 J Biodiversity, 6(1,2): 22-29 (2015)

Traditional Knowledge for Biodiversity Conservation, Maintain Ecosystem Services and Livelihood Security in the Context of Climate Change: Case Studies from West Bengal, India

Raktima Mukhopadhyay and S. B. Roy

Indian Institute of Bio Social Research and Development (IBRAD), VIP Road, Kestopur, Prafulla Kanan, Kolkata 700101, West Bengal, India
E-mail: <info@ibradindia.org>, <ibrad@giascl01.vsnl.net.in>

KEYWORDS Traditional Knowledge. Forest Ecosystem. Sacred Groves. Ethno Medicine. Spiritual Ecosystem. Services

ABSTRACT India is facing the challenge and threat of climate change that has serious consequences on the food and livelihood security of people depending on climate sensitive livelihood practices. The close association and dependence of the indigenous and rural people on natural ecosystems have developed their acumen to identify any changes in the nature and to develop adaptive measures under climatic variability. Such Traditional Knowledge can provide critical insights to develop climate change adaptation and mitigation strategies that are cost-effective, participatory, and sustainable. This is recognized at the highest bodies at the international level also. The present paper is prepared based on the studies conducted in four districts of West Bengal, India to assess the traditional knowledge and practices of the local people for conservation of biodiversity and its associated ecosystem services that can help in designing adaptive measures, ensure livelihood security and heighten resilience under climatic stress.

INTRODUCTION

India, a country with nearly seventy percent of rural population, is facing the constant challenge and threat of climate change. According to the report of Maplecroft (2010), India is ranked as the second most vulnerable country in the world to extreme climate related events and changes in major climate parameters. The report states: 'Almost the whole of India has a high or extreme degree of sensitivity to climate change, due to acute population pressure and a consequential strain on natural resources. This is compounded by a high degree of poverty, poor general health and the agricultural dependency of much of the populace.'

About 833 million (Census of India 2011) of rural population of the country who depend on natural resource based climate sensitive livelihood like agriculture, water and forestry are going to be the worst hit in the years to come. The changes in the climatic conditions have direct impact on the livelihood security of the people in these sectors. As projected "a rise of up to 4°C in surface air temperature would affect many sectors such as agriculture and in case of wheat even a rise in temperature of only 1°C would cause drop in wheat production by 4-5 million tons" (WBSAPCC 2010). Erratic monsoons will not only have negative impact on India's rainfed agriculture, but would also affect the water and power supply. Displacement along the coastline may happen due to rise in sea level that would also threaten freshwater sources. It is projected that over 50 percent of India's forests are likely to experience a shift in forest types causing loss of biodiversity and livelihoods based on forest products. Altogether climate change is going to hit the food and livelihood security of millions of Indians.

Address of correspondence:
Dr. Raktima Mukhupadhyay
Executive Director
IBRAD (Indian Institute of Bio Social Research and Development)
VIP Road, Kestopur, Prafulla Kanan
Kolkata 700 101, West Bengal, India
Phone: 033 66210310, 09830266403
Fax: 033 66 210300
E-mail: info@ibradindia.org, raktima1967@gmail.com

Traditional Knowledge and Practices to Adapt to Climate Change

While there have been many efforts, strategies and action plans made to address the issue of climate change, identification and rejuvenation of traditional knowledge and practices can offer alternatives of our resource use pattern to facilitate the process of climate change adaptation. The intricate interaction and dependence of indigenous population on natural ecosystems

have developed their acumen for preparing adaptive measures under climatic variability over time. Such traditional knowledge can provide critical insights to develop climate change adaptation strategies in the present context. The agility of the community to cope with or adjust to the impacts of the climate would provide options to reduce vulnerability related to the changing climate.

Traditional or Indigenous knowledge has been defined as institutionalized local knowledge that has been built upon and passed on from one generation to the other by word of mouth (Osunade 1994; Warren 1992) and forms the basis for local-level decision-making in many rural communities. "It is a cumulative body of knowledge, practices, and beliefs evolving by adaptive processes and handed down through generations by cultural transmission, about the relation of living beings (including humans) with one another and with their environment (Berkes et al. 2000)." The knowledge set is influenced by the previous generation's observations and experiment (Woodley 1991) and provides an inherent connection to one's surroundings and environment.

"The social elements that increase the adaptive capacity of social–ecological systems include traditional ecological knowledge and institutions that store collective memory and promote social cohesion within communities" (Berkes et al. 2003). Over time, resilient social–ecological systems are able to adapt to change and reorganise after disturbance, thereby maintaining ecological structure and function and associated ecosystem services (Blondel 2006).

These communities based and collectively hold traditional knowledge can help in developing cost-effective and sustainable climate change adaptation and mitigation measures. This was reaffirmed at the 32nd Session of the IPCC 2010 which states that "indigenous or traditional knowledge may prove useful for understanding the potential of certain adaptation strategies that are cost-effective, participatory and sustainable" (http://unu.edu/publications/articles/why-traditional-knowledge-holds-the-key-to-climate-change.html).

With their close association with nature, the indigenous people can interpret any change in the nature and environment. "Traditional knowledge, innovations and adaptation practices embody local adaptive management to the changing environment, and complement scientific research, observations and monitoring" (IIPFCC 2009). They are constantly renewed through learning-by-doing, experimenting and knowledge building (Berkes 2012). Such knowledge with scientific validation would help in developing alternate models for climate change adaptation for replication in a much broader spatial and temporal scale to sustain resilience of socio - ecological systems.

Objectives

The present study was carried out with the objectives to explore and identify the relevance and of traditional knowledge and practices of the indigenous and rural communities for biodiversity conservation and maintain ecosystem services that can help in developing strategies for climate change adaption and mitigation enhance climate resilience and ensure livelihood security of the people.

MATERIAL AND METHODS

The present study was conducted in four districts of West Bengal, viz., Bankura, Paschim Medinipur, Jalpaiguri and South 24 Parganas in the year 2013. The study was supported by Deutsche Gesellschaft Für Internationale Zusammenarbeit (GIZ) India. The study was conducted by following both qualitative and quantitative methods.

Secondary Research

It included secondary desk research through review of literatures covering leading journals of Anthropology, Sociology and Traditional Knowledge, as well as from the field of Agriculture, Forestry, Animal Husbandry and Water Management. Altogether, 130 journals have been consulted covering 493 volumes and 1445 issues. Out of about 12500 articles 107 articles are shortlisted from India with 72 articles on West Bengal. Apart from these 12 books and 63 published papers are also studied.

Selection of Study Area

To identify the study area People of India West Bengal, Vol. XXXX Part I and Part II edited by Dr. K. S. Singh and People of India National

Series, The Scheduled Tribes edited by Dr. K. S. Singh were consulted. Further discussions were made with the officials of Anthropological Survey of India to identify the tribes with rich repository of Traditional knowledge and practices related to biodiversity conservation. Accordingly Lodha, Santhal and Toto tribes and their habitats are identified covering the districts of West Medinipur, Bankura and Jalpaiguri respectively. These districts are also facing the challenges of climatic vulnerabilities, projected negative impact of climate change in coming 50 years and have the major share of the state forest resources (WBSAPCC). Sundarban areas are also selected for the study considering high impact of the climate change in the area. Lodha and Toto are declared as primitive tribes and it is assumed that they would be a rich source of Traditional Knowledge.

Application of Participatory Assessment Methods for Collection of Primary Data

Various methods are used to understand about the existing as well as abandoned traditional knowledge and practices in relation to conservation, coping and adaptation to climate risks considering the interdependent components of forest, water and agriculture. Participatory methods like Historical Transect, Seasonal Calendar, and Species Matrix etc are applied for identification of the Traditional Knowledge base of the people. *Focus Group Discussion* is held with the selected members of community, differentiated in terms of age, gender, education qualification and exposure to the outer world to identify the knowledge base. Recall method was used to facilitate the elder persons to recall the practices that were being used earlier. *In depth interviews* were conducted with the elder persons, traditional healers etc to capture their knowledge base.

Rationale for Selecting the Sectors

Three sectors, viz., agriculture, forest and water are covered in the present study that are also identified as the key sectors by The State Action Plan on Climate Change as they are likely to be most vulnerable in the context of climate change and require coping strategy to become resilient towards climate change. Efforts are made to identify the traditional practices and knowledge of the local people that are low input based, depended on recycling principles and generate minimum waste and promotes conservation of forest and agro biodiversity, water, soil etc. and therefore have minimum negative impact to act as driver for climate change.

RESULTS AND DISCUSSION

Traditional Knowledge has not been integrated much in designing the climate policy as most of them are not being documented properly. These are mostly held by oral transmissions through generations and are thus overlooked. The customary traditions and its associated traditional knowledge and practices are threatened and rapidly disappearing due to the shift in the practices of production and resource utilization pattern to adapt to the modern system of resource use to have higher yield, production and quick monetary return. The indigenous communities are exposed to significant stress of natural resources depletion in their traditional territories due to various economic forces and are often compelled to abandon their traditional practices. The disruption of the traditional resource base and its use pattern reduces their resilience to face the climatic variability.

Traditional Knowledge to Maintain the Biodiversity and Ecosystem Services

The traditional ways of living by the indigenous people were based on low carbon use. The cultural practices developed by the community and the social institutions created to maintain such practices promoted conservation of natural resources, biodiversity in particular, the natural ecosystems and its associated ecosystem services. This is largely a result of their inter dependence on local biodiversity and ecosystem services for their sustenance and well-being.

There have been traditional practices to conserve biodiversity by adopting various rituals and practices. The authors have documented some of the practices that are followed by the tribal communities in West Bengal that are found to be effective in the context of conservation of genetic resources under the threat of climate change.

Conservation of Forest Biodiversity Resources

Forest is adobe of rich biodiversity resources. Conservation of forest is expressed through

various management practices, one of the most effective being maintenance of sacred groves. Sacred groves is one of the unique traditional in-situ ways of nature conservation by active people's participation (Konar 2010). These are small patches of near virgin forests protected in the name of different deities. These sacred groves have rich repository of plant species and the species diversity are much higher than in the adjoining forest areas. A number of studies have emphasized that many sacred groves are repositories of rare species. Haridasan and Rao (1985) have reported at least 50 endangered and rare species in sacred groves of Meghalaya. Sacred grove provides micro-climatic conditions for the luxuriant growth of those plant species which are not present in the surrounding areas at the same altitude.

A study carried out covering 25 scared groves has identified 139 species of which 93 have ethno medicinal value which represent almost 1/3rd of the total medicinal plants found in West Midnapur District (Pandit 2011).

Sacred Grove and its Role in Maintaining Biodiversity

The Santhal tribes living in Jharia Bankathi, Guabari, Seyalkunda, Benechapa, Ghughudanga, Kulupukur, Lagardanga, Kharigara Kurarbari and Baburdanga villages under Bishnupur block in Bankura district of West Bengal maintain a scared place of about 1.5 acres of sal (*Shorea robusta*) forest in their respective villages. They have the belief that it protects them from all kinds of evils. These sacred grooves are the habitats for number of medicinal plants, like Ananta mul *(Tylophora indica),* Swata mul *(Asparagus recemosus),* Tulsi *(Oscimum sanctum),* Basak *(Adhatoda vasica),* Haritaki *(Terminalia chedula),* Aamlaki *(Emblica officinalis),* Bohera *(Terminalia bellirica),* Kalmegh *(Andrographis paniculata),* Swarpaganda *(Rauvolfia serpentine),* Gond *(Cochlospermum gossipium) etc*. The Santhals of Patharali Forest Protection Committee (FPC) of West Medinipur district under Khargapur Forest Division also maintains half acre area as the sacred groove, locally known as Jahirthan/Garamthan within the forest.

In Totopara in Jalpaiguri district the Toto tribes, one of the primitive tribes in India, maintain two sacred places in the name of gods, Ishpa and Cheima. Two hillocks are considered as the scared place where the two gods reside who protect them from any kind of evils and ailments. Sishu (*Dalbergia sissoo),* Sal (*Shorea robusta),* Gamhar (*Gmelina arborea),* Simul (*Bombax ceiba)* and Kadam (*Anthocephalas kadamba)* are the major tree species here. Totos conserve the forests in the two hills and protect them religiously. Apart from that the places where Peepal and Banayan trees are located is fully protected. Totos only use minor forest produces and firewood in a controlled manner and do not destroy the biodiversity resources.

These indigenous people also have rituals to control harvesting of forest produces. The Santhals start collecting sal leaves from the forest only after observing Salui festival in the month of Chaitra (Mid March to Mid April). Similarly they would start collecting sal fruits only after baha festival observed on the Full Moon Day of Holi.

Traditional Knowledge to Uphold Spiritual Eco System Services of Forest and Biodiversity Conservation

One of the major threats of climate change is projected to be loss of biodiversity. Traditional Knowledge and practices to recognize the spiritual services of the forest ecosystem in the form of maintaining sacred groves and places, associating religious belief with certain species, developing norms and rituals to have a regulatory process for controlled harvesting of the biodiversity resources would certainly be helpful in maintaining genetic and species diversity. Recognising the spiritual services of forest ecosystem through such traditional practices ensure maintaining off take sustainability and ecosystem sustainability of biodiversity and improve the sustained flow of ecosystem services.

Traditional Knowledge on Conservation and Use of Ethno Medicine

The Lodha community of Nayagram area in West Medinipur district of West Bengal possesses traditional knowledge to use different plants for treating various ailments. The knowledge is passed through generations orally. It is found during the study that they use about 70 species from forest (Table 1) as medicinal plants like *Rauwolfia serpentine, Ocimum sanctum, Premna herbacea, Aerva lantana, Andrographis paniculata, Aegle marmelos, Costus speciosus, Bryonia lacinosa, Euphorbia hirta, Justicia adhatoda, Jatropa curcas* etc. The plant parts are used to treat ailments like hyperten-

Table 1: Name of the medicinal plants, it's parts and uses by the Lodha Community in Nayagram, West Medinipu district, West Bengal

S. No.	*Name of medicinal species*	*Parts used*	*Diseases cured*
1	*Rauwolfia serpentina*	Root	Hypertension, Cold, fever, Abdominal pain
2	*Clerodendron serratum*	Root	Malaria , Anti infective
3	*Ocimum sanctum*	Leaves	Cold fever
4	*Aloe vera*	Leafy sten	Piles , Fistula, Anal fissure, Migraine
5	*Premna herbacea*	Tuber	Rheumatoid arthritis, Osteo arthritis
6	*Abrus precatorius*	Root , leaves	Leucorrhoea , Mumps
7	*Aerva lantana*	Root	Leucorrhoea
8	*Ambroma augusta*	Whole plant	Dismanorrhoea
9	*Andrographis paniculata*	Whole plant	Worm infestation , Malaria, Leprosy, Abdominal pain
10	*Aristolachia indica*	Root	Abdominal pain, Dysentery
11	*Asparagus recimosus*	Tuber	Leucorrhoea, Mastitis
12	*Azadirachta indica*	leaves	Worm infestation, Hepotospleenomagaly
13	*Azanza lampas*	Root	Pulmonary tuberculosis
14	*Cassia occidentalis*	Seed , Leaves	Dermatitis, Ringworm
15	*Catharanthus roseus*	Leaves	Diabetes
16	*Centella asiatica*	Leaves	Leprosy , Worm infestation, Dysentery
17	*Lasia heterophylla*	Tuber	Pulmonary tuberculosis
18	*Achyranthes aspera*	Leaves	Cold fever, Malaria
19	*Woodfordia floribunda*	Root , flower	Eye – ache, Dysmanorrhoea
20	*Caesalpinia bonducella*	Seed	Diabetes, Malaria, Dermatitis
21	*Clitorea ternatea*	Root	Visceromagaly
22	*Curculigo orchioides*	Tuber	Pulmonary tuberculosis
23	*Cymbopogon martini*	Leaves	Dysentery
24	*Gymnema sylvestre*	Leaves	Diabetes
25	*Jatropa curcas*	Latex	Dysentery
26	*Justicia adhatoda*	Leaves	Pulmonary tuberculosis, respiratory infection
27	*Buetteneria herbacea*	Tuber	Pulmonary tuberculosis, Filariasis
28	*Kalanchoe pinnata*	Leaves	Diarrhoea
29	*Lygodium pinatifidum*	Root	Abdominal pain
30	*Rangia peetinata*	Root	Abdominal pain
31	*Scoparia dulcia*	Root	Malaria, cold fever
32	*Stephania hernandifolia*	Root	Malaria, cold fever
33	*Tinospora cordifolia*	Leaves	Malaria, cold fever
34	*Rauwolfia tetraphylla*	Root	Hypertension
35	*Holarrhena pubescens*	Bark	Abdominal pain, Dysentery
36	*Vitex negundo*	Leaves	Rheumatoid arthritis, Osteo -arthritis
37	*Smilax macrophylla*	Root – pith	Leucorrhoea
38	*Curcuma longa*	Tuber	Leucorrhoea , worm infestation
39	*Curcuma augutifolia*	Tuber	Blood dysentery
40	*Euphorbia hirta*	Root	Blood purifier
41	*Acorus calamus*	Tuber	Pulmonary tuberculosis, respiratory infection, Hypertension
42	*Polygala crotalarioides*	Root	Pulmonary tuberculosis, respiratory infection
43	*Piper peepuloides*	Fruit , leaves	Pulmonary tuberculosis, respiratory infection
44	*Allium species* (wild variety)	Tuber	Scorpion bite
45	*Zingiber species* (wild variety)	Tuber	Poisonous bite
46	*Cocculus hirsutus*	Leaves	Flatulence
47	*Bryonia lacinosa*	Tuber	Chest pain
48	*Costus speciosus*	Tuber	Leucorrhoea
49	*Terminalia bellerica*	Fruit	Abdominal pain
50	*Terminalia chebula*	Fruit	Abdominal pain
51	*Cleradendron viscosum*	Root	Dysmanorrhoea
52	*Ceiba pentandra*	Flower	Leucorrhoea
53	*Salmalia malabericum*	Flower	Dysmanorrhoea, Leucorrhoea
54	*Hibiscus rosa-sinensis*	Flower	Dysmanorrhoea
55	*Enhydra fluctuans*	Leaves	Respiratory infection
56	*Gymnema arborea*	Tuber	Leucorrhoea
57	*Bacopa monieri*	Whole plant	Memory loss
58	*Nyctanthes arbor-tris-tis*	leaves	pyrexia

Table 1: Contd...

S. No.	Name of medicinal species	Parts used	Diseases cured
59	*Emblica officinale*	fruit	Gastro-intestinal disorder
60	*Punica granatam*	Flower	Dysmanorrhoea
61	*Zingiber officinale*	tuber	pyrexia
62	*Tylophora fasciculata*	root	pyrexia
63	*Aegle marmelos*	fruit	Gastro-intestinal disorder
64	*Glossogyne pinnatifida*	Whole plant	Menorrhagia
65	*Ehretia microphylla*	Whole plant	Menorrhagia
66	*Capparis sepiara*	Bark	Menorrhagia
67	*Withania somnifera*	tuber	leucorrhoea
68	*Datura fastuosa*	Root-bark	Arthritis
69	*Diospyros melanoxylum*	Bark	Malnutrition
70	*Ricinus communis*	Root	Arthritis

sion, cold, fever, abdominal pain, rheumatoid arthiritis, osteo arthiritis, leucorrhoea, worm infestation, malaria, leprosy, gastro intenstinal disorder, chest pain, blood purification, pulmonary tuberculosis, respiratory infection etc. Different parts of the plants are used like roots, leaves, tuber, seed, flower, latex, bark, root bark and in some cases the whole plant is also used. Similarly the Toto tribe also use different plant species like Duba *(Cylodon dactylon)* for treating their ailments.

Medicinal Plants and Livelihood

Traditional Knowledge on use of medicinal plants can be an important livelihood option for the people and can act as a positive driver for biodiversity conservation. There has been a great demand of medicinal plants at the national and international level. Diversified livelihood systems would allow people to draw on various sources for income and in doing so, reducing the risks of vulnerability to climate change.

The Biological Diversity Act 2002 also calls for developing equitable access and benefit sharing arrangements over the locally available biodiversity resources of any area, document biological diversity related traditional knowledge systems and develop the bio cultural protocols to recognize the right of the local people on their biodiversity resources.

Traditional Knowledge for Bio Control Methods for Pest Management

The Lodha community in Nayagram village apply Parasi (*Clistanthus collinus*) and Asar (*Asclepias arenaria*) leaves in their agriculture fields to protect their plants from pest attack. The santhal villagers of Bankura district have shared that earlier they used to insert branches of Neem (*Azadirachta indica*) tree in the agriculture field and also used to apply Sirhi leaves in the agriculture field to control pests. This practice is abandoned now due to easy availability of pesticides and their promotion on the one hand and reduction in number of trees like, Neem on the other. They have also observed that when the traditional straight line varieties of paddy have started to be replaced by the high yielding varieties, application of chemical fertilizers and pesticides needed to be increased. They have also found that there has been marked decrease in spider and other favorable predators that used to help in controlling pests after the rise in application of chemical pesticides.

With the changing climate and increase in temperature the number of pests is likely to increase. Most studies have concluded that insect pests will generally become more abundant as temperatures increase. The possible increases in pest infestations would lead to higher rate of usages of chemical pesticides resulting in more financial burden on the farmers on the one hand and having negative ecological implications on the other. Under the circumstances it becomes extremely important to adapt sustainable methods of pest control with a balanced use of organic solutions and the chemical pesticides. In this context the Traditional Knowledge on biological control of pests would certainly provide effective inputs.

Traditional of Organic Agricultural Practices and Their Importance to Ensure Livelihood Security

It is urgently needed to develop adaptive capacity of the people to maintain the soil health and nutrient conditions for crop protection un-

der the context of climate change. The traditional knowledge of organic cultivation practices preserve and restore soil organic matter, maintain soil structure and its water holding capacity, increase soil moisture content and therefore are resilient even under extreme climatic events such as drought, erratic rainfall and rising temperatures.

This traditional way of farming is evolved based on recycling principle and strong dependence between agriculture and animal production system, viz., use of animal excreta as manure. But the relationships among the different interconnected parts of the agro ecosystem are becoming disconnected and ecological processes are breaking down due to excessive use of chemical fertilisers and pesticides. Revival of the traditional system of organic farming and agronomic practices with balanced use of chemical inputs can offer sustainable productivity of the agro ecosystems.

Traditional Knowledge to Conserve Agro Biodiversity

It is proved that the traditional varieties of crops can withstand extreme weather like long dry spell, flood, variable moisture availability etc. Such indigenous cultivars are hardier with respect to vagaries of climate and are more resistant to pest attacks. Identification and reintroduction of traditional varieties is considered as an important measure for increasing resilience. People of Sundarban used to cultivate salt resistant varieties like Matla, Hamilton during their first settlement in the area. After their settlement and with the consequent decrease of soil salinity paddy varieties like Dudheswar, Nona Bokhra, Nona Sal, Nona Khetis, Getu, Tal Nugur, Kalo Nunia, Dar Sal, Mari Sal etc were introduced in the area long time back. With the increased threat of tidal surge and saline water intrusion, it is urgently required to re introduce those salt tolerant varieties in the area that have been replaced by the high yielding varieties.

Use of Traditional Knowledge for Crop Diversification to Increase Resilience

Crop diversification needs to be done by introducing alternate production systems. This can be done through exploitation of the biodiversity and encouraging diversification to new crops that are a part of the biodiversity of the zone (WBSAPCC). Nutritious crops such as small millets, and other cereals, pulses and oil seeds that requires less water are to be promoted. Millets like Marua, Kodo, grams, lentils used to be raised by the indigenous people that have high nutritious value need to be re introduced. These can be raised as sole or intercrop. People of Kharagpur shared that they cultivate grams like red gram, black gram, ground nut etc prior to paddy cultivation period. Similarly people of Bishnupur cultivate *Til* (sesame) after harvesting of potato to increase fertility of the soil. They also practice intercropping of mustard with potato. Mixed cropping is still a good practice in the Gangarampur block in Dakshin Dinajpur where different types of crop combinations have been reported like coriander+ lentil; mustard+ wheat; mustard+ lentil. All three combinations are good soil fertility restorer as well as enhancer of soil nutrients. Such combinations would make the farming system more flexible to cope with adverse effects of climate change and variability with reduced risk of partial or total failure of any single crop. As such, it would improve the resilience of poor and marginal farmers.

Diversification of Rural Livelihood Through Conservation Based Use of Biodiversity Resources

The forest fringe dwellers have in depth knowledge about different types of Non Timber Forest Produces (NTFPs) available in the forest and their uses. They collect NTFPs in the form of fruits, leaves, fibers, roots, tubers, grasses etc. that are used for their own sustenance as well as to earn livelihood. Such NTFPs act as a buffer especially during the lean period and during extreme climatic conditions like drought, flood etc. Through Joint Forest Management policies the conservation based sustainable use of NTFPs are promoted by almost all the state forest departments. The forest fringe dwellers of Kharagpur division in West Medinipur district of West Bengal sell semi processed sal leave plates at the rate of Rs 200 – 250 per thousand while one plate is made out of seven leaves. They also collect herbs like ishwar mul, dudhilata, anantamul, kalmegh, sarpagandha and sell them in the local market. Mushroom is sold at the rate of Rs 100 per Kg. They also collect and sell sabai grass (*Eulaliopsis binata*). The peo-

ple of kharagpur as well as Nayagram traditionally rear silkworms to produce Tasar cocoons (locally known as Polu cultivation) in forest that is one of major contributor of their household income.

Diversified use of the landscape, mobility and access to multiple resources (land, forest, water) increase capacity of the people to respond to environmental variability and climate change and provide a low-risk buffer in uncertain weather conditions.

CONCLUSION

The traditional knowledge base and natural resource governance systems of the indigenous communities attach collective responsibility for sustainable use of the biodiversity resources. The traditional knowledge and practices develop adaptive capacity of the communities to collectively respond to stressed condition and thus heighten their resilience. Blending of relevant traditional knowledge and practices for developing any strategy for climate change adaptation and mitigation have higher potentials to lead to sustainable solutions. Systematic documentation, protection and strengthening such traditional knowledge systems and institutions would be a key for climate change adaptation.

ACKNOWLEDGEMENTS

The present paper is prepared based on a study conducted by IBRAD on "Assessing the Relevance of Traditional Knowledge for Climate Change Adaptation" in the state of West Bengal supported by GIZ Natural Resource Management Program India. The authors acknowledge the support provided by GIZ India for conducting field work. Authors also acknowledge the encouraging participation of the villagers of Bankura, Paschim Medinipur, Jalpaiguri, Sundarbans and South Dinajpur districts and sharing their valuable traditional knowledge.

REFERENCES

Berkes F, Colding J, Folke C 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications,* 10: 1251–1262.

Berkes F, Colding J, Folke C 2003. Navigating social-ecological systems: Building resilience for complexity and change. *Ecology and Society*, 9(1): 1.

Berkes F 2012. Implementing ecosystem-based management: Evolution or revolution. *Fish and Fisheries,* 13(4): 465-476.

Blondel J 2006. The design of Mediterranean landscapes: A millennial story of humans and ecological systems during the historic period. *Hum Ecol,* 34: 713-729.

Census of India 2011. From <http://censusindia.gov.in/> (Retrieved on 2 June 2014).

Haridasan K, Rao RR 1985. *Forest Flora of Meghalaya.* Volume 1. Dehradun, India: Bishan Singh Mahendra Pal Singh.

Indigenous People's Climate Change Portal YEAR. From< http://www.indigenousclimate.org> (Retrieved on 4 March 2014).

IIPFCC 2009. *Policy Paper on Climate Change Discussed and Finalized at the IIPFCC Meeting,* Bangkok, Thailand from September 26-27.

Konar AK 2010. Tribal communities and their age-old sacred groves: A fair fieldwork in the Purulia District of West Bengal, India. *Studies of Tribes and Tribals,* 8(1): 1-12

Maplecroft 2010. From<http://www.maplecroft.com/about/news> (Retrieved on 3 March 2014).

Osunade MA 1994. Indigenous climate knowledge and agricultural practices in Southwestern Nigeria. *Malays J Trop Geogr,* (1): 21–28.

Pandit PK 2011. Conservation and cultural dimensions of sacred groves in Paschim Medinipur District, West Bengal, India. *The Indian Forester,* 137(5).

Reports of IPCC. From<www.ipcc.ch/publications_ and.../publications_ and_data_ reports. shtmlý.> (Retrieved on 3 June 2014).

Warren DM 1992. Strengthening Indigenous Nigerian Organizations and Associations for Rural Development: The Case of Ara Community. *Occasional Paper No*. 1, African Resource Centre for Indigenous Knowledge, Ibadan.

West Bengal State Action Plan on Climate Change 2010. Government of West Bengal. From<moef.nic.in/downloads/public-information/West-Bengal-SAPCC.pdf> (Retrieved on 20 February 2014).

Woodley E 1991. Indigenous ecological knowledge systems and development. *Agric Human Values,* 8: 173–178.