Global NEST Journal, Vol 17 No 1, pp 41-49, 2015

CLIMATE CHANGE AND RURAL LIVELIHOODS-ADAPTATION AND VULNERABILITY IN RAJASTHAN

KAUSHIK G. *
SHARMA K.C.

Department of Environmental Science, School of Earth Sciences
Central University of Rajasthan, Bandarsindri, Ajmer, 305801, India

Received: 18/02/2012
Accepted: 02/12/2014
Available online: 12/01/2015

*to whom all correspondence should be addressed:
e-mail: garimakaushik@curaj.ac.in

ABSTRACT

Rajasthan, with its climate ranging from arid to semi-arid to sub-humid, and rapidly depleting natural resources, is already experiencing the effects of climate change. The region's climate is projected to become harsher, with increased average temperatures, intensity of rainfall events, and increased variability in space & time of monsoon rains being consistently projected for the region. Without action in the form of adaptation of social, human, economic, and natural resource management systems, these weather changes are predicted to result in decreasing surface and ground water availability, flash floods, degradation of soil resources, decrease in crop yields, greater vulnerability to crop pest outbreaks, and declines in forest and pastureland ecosystem goods and services, thus rendering agricultural and herding communities extremely vulnerable to weather related losses of life, livelihood, and food security.

In Rajasthan, government is focussing for sustainable development and climate change adaptation by finding and administering alternative methods to deal with issues of poverty and environmental degradation in context of linkage between livelihood and the immediate environment of the people. The livelihoods of the rural poor are directly dependent on environmental resources like land, water, forests — and are vulnerable to weather and climate variability. Climate change affects every aspect of society, environment and economy requiring adjustments in behaviour, livelihoods, infrastructure, laws, policies and institutions in response to experienced based expected climatic events. However, it was found that local coping strategies and traditional knowledge need to be used in synergy with government and local interventions. Solutions must be integrated to address the interrelationships between water, agriculture, forests and pastures, livestock. Finally, there is great potential for existing policies and schemes to be employed synergistically towards building true adaptive capacity for the rural communities. However, adapting to climate change will entail adjustments and implementation at every level – from community to national and international.

Keywords: Rajasthan, Climate change, Natural resources, Livelihoods, adaptation

1. Introduction

The global climate is changing: the impacts associated with the accumulation of greenhouse gases in the atmosphere from human activities–changes in mean temperature, shifts in seasons and an increasing intensity of extreme weather events–are already occurring and will worsen in the future. Millions of people, particularly those in developing countries, face shortages of water and food and greater risks to health. Adaptation measures that reduce vulnerability to climate change are critical, especially in many countries where the risks are here and now.

India, is particularly concerned about climate change due to the importance of climate-sensitive sectors – notably agriculture, forestry, fisheries and also because around two-thirds of the population are rural and depend on climate sensitive natural resources (Chatterjee *et al.*, 2005). In India, climate change will put additional stress on ecological and socio-economic systems that are already facing tremendous pressures due to rapid urbanization, industrialization and economic development. With its huge and growing population, long densely populated and low-lying coastline and an economy that is closely tied to its natural resource base, India is considered to be especially vulnerable to the impacts of climate change (Schipper *et al.*, 2008).

Rajasthan, with its climate ranging from arid to semi-arid to sub-humid, and rapidly depleting natural resources, is already experiencing the effects of climate change. The region's climate is projected to become harsher, with increased average temperatures, increased intensity of rainfall events, and increased variability in space and time of monsoon rains being consistently projected for the region. Without action in the form of adaptation of social, human, economic, and natural resource management systems, these weather changes are predicted to result in decreasing surface and ground water availability, flash floods, degradation of soil resources, decrease in crop yields, greater vulnerability to crop pest outbreaks, and declines in forest and pastureland ecosystem goods and services, thus rendering agricultural and herding communities extremely vulnerable to weather related losses of life, livelihood, and food security. Rural development and natural resource management efforts must factor in this increased variability and vulnerability in order to implement sustainable solutions to accelerating cycles of poverty and environmental degradation.

The state covers over 10% of the land area of India, is home to 5% of its human population, of whom 75% are dependent on agriculture and/or animal husbandry for livelihood, but has only 1.2% of India's water resources. With over 60% of Rajasthan's agriculture being rain-fed, or largely non-irrigated, a majority of Rajasthan's landholding farmers holding one hectare or less, and over 20% of rural people being landless, the state faces many rural development challenges. Most of these challenges stem from chronic water shortages. While not a new phenomenon in the state, it is clear that the current combination of unsustainable land-use practices and a changing weather patterns have accelerated natural resource depletion such that food and water security are at serious risk, putting adaptation to climate change at the forefront of development concerns (Rathore, 2005).

This paper review aims to provide a glimpse of some of the activities and policies addressing facets of climate change adaptation that are being undertaken by communities, NGO's, research institutions, private enterprise, and government, as well as summarize the major challenges of climate change adaptation in Rajasthan. Efforts have also been made to take into account the analysis of implemented policies as response mechanism against the threats such as climate change.

2. Current Realities

Rajasthan, the largest state of the country situated in the western side of the country faces severe water scarcity, has poor rainfall, and is classified as arid/semi-arid region. On the basis of climatic conditions and agricultural practices, Rajasthan is divided into 10 agro-climatic zones ranging from arid western to flood prone eastern. State's major economy is associated with agriculture which is entirely dependent on rainfall. The farmers' concerns are generallycentred around water: growing unpredictability in the onset, duration, and intensity of the monsoon rains, a high degree of spatiotemporal variation in intensity and amount, increasing drought frequency, rising water demands, dropping water tables, and declines in quality of water. They point to cause and effect relationships between these water changes, and changes in their land-based livelihoods.

Changes in the amount of forest cover, due to previous clearing and poor regeneration, has led also to a lack of available forest resources, such as fodder and food. Changes in forest biodiversity has had effects not only on livelihoods, but on traditional decision making strategies for farming, which, these

farmers recalled, relied on faunal indicators and signals. Now these fauna have disappeared, their signals are no longer available, and are being replaced by a reliance on weather forecasting.

The traditional resilience strategy of maintaining livestock, too, is facing challenges due to weather and land use change: grass diversity in the pastures has decreased, with noticeable impacts on animal health, and ultimately shrinking flock sizes of herders whose animals either die, are sold, or simply abandoned. With declines in fodder quality and availability, people's private lands can no longer suffice to support livestock, and as one testimonial put it, now "public lands are used for private purposes".

In the context of climate change adaptation, these observations point to the erosion of, and need to support the building of strong natural, social, and human capitals in order to meet the growing challenges facing rural people in Rajasthan Thus, society will require robust knowledge to pursue strategies for mitigation as well as adaptation in order to address the challenges associated with global warming and climate change (Shah, 2009).

3. Adaptation and Vulnerability

Adaptation to climate change cannot be defined as a set of fixed activities meant to ameliorate a particular set of conditions. Instead it must be a systemic response aimed at creating and preserving options that enable communities to respond to changing environmental and social conditions. It is important to take into account the local information while framing adaptation strategies to deal with the potential multi-sectorial impact of climate change. Any climate change response strategy will only be effective if it involves the two realms of adaptation and development together with a proper understanding of integrated policies meant to sustain the local needs (IUCN 2004).

The often the terms "coping with," "resilience" and "adaptation" are used interchangeably, though they imply respectively, survival, recovery, and progress after a loss, be it sudden loss, as in catastrophic drought, or gradual loss, as in progressive decline in water availability. The term "vulnerability" here is used as a concept that encompasses a combination of exposure and sensitivity to weather changes, and adaptive capacity (the latter being an ability to adjust) enabled by a combination of natural, social and human capitals. Consequently, to reduce vulnerability, adaptive capacity must be built across the various components.

4. The green revolution and its effect on resilience of rural livelihoods

4.1 Agriculture

The relationship between climate change and agriculture is two-way; agriculture contributes to climate change in several major ways and climate change in general adversely affects agriculture. It is often recognized that climate change will disproportionately affect the rural poor and marginalized communities, such as the Below Poverty Line (BPL). However, it is also true that in agrarian economies, weather-related disasters – in Rajasthan, largely droughts – have the ability to confer catastrophic losses on all sectors of society. Thus, those who have largely benefited from and arisen out of poverty from past decades of agricultural development interventions may experience a different kind of vulnerability to effects of climate change – one largely dependent on high input, water demanding, exogenously developed agricultural systems, which are least adapted to the harsh natural conditions and increasing variability.

Water scarcity has both its origins and its most immediate and visible effects on agriculture, and solutions addressing the two topics cannot be easily viewed in isolation. Unreliable monsoons and declining availability of groundwater, compounding the effects of saline soils, soil erosion, and increasing rates of evapo-transpiration due to rising temperatures have the effect of decreasing the marginal returns on agriculture for large farmers, and putting food security for subsistence farmers in a precarious position (Morton, 2007). Green Revolution technologies developed in entirely different agro-climatic zones, when transplanted to Rajasthan's semi-arid areas, have resulted in a heightened need for

irrigation and bore wells, leading to excessive groundwater abstraction, ultimately affecting everyone, urban and rural, large landowner and marginal farmer alike. In the context of changing climate, one study (Sanghi and Mendelsohn, 2008) concluded that in much of southern and eastern Rajasthan, elevated temperatures and evapo-transpiration are likely to result in net decreases in farm income, even without factoring in catastrophic drought events.

Given that a small percentage of the state's farmers have access to irrigation, resilience strategies for agricultural production must consider a variety of options, and those options must be based on local conditions, agro-climatic variation from district to district, and locale specific water availability, in addition to offering options for farmers with different landholding sizes. Besides the use of traditional and/or improved crops and varieties which can withstand low water, heat, and soil salinity, promoting agricultural practices that build soil fertility, retain moisture, and confer pest resistance, such as intercropping of diverse crops, green manuring, mulching, vermicomposting, and low-till methods can build systems that require low inputs, thereby increasing the marginal returns on agriculture for both food security as well as livelihoods purposes. Organic agricultural systems may be suited to Rajasthan's large population of marginal farmers because the optimization of soil health, water conservation, quality of product, and maintenance of diversity do not allow a reliance on traditional economies of scale models for farm inputs. Returns on horticulture (fruits, vegetables, flowers) are estimated to be greater than returns on grain crops. Thus, expanding efforts to include regionally appropriate horticultural crops will provide a more diverse income base, and needed nutritional additions to subsistence farmers (ICAR, 2010).

Moreover, agro-forestry plantations have significant co-benefits such as soil retention, water infiltration, micro-climate modulation, and fuel wood provisioning. Tree-based farming, however, requires an investment in time before yields start, and is not amenable to crop switching, thus may be perceived as higher risk systems. Finally, it must be noted that sustainable, locally appropriate agricultural systems and technologies are not useful unless the food security value and market potential of any change in practice can be demonstrated to farmers. While it may be ecologically sound to use organic methods or plant rain-fed crops such as pearl millet (*bajra*), equal emphasis must be put on developing reliable and lucrative markets for these crops, especially when they are meant to replace staples such as wheat which have a domestic as well as international market.

There are several initiatives in progress in the state that address issues of sustainable agriculture, many of which also include development of market linkages. Research institutions in the state are conducting research addressing climate-ready varieties, low-input technologies, and contingency crop planning based on weather forecasting, as well as capacity building.

4.2 Livestock and livestock health

Where livestock are vulnerable, pastoralists are vulnerable. The direct effects of climate change, in particular a rise in temperatures, may lead to physiological stresses on livestock that would reduce their productivity of milk, wool, meat, and draught ability, and affect reproduction success. Heat stress will also result in greater water and food needs of livestock, and increases in disease incidence. In vulnerable livestock populations, that is, those which may be suffering from nutritional or water stress, the probability of disease spread will be even greater. While breeding and livestock improvement programmes may begin to address some of these projected problems, it is clear that there must be a resilience strategy for livestock as well that relies on maintaining animal health and immunity by ensuring water, amount and quality of fodder, and maintaining breeds that are appropriate for local conditions.

Over the longer-term, indigenous breeds may be a more valuable starting point for continued breeding and artificial selection, over the low-value goat breed that is commonly kept. Moreover, developing a strategy of mixed breed flocks, not commonly practiced, may also help to ensure diversity, and therefore resilience for livestock herders. Finally, livestock related incomes need not be only dairy. Rajasthan's herders keep sheep as well as goats, and development of a village wool production and

value added industry, while not currently ongoing, has in the past been a viable economic activity and may be an option for future.

5. Common property resource management

Vulnerability to the effects of droughts for a particular household, or for a geographic area on the whole, will change as a function of changes in the various forms of capital. For example, healthy natural capital stocks such as forests, pastures and groundwater will not only ameliorate the bio-physical severity of drought, but will serve to buffer communities by providing them with resources and income besides farm products.

5.1 Water

Any strategy for climate change adaptation in Rajasthan must be focused around water. Water scarcity lies at the root of most of the adaptation challenges that people in the state are facing. This scarcity has its origins on the continuously increasing water demands, inequity of access, low water use efficiency; hence, leading to unsustainable usage patterns of water. On average 90% of drinking water and 60% of agricultural water is extracted from groundwater reserves, while out of the state's 237 administrative blocks, 207 are designated as groundwater "dark zones" since abstraction rates have exceeded recharge rates, such that natural recovery is impossible. Water availability in Rajasthan is 780 m^3 per annum per capita, far short of the accepted minimum requirement of 1000 m^3 for arid zone areas; furthermore, it is projected to drop to 450 m^3 by the year 2050 (Hussain and Husain, 2012). Drought to date has been considered an "event" to be managed in the short-term, creating a dependency among people for governmental assistance, as opposed to capacitating them to manage their own resources for any eventuality (Chaterjee *et al.*, 2005).

Demands on water resources in the rural areas have increased, in large part due to Green Revolution technologies being adopted in the agro-climatic zones for which they are not well suited; these technologies rely on consistent and ample water supplies being available. A reliance on these technologies can result in devastating impacts when the rain fails and groundwater reserves are already low. While often relied upon for irrigation, groundwater's first and foremost use is meant to be for human consumption; thus, demand-management strategies for water conservation must address the issue of use appropriate crop varieties if an agricultural economy and water security are to co-exist in Rajasthan's rural areas.

Current policy for areas designated as groundwater "dark zones" put restrictions on digging of new borewells, using electrical pumps, and require new builders to mitigate their water footprint through recharge measures. While these steps are necessary to slow further unsustainable abstraction, there remains a need also for preventative policy measures to be put in place to protect the 13% of aquifers which are not designated as dark zone from unsustainable use (Ramesh and Yadava, 2005).

Rajasthan has recently adopted the Integrated Water Resources Management (IWRM) approach to managing its resources. The state's water policy, unveiled in February 2010, combines a bottom-up, community-based approach to governance and decision-making regarding water resources, and a top-down approach to technical support. The policy requires coordinated planning of all agencies dealing with water by a single agency, the Department of Water Resources, and among other things, mandates micro-watershed level planning, a focus on use efficiency and demand-management, and formulation of community-based water user groups (WUG), facilitated by NGO's, in order to involve ownership of the entire populace; moreover, prioritization of water uses lists human and animal uses as the top priorities, and agriculture and industry lower down, thus protecting communities against the privatization of their water resources. While the policy makes great strides toward ensuring water planning and water security for the people of the state, developing capacity and commitment in order to effectively implement this policy is a major task ahead, and requires engagement at all levels of society.

5.2 Forests and grazing lands

Livestock, while often considered to be a major contributor to climate change, have long been a risk reduction mechanism for people living in Rajasthan and must factor heavily in adaptation planning. In an area where agriculture has always been subject to the possibility of drought and crop failure, livestock have provided communities with a resilience strategy. While different groups have maintained both herding and agriculture to different extents traditionally, thus maintaining some degree of distinct resource needs, communities are now becoming more homogeneous in their livelihood activities, and are abandoning migratory herding, resulting in increased grazing pressures on common property pastures, whether they be panchayat land, revenue wastelands, or forests. The landless or marginal landowners must rely largely on common property resources, which comprise 30% of the Rajasthan's area and provide BPL families with 20% of their income, for grazing their animals and collecting fodder. Thus, any natural resource management efforts must address sustainable and equitable use of the commons.

Increased pressure can be exacerbated due to other factors, such as lack of regulation on the amount of grazing allowed, and absence of boundary enforcement by a village or habitation, and even further compounded by weather variables, with poor rainfalls affecting productivity of pastures and grazing lands, as well as crops. Crop failures may result in farm-based fodder shortages, thus adding another component of pressures on the commons. Short-term relief efforts by the government include distribution of fodder kits; however these are useful only for those with land on which to plant it. Short-term solutions, such as dry fodder banks, are needed as well for landless or marginal farmers for fodder needs in the event of weather catastrophes.

Over the medium and longer-term, it is clear that adaptation capacity must revolve around building strong community institutions, collective decision making, and unified enforcement of decisions meant to restore the productivity of common property resources (CPR).Additional benefits from protecting the commons have arisen in recent years. Given the ecosystem service benefits of re-vegetation of common property areas, that is, carbon sequestration, soil conservation, and groundwater infiltration, communities could develop incentives-for- environmental-services agreements. While such agreements are complicated to develop, enforce, and monitor, they could provide an added financial benefit from CPR protection, thereby adding one more layer to a resilience strategy of multiple sources of sustenance. Such funds could be used as revolving funds for further community livelihood development, collective development projects and short-term relief needs.

The benefits of ecosystem restoration for climate change adaptation strategy are similar for grasslands or forested lands, and are often called "drought-proofing" an area. Increased vegetative cover buffers the effects of warming trends and the increased weather variability by retaining soil moisture, increasing water infiltration into underlying aquifers, preventing soil erosion, and increasing productivity. When re-vegetation is assisted by communities by planting and nurturing diverse native species, this has concomitant benefits for fodder quality, non-timber forest produce availability, and resilience of the restored ecosystem itself.

6. Migration and non farm livelihoods

Migration has been a traditional resilience strategy, and moving due to weather related change is not a new concept for many pastoral peoples of Rajasthan. Today, as agricultural economies become less viable, migration from resource-poor areas has become commonplace as people follow opportunities to earn a supplemental income with daily wage labour.

According to a regional NGO, more than 60% of households reported that seasonal labour provided them with almost half of their annual income. Studies of multiple drought and flood events in South Asia (Moench and Dixit, 2004) showed that maintaining non-farm income sources through seasonal or permanent migration was the single most important measure of a family's ability to cope and rebuild their farm-based livelihoods after an extreme event. Thus, diversification into non-agricultural

livelihoods is not only a critical short-term coping strategy, it is also critical for the resilience of agricultural livelihood systems themselves.

Many NGO's work to develop alternative livelihoods with communities, such as handicraft development and marketing, value added non-timber forest products, and small-scale food processing. These are largely meant to provide diversification of farm-based incomes, often facilitated by formation of Common Interest Groups or Self-Help Groups. In addition to the benefits of a more diverse income base, these social institutions can provide crucial support systems to women during times of extreme weather related losses, providing, for example, access to information and credit. Building skills and reducing the risk and exploitation that the migration process often holds is important for helping families retain options for their immediate coping needs and future adaptive capacity.

7. Innovations in knowledge and finance

Knowledge is one of the key factors for design of suitable interventions to respond to the threats of climate change. The state's mission on Strategic Knowledge on Climate Change intends to create a knowledge system that would help take actions to reduce vulnerabilities as well as take advantage of the mitigation opportunities. Strategic Knowledge on Climate change is therefore, the system of knowledge that is required by various stakeholders to respond to climate change. The mission is cross cutting in nature and is intended to serve as a support mission for generating and providing strategic knowledge to all other thematic missions under the State Action Plan on Climate Change, in consonance with the National Mission on Strategic Knowledge for Climate Change (RSACC, 2011).

One of the key factors identified by Moench and Dixit (2004) in determining adaptive capacity is the flow of information. This is true for short-term responses to extreme events, and is also true for building longer-term adaptive capacity. Access to information and knowledge of how to employ it enables communities to develop their own early warning signals, and link what they are experiencing to the larger global picture, thus helping them to envision their own options. Moreover, information often reduces the perception of risk and makes farmers more willing to innovate.

Some NGO initiatives that focus on weather forecasting and agricultural advice, and which enable local community members to manage the systems include AFPRO and partners' agro-met station, located in a village in southern Rajasthan, with the goal of providing weather data to farmers who integrate it with traditional knowledge to make decisions on crop planning. Society for the Promotion of Wasteland Development (SPWD) and partners have built an internet-enabled Village Resource Centre which provides farmers with information on the changing farming scenario, GIS data on the watershed, and links to agricultural extension experts who can advise them about problems they may be facing. The VRC serves to facilitate NREGA micro-planning for panchayats so that funds can be used effectively for their priority needs.

Among the most well-known information dissemination models are Indian Tobacco Corporation's (ITC) e-choupals, entrepreneurial internet-enabled kiosks which provide information on daily crop pricing, weather, and agricultural advice. The information is disseminated free of cost, with the assumption being that farmers will opt to sell their crops to ITC at the quoted rate, and with the agricultural information will produce a higher quality product. The local person who has been trained to disseminate the information receives a commission if the farmer sells to ITC, the farmer receives a fair price with no middleman or the option to sell elsewhere (with competing buyers often offering higher rates in response), and ITC receives a reliable supply of high-quality produce.

New informational needs lie not only in weather forecasting and agricultural advice, but for example, in the implementation of community water management, as per the new water policy. Interpretation of groundwater data and GIS information on NRM issues will help provide true capacity for decision making, as opposed to the models of simple information dissemination about single issues.

7.1 Crop Insurance

At the governmental level, subsidies for transitioning to organic farming, advocacy of reduced input methods, and the recent weather-based crop insurance program are included in the repertoire of risk management and risk reduction strategies that are aligned with climate change adaptation.**Weather Based Crop Insurance Scheme** aims to mitigate the hardship of the insured farmers against the likelihood of financial loss on account of anticipated crop loss resulting from incidence of adverse Weather conditions. The scheme covers the risk of weather related issues like rainfall, frost, heat (temperature), humidity etc. Insurance against crop losses must take into account the crop specific weather requirements, and verify losses with weather data taken at the block level. It does not, at this point, compensate farmers whose crop losses also resulted in loss of winter fodder that comes from crop residues. This may be a point for further enhancement of this scheme (Mall *et al.*, 2006). Around 40 crops are insured under the category for various climatic phenomena like deficit rainfall, dry-spell, excess rainfall, low temperature, high temperature, high humidity, and high wind (RSACC, 2011).

8. Implementation

To be able to implement the various strategies and actions proposed in the State Action Plan for Climate Change, implementing agencies could play a very significant role in this regard. These could be in the form of academic institutes, research institutes, universities in case of research and development (R & D), private sector in case of technology implementation, government departments in case of creating fiscal structures and community based organizations, scientific organisations for raising awareness and capacity building.

One example of the implementation program in the state is rainwater harvesting, which has met with enormous success in parts entire parts of the state, using traditional harvesting and recharge structures that take advantage of the topographical and permeability features of the land to harvest and store rainwater, reviving old structures in some cases with modern additions to make them more efficient and longer-lived. There exists a diversity of rainwater harvesting methods, each one tailored to the particular history, landscape characteristics, and needs of the population. This policy has been identified as one of the strategy in the form of ground water management by constructing for instance, check basins, percolation ponds, artificial recharge through dug wells structures, etc. with particular focus on critical and over-exploited regions of the state. Public awareness campaign to encourage rain water harvesting in rural and urban areas along with capacity building of farmers to adopt scientific water management practices through education and training on improved farm practices, such as through the use of sprinkler and drip irrigation systems.

Similarly other social, natural and human capital areas are to be strengthened through effective implementation and adoption of state policy and programs in all the areas. For ensuring greater success at implementation level coordination between different nodal departments and diverse stakeholders is critical for sustainability of specific strategies adopted by the state action plan for climate change.

9. Conclusions

Within the State Environment Mission, some sectors have been identified as being critical in terms of the climate change impacts on them. These include human health, agriculture and animal husbandry, enhanced energy efficiency including solar energy, and strategic knowledge for climate change. Hence, it is clear that single topic-specific interventions cannot provide what is needed to build adaptive capacity. Solutions must be integrated across spatial, social, and natural features boundaries. Across topical areas, several generalizations have emerged regarding building adaptive capacity. First, solutions and options must be place-based. That is, the specific bio-physical and social conditions of any particular village will determine how they experience climate change and its ramifications, and what they consider viable options. Secondly, community ownership of resources and their management is critical, and community institutions must involve all members in order to implement solutions that cut across social

barriers. Thirdly, adaptation requires flexibility and options. There must be room for experimentation in development projects, which requires a lowering of perceived risk. Fourth, access to information allows communities to exercise and build their own options with knowledge of the larger context. Any strategy for adaptive capacity building should account for short, medium, and long-term measures that build communities' abilities to cope, recover, and progress in the face of changing and unpredictable conditions. Natural, social and human capitals are critical in creating and preserving viable options, using the expertise and experiences of numerous civil society organizations. Finally, there is great potential for existing policies and schemes to be employed synergistically towards building true adaptive capacity for the rural communities of Rajasthan.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Associate Editor and two anonymous reviewers for their constructive comments which much improved the quality of the manuscript.

REFERENCES

Chatterjee K., Chatterjee A. and Das S. (2005), Case Study 2: India. Community Adaptation to Drought in Rajasthan, *IDS Bulletin,* **36**(4), 33-52.

Hussain J. and Husain I. (2012), Water Harvesting to Augment Water Resources: Traditional Technology and Communities are Part of the Solution, Workshop Abstracts proceedings, Water and Food Security, **94**, Stockholm.

ICAR (2010-2011), Annual Report, ICAR network project on climate change.

IUCN / IISD / IISDnet. 2004, Sustainable livelihoods and climate change adaptation. A review of phase one activities for the project "Climate Change, Vulnerable Communities and Adaptation".

Mall R., Singh R., Gupta A., Srinivasan G. and Rathore L. (2006),Impact of climate change on Indian agriculture: A review, *Climatic Change,* **78**(2), 445-478.

Moench M. and Dixit A. (2004), Adaptive Capacity and Livelihood Resilience: Adaptive Strategies for Responding to Floods and Droughts in South Asia, The Institute for Social and Environmental Transition, International, Boulder, Colorado, U.S.A. and Institute for Social and Environmental Transition, Nepal.

Morton J. (2007), The impact of climate change on small holder and subsistence agriculture. *PNAS,* **105**, 19680-19685.

Ramesh R. and Yadava M.G. (2005), Climate and water resources of India, *Current Science,* **89**(5), 818-824.

Rathore M.S. (2005), State level analysis of drought policies and impacts in Rajasthan, India. Colombo, Sri Lanka: IWMI. *(Working paper 93: Drought Series Paper No. 6).*

RSACC (2011), Rajasthan State Action Plan on Climate Change. Government of Rajasthan, [http://rpcb/ReportsAndPaper/ClimateChange.PDF] (Accessed on June 20, 2014).

Sanghi A. and Mendelsohn R. (2008), The impacts of global warming on farmers in Brazil and India, *Global Environmental Change,* **18**, 655–665.

Schipper E.L.F., Cigarán M.P. and Hedger M.M. (2006), Adaptation to climate change: the new challenge for development in the developing world, An Environment & Energy Group Publication.

Shah T. (2009), Climate change and groundwater: India's opportunities for mitigation and adaptation, *Environmental Research Letters,* **4**, 035005, doi:10.1088/1748-9326/4/3/03500.