationships in dealing with the natural hazards such as droughts. The country is also need to brief up its drought prediction and monitoring mechanism in order to initiate a timely response through enhanced operational preparedness.

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