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Natural resource management in changing climate – reflections from indigenous Jharkhand

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Abstract

Purpose – Addressing probable complexities of climate change on rural livelihoods, food security, and poverty reduction, requires mainstreaming of cross-sectoral interventions and adaptations into existing frameworks. Indigenous communities due to their isolation, reluctance to current practices, and knowledge deprivation are difficult to reach by many developmental programs. The purpose of this paper is to identify relevant adaptations from indigenous rural Jharkhand (India), applicable to improving livelihoods through integrated natural resource management (NRM). Prospects of rainwater harvest and management for supporting local rural livelihoods were also examined.

Design/methodology/approach – Tested and applicable models of participatory research methods widespread in sociological research were used. Focussed group discussions and structured interviews were conducted for primary data collection from micro-watershed units of this study.

Findings – *In-situ* soil and water conservation methods showed increased availabilities of freshwater both for food and non-food consumption in the area. Construction of rural infrastructure and land husbandry practices improved agricultural productivity and resulted in subsequent reductions in women's drudgeries. Culture fishery provided ample scope for livelihood diversification, food and nutrition security of households. Overall, micro-watershed area developmental approach improved food and nutrition securities, generated employment opportunities, improved agricultural productivity, diversified livelihoods and were widely accepted by communities.

Originality/value – Creating greater sense of ownership among grass-root communities was an important thrust behind the success of this particular project. By entrusting tribal communities with fund management, rural planning, and execution of various interventions, a successful replicable model was produced, which has wider community implications extending beyond societies and geographies.

Keywords Resource management, Adaptive measures, Climatic threats, Jharkhand, Livelihood diversification, Tribal development

Paper type Research paper

Introduction

After the release of fourth assessment report of Intergovernmental Panel on Climate Change (IPCC, 2007), climatic concerns received global attention and top priority. However, throughout twentieth century the entire globe underwent various ecological changes (IPCC, 2001). These ecological anomalies had serious adverse impacts on sustainability of land and water resources and on ecosystems, which may in turn affected the well-being of billions of people on earth. For poor people, vulnerability is both a condition and a determinant of poverty, and refers to the (in) ability of people to avoid, cope with or recover from the harmful impacts of factors that disrupt their lives and that are beyond their immediate control (Kasperson *et al.*, 1996). This includes the impacts of shocks, e.g. sudden changes such as natural hazards, war or collapsing market prices, and trends, for example, gradual environmental degradation, oppressive political systems or deteriorating terms of trade, etc. (Ganguly and Panda, 2009).

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Impacts of climate change may disproportionately affect poor since they lack means, and have limited resources to deal with the former. The need for and the scale of adaptation reflects the vulnerabilities of people and natural systems to disruption from changes that reflect the impacts of climatic conditions. Thus, addressing the probable complexities of climate change interactions and their potential impacts on livelihoods may require mainstreaming of cross-sectoral responses, such as those for food security, poverty reduction, emergency preparedness and others, into existing frameworks.

Although the knowledge on adaptation related economics is limited, particularly in the context of sustainable rural development, recent studies (World Bank, 2010) may be sought for comparing different options. Additionally, by improving communication channels among communities various areas of needs can be effectively coordinated and managed. Adaptation does not mean search of entirely new concepts or ideas, it rather builds on existing knowledge and experience. Sustainability of water-based ecosystems may be ensured by ensuring adequate water supplies that would meet the food and non-food needs of a growing population (Saxena, 2009). Global freshwater supplies are expected to significantly reduce by 2050 in many regions which in turn are likely to affect four aspects of food security namely production, stability, access and utilization, consequently resulting in increased food insecurities (IPCC, 2008). In rain-fed areas major thrust points against climate change may be on promoting activities related to rainwater harvesting, soil conservation, land shaping, pasture development, vegetative bunding, water resource conservation, etc. based on micro-watershed approach (Saxena, 2009).

In developing countries hundreds of millions of undernourished people depend solely on rain-fed agriculture living in arid and semi-arid areas (Rockstrom *et al.*, 2007), where agriculture is adversely impacted by water scarcity (Molden *et al.*, 2007b). Since agriculture is the largest water user of rural India providing sustenance to rural community, former requires efficient irrigation systems and adoption of water conservation strategies. Further, agriculture plays dual role in climate change, first it is severely affected by it and second it is a significant contributor of green house gas emissions. Soil erosion is yet another concern directly related to rainwater flows in such areas, and is expected to increase $\sim$9 percent by 2090 (Yang *et al.*, 2003). Therefore, watershed based area developmental approach may be promising both for addressing water demands, and checking soil erosion in degrading rain-fed areas, which may be achieved through application of appropriate land and water management (LWM) techniques (World Bank, 2008). Among the various options available under watershed management for LWM technologies, construction of water harvesting tanks, ponds, various trenches, gully plug, water canals, stone bunds, gabion structure, farm bund, land treatment, etc. are widespread (Saxena, 2009). Thus, adaptations related to agriculture sector may focus on addressing the negative impacts of climate change and making optimum use of available opportunities (GIZ, 2011). However, the success of agricultural adaptation practices may depend on successful amalgamation of concrete options available at hand through community based adaptation approaches.

Global capture fishery resources due to overexploitation are likely to lose production over the subsequent years (FAO, 2007). Although, small scale fisheries to some extent have the potential for commercialization, involving sales of harvests (Berkes *et al.*, 2001), freshwater ecosystems faces risks of alterations in flows due to changes in global climate (Orr *et al.*, 2005). Additionally, communities engaged in fisheries activities are also vulnerable because of extreme weather events and other socio-economic pressures (Nicholls *et al.*, 2007a). Hence, aquaculture habitat restoration of existing or newly

identified watersheds in rural areas may contribute to increased probability of livelihood diversification, resource utilization, system productivity and food security in the perspective of community adaptive measures to changing climate (Allison *et al.*, 2007; World Bank, 2010).

Women's work is considered crucial in terms of food provisioning, income earning and management of financial resources. For rural women, climatic changes may increase drudgery related to collection of water, fuel wood, agricultural works, collection of non-forest timber produces, etc. Furthermore, women also play significant role in providing nutrition and health securities to families. Due to the delicate roles played by rural women, the latter are more vulnerable to climate change and may have to bear more climate adaptation burden when compared to males (Parikh and Denton, 2003). The latter may mainly be due to the fact that men and women have different roles in society, and women by default face discrimination in various forms, which also affects their capacity to adapt. Thus, the main aim of the present study was to test the applicability and relevancy of few interventions, in the context of developing adaptation measures, related to tribal (indigenous) development in Jharkhand (India). Prospects of rainwater harvest through water conservation practices were also examined in the context of freshwater usages and management. Other aims were to recommend suitable adaptive measures based on acceptability of interventions, relevant to land and water resource management (NRM), by indigenous community.

Methodology

Area profile

Jharkhand came into existence on November 15, 2000 as a newly formed State of India from divided Bihar. Jharkhand has an area of 79,716 sq km, consisting of 32,616 revenue villages, 24 districts and a population of 33 million according to India's 2011 census. The State is considered as one of "Tribal States" of India, where about 28 percent population is represented by 32 tribal (indigenous) communities. Eight out of 32 tribes fall in the category of "Primitive Tribal Groups" namely Asur, Birhor, Birajia, Korwa, Savar, Paharia (Baiga), Mal Paharia and Souriya Pahariya based on their primitiveness, backwardness and extinction (Roy, 2012). Climatic conditions of the state varies between humid and sub-humid tropical monsoon to sub-tropical monsoon, characterized by undulating terrain, absence of perennial rivers, erratic rainfall, low water retention capacity of soil, low ground water level, high soil erosion and absence of soil and water conservation measures (UN-WFP and IHD, 2008). Hence climatic and other conditions are inapt for agriculture and other natural resource based livelihoods.

Micro watershed profile of study area

NRM through watershed area development approach is universal in its application irrespective of geographical boundaries among various nations (Kenney, 1997, 1999a, b), hence the basis of the present study also consisted of similar concept of watershed based area development. A total of 97 micro watersheds were identified during program inception and scale-up (1999-2001 and 2007) under internationally funded (International Fund for Agricultural Development, Grant No. IN-506) rural development project namely, "Jharkhand Tribal Development Program (JTDP)". These micro watersheds were approximately around 500-600 ha in area, representing five districts of Jharkhand namely, Ranchi, Khunti, West Singhbhum, Saraikela-Kharsawan and East Singhbhum.

Data collection

For primary data collection Participatory Rural Appraisal (PRA) exercise which consists of various methods for collecting information in a participatory fashion from rural communities was used in the present study (Chambers, 1992, 1994). The PRA tool had been suggested to be advantageous over other methods because it allows wider community participation, thus the collected information is likely to be more accurate (Chambers, 1994). Following the similar methods one of the PRA tools – Focus Group Discussion (FGD) was conducted (32 FGDs during June-August 2012) in sampled watershed villages of the present study (Table I). Each FGD group consisted of 40 participants in each village and the total duration was approximately four to six hours. The duration of FGDs was slightly longer than usual due to the fact that tribes of Jharkhand are yet to perceive the current notion of climate change and its probable effects on their ecosystem, livelihood and food securities. Further, literacy rate of tribes belonging to survey areas tends to be poor, hence it took considerable effort for moderators to first inculcate the concept and thereby collection of relevant data. The present study examined the watershed areas of JTDP, with a specific goal of examining the "Prospects of Rainwater Harvesting" as a tool for "NRM". Hence primary data collection focussed on few of the NRM indicators, centered toward the harvest and use of rainwater as a primary source of freshwater. Besides FGDs cross-check interviews with key informants were also conducted including a total of 30 key informants, consisting of district and block government officials, relevant non-governmental organization (NGO) workers and project staff. Contradictory responses of FGDs were thus corrected through such cross-check interviews. Relevant secondary data were also collected from State Program Management Unit located at district headquarters Ranchi, as well as from NGOs and local government offices.

Data analysis

Application of "Mixed Research Approaches" gained momentum during 1960s by combining the concept of mixing both qualitative and quantitative methods (Denzin and Lincoln, 2000; Creswell *et al.*, 2003). Since its evolution, mixed models had been used in various disciplines such as health sciences (Morgan, 1998), nursing (Sandelowski, 2001), sociology (Hunter and Brewer, 2003), management and organizational research (Currall and Towler, 2003), program evaluation (Rallis and Rossman, 2003), etc. Due to evaluative nature of the present study, mixed models technique was used for data

Table I.
Sampled villages undertaken for primary data collection

SN	District	Block	Programme village under JTDP
1.	Ranchi	Angara	Baxidih, Haratu
2.	Ranchi	Bundu	Amanburu, Bera, Muisudih
3.	Ranchi	Tamar	Baru, Kutachwli, Degadari
4.	Khunti	Erki	Kochang, Sinjuri, Longa, Kasmar
5.	East Singhbhum	Potka	Chakri, Tangrain, Jojodih, Damudih
6.	West Singhbhum	Sonua	Edelbera, Raghoi, Simbanda, Golasai
7.	West Singhbhum	Khutpani	Aburu, Jonkosasan, Karkatta
8.	West Singhbhum	Goelkera	Nungri, Narsanda, Chotakuira
9.	Saraikela-Kharsawan	Kuchai	Rugudih, Ramdih
10.	Saraikela-Kharsawan	Rajnagar	Potka, Joldiha, Kesargaria, Kamarbasa

Note: JTDP, Jharkhand Tribal Development Programme (funded by IFAD Grant No. IR-506)

collection and analysis. Following the instrument design model, survey theme and questionnaire were designed through reference to available scientific literature on climate change and its probable threats on natural resources, livelihoods and rural societies. Based on specified cross-sectorial questionnaires, responses were shaped into three main categories, thus responses pertaining to various chosen indicators of the respective sectors, i.e. land and water resource management, agriculture, fishery and gender perspective were set on numerical scales in an ascending order, where 1 = no/nil adaptation, 2 = partial adaptation and 3 = complete adaptation. Further, for quantification of data, however, the three set scales of responses were assigned equal percentages, i.e. each of three responses carried 33.3 percent marks. Participants of FGDs were asked to collectively vote for any of the three responses. Community responses thus collected by means of the survey tool (questionnaire) were numerically coded and analyzed by entering data into standard spreadsheets (MS Office Excel-2007). Critical observations were applied for drawing conclusions based on adaptation responses, regarding validation and relevancy of the interventions, or making recommendations on adaptability of interventions. In addition to the survey tool, additional community responses to various program interventions were also recorded separately in textual form.

Results and discussion

Adaptive measures

Smit and Wandel (2006) described adaptation in the context of human dimensions of global change as sociological process, action or outcome that allows better coping or adjustment mechanisms to changing conditions, stress, hazard, risk or opportunity. In the context of climate change, adaptation had also been defined as socio-economic coping mechanisms to climatic changes that threaten natural resources and associated livelihoods (Brooks *et al.*, 2005). Revolving around the central theme of various adjustments to external stimuli, adaptations may either be spontaneous or planned. Rural communities (including indigenous) have undergone various adaptations over the course of development, however, the current rate of environmental degradation is outpacing their adaptive capacity. Since indigenous communities are much more vulnerable among rural communities (Salick and Byg, 2007), they may require added and specific developmental support projected toward their own objectives. Paternalistic developmental approaches are often not accepted by indigenous people since they aim at streamlining indigenous societies with others. Hence, success of such developmental efforts depends to a great degree on community acceptance, and their applicability in addressing the barriers faced by them, thereby serving to protect their livelihoods, heritage and cultural identity.

Exclusive and innovative community participatory approaches

Although previously tested adaptive measures pertaining to various aspects of watershed management related to NRM namely, rainwater harvest, checks in soil erosion, plantations, fodder development, livestock development, agricultural crop management, etc. were rather planned than spontaneous, nevertheless, few exclusive strategies that were adopted for goal optimization were of innovative and pioneering in nature. Usually every Indian village tends to have its own governing body called as "Gram Sabha (GS)" (formed under PESA – Panchayat Extension to Scheduled Areas Act, 1996 of Government of India), however, contrary to rest of India, "Panchayati Raj Elections" were held in 2010 in Jharkhand. Thus GS was totally absent from project areas of this

particular study at the time of program initiation. Hence, first GS was formalized in all of 330 targeted villages, thereafter "Programme Executive Committee (PEC)" was institutionalized with the sole purpose of decentralization, and for constituting leadership among grass-root communities. Following grass-root institutionalization, funds were transferred directly to PEC bank accounts that were allocated specifically for the interventions identified by the communities itself. Rural communities were thus entrusted with village development responsibilities after appropriate capacity buildings. Project thus pioneered in transferring funds and other resources directly to grass-root community based organizations, which was not a common practice in any other state or nation supported program in India. Later on, "thrift and savings" habits were gradually developed among communities which resulted in formation of "Village Development Funds" in the village itself. Direct planning, management and execution of interventions created a high sense of ownership among communities. Similarly, male and female (one each) animators were identified for monitoring as well as management of progress of various interventions at village level. Besides, extending beyond the existing "patriarchal societal values," special emphasis was placed on gender and equity throughout the program, with an emphasized focus on women empowerment for facilitating improvements in the status of women. For achieving this particular goal, more women participation (exceeding above 50 percent levels) was ensured by forming gender strategies at all levels, i.e. family, hamlet, village, institution, etc. Strategic application of above mentioned participatory practices significantly contributed toward effective implementation of program activities, specifically targeted toward livelihood enhancement in the context of integrated NRM, thereby setting an example for increasing resilience among targeted tribal communities of Jharkhand, through effective allocation and management of developmental fund. Thus the roadmap of inclusive growth was built upon indigenous wisdom, knowledge, capabilities and traditional values of the targeted communities.

In the context of climate change, rainfall vagaries, depleting water resources, degrading land, loss of agricultural productivity, water run-offs, depleting forest resources, etc. are some of the major concerns among many, posing serious threats to tribal livelihood and ecosystem in Jharkhand. Prior to JTDP, except few projects undertaken by State government departments, namely, soil and water conservation, drinking water and sanitation, agricultural department, animal husbandry and fisheries, etc., watershed based area developmental programs were totally absent from JTDP areas. Additionally, government programs that existed in the area merely focussed on sole purpose of creation of rural assets, and to some degree to their own specific goals. However, by applying an alternative strategy, JTDP aimed at integrated development combining five major components of natural resources namely people, land, water, forest, and livestock. Beginning with the basic form of life, project focussed on development of water resources for raising water security among beneficiaries. It was conceptualized that once water security has successfully been raised, people would look beyond the ways in which water would be used, resulting in anticipated maximization of water usages for increasing productivity from their production systems. The latter was expected to result in generation and transfer of new technologies. Consequently, focus was on dealing with the entire ecosystem, through shifting focal point down from watershed based area developmental approach to water harvesting beyond pre-existing water sources, etc. Thus goal was on rain water harvesting and optimal use of seasonal flows in rivulets/streams in the watershed area to supplement the vagaries of the rainfall. For the purpose of optimization of seasonal water flows,

watershed based engineering designs were promoted such as gabion structures, diversion canals, percolation tanks, stone bunds, earthen check dams, guard wall construction, etc., in addition to plantations of grass and fodder (Subabool – *Leucaena leucocephala* in particular).

Extending beyond the general water conservation, project aimed at adoption of strategic water management approaches by increasing the impacts of water conservation measures, which were implemented in three ways. First, water management practices were integrated according to farmer's needs, consistent with their production systems. Second, considerable scope for gradual technology adoption was left by conceptualizing that farmers will adopt mechanisms, consistent with their agronomic practices that will fit the topography and agro-ecology, thus resulting in an overall water management of program watershed areas. For addressing various water management issues emphasis was placed on treating all prevalent land types, namely, low, medium and up lands through a combination of engineering structures such as 5 percent model ponds, 30×40 model tanks, trenches (staggered continuous trench (SCT) and continuous contour trench (CCT)), canals, seepage tanks, water access tanks, gully plugs, etc. This particular development strategy of focussing on various types of lands differentiated JTDP from concurrent beneficiary schemes of State government in the area, which centered primarily on excavation of ponds, bore wells, drinking/irrigation wells, and check dams in low lands. Third, project focussed on broadening the available choices through access to conservation technology based more on agronomic changes rather than merely focussing on land husbandry practices. For the purpose of imparting specialized agronomic techniques, skilled manpower in the form of technical expertise called as "master trainers" were identified, and promoted from among the communities for providing on-farm technical hands related to agriculture and associated trades. Besides, "common interest groups" were also formed for promoting group on-farm activities as well as for running "Farmer Field Schools". At the institutional level, component experts were employed for taking particular care regarding various components of integrated development strategy (discussed above). Thus by applying alternative implementation mechanism, project endeavored to devolve the power of bottom-up planning, execution and monitoring village developmental activities by directly engaging community based institutions, through combination of innovative as well as tested participatory developmental practices (Kerr, 2004).

Community adaptations supported through land and water resource management

Selective indicators chosen for measuring adaptability against this particular category revolved around rainwater harvesting, and contribution of the latter toward freshwater availabilities for food and non-food consumptions, in the context of JTDP (Table II). The overall community responses showed increased availabilities of fresh water in rain-fed program areas, which was facilitated through water harvesting structures (Table II). Improvements in water availability for irrigation purposes were also reported which was sufficient for paddy mono-cropping (63.2 percent), and to some extent two crops (31.6 percent) were also irrigated. It was notable that small percentages (5.3 percent) were also able to irrigate more than two crops annually. Similarly, responses on available drinking water showed an overall improvement. Equal votes were obtained on either year round drinking water availability (42.1 percent), or for nine months (42.1 percent). However, one-tenth of population (10.5 percent) also reported less than three months' access to the same, thus depicted their dependency on other sources requiring subsequent travels for fetching water.

SN	Particulars	Responses (%) (3) Yes	(2) Partially	(1) No
1.	Has the land and water management interventions helped in increased water availability?	52.6	47.4	–
2.	Is water available for irrigation?	42.1	42.1	15.8
3.	If yes, for how many crops?	More than 2 – 5.3	2 – 31.6	Mono – 63.2
4.	Has the availability of drinking water improved?	42.1	31.6	26.3
5.	If yes, for how long drinking water is available?	Whole year – 42.1	6-9 months – 42.1	Less than 3 months – 10.5
6.	Did water management activity recharged ground water level in the area?	52.6	42.1	5.3
7.	Did farm bund helped in improvements of fields (increased water holding, reduction in seepage etc.)?	78.9	5.3	15.8
8.	Increased soil moisture due to farm bund?	52.6	31.6	15.8
9.	Did land management interventions (Trenches, i.e. CCT, SCT; gabion structures, percolation tanks, farm bund, land leveling, plantations, etc.) checked soil erosion?	63.2	36.8	–

Notes: CCT, continuous contour trench; SCT, staggered continuous trench

Table II.
Perceived community responses on adaptive measures supported through JTDP land and water management interventions

Farm bund improved *in-situ* soil moisture of agricultural fields by either retaining or checking water seepage. Community believed that ground water tables were slowly recharging in the area although the current rate of water exploitation was way over the recharge rates. Similarly, responses related to checks in soil erosion went in favor of selective soil conservation techniques such as trenching (SCT, CCT), farm bund, plantations, etc. (Table II). Additionally, plantations of subabool in particular, also served multiple benefits as fire wood and cattle fodder besides checking soil erosion. Hence consistent with findings of other international experiences (Turton *et al.*, 1998; Sakthivadivel and Scott, 2005), LWM implemented through watershed management effort in Jharkhand was successful among tribal community, which may be attributed to bottom up grass-root planning and decentralization (Kerr, 2004). Yet the maintenance of created rural assets is still a concern since local communities requires to be strengthen further for achieving long term sustainability and adaptations. However, further analysis of FGD data showed an increased awareness among communities regarding their land and water resources, since communities were found to benefit from various national flagship schemes of Indian government such as MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act), IWMP (Integrated Watershed Management Programme), ITDA (Integrated Tribal Development Agency), etc., both for creation as well as maintenance of rural assets. Additionally, community also reported the use of micro-irrigation as well as agricultural implements such as water pumps, drip-irrigation units, weeder, sprayer, etc. that had been obtained from various government departments.

Previously, Food for Work (FFW) program was proved to be an effective strategy for tackling seasonal unemployment, climate induced famine and other disruptions for addressing rural food insecurity and unemployment (Subbarao, 2001). Providing food grains in exchange for daily wage contribution earned from rural infrastructure work had been the main concept of such FFW programs (Gedamu, 2006). Similar program partnered with United Nation World Food Program (UNWFP) was run simultaneously along with LWM component of watershed approach of JTDP, consisting of distribution of rice and pulses. The latter contributed not only to food security concerns but at the same time arrested tribal community's interests for proactive implementation of LWM activities. According to local community, UNWFP program either partially (15.8 percent) or completely (84.2 percent) addressed household food demands during the course of program. Thus, simultaneous application of two different programs, in the context of Jharkhand, proved to be synergetic and suggested prospects of amalgamation of various technologies available at hand. Additionally, in the context of food security by means other than agricultural production, during FGDs various "Public Distribution System (PDS)" units were found to run exclusively by Self-Help Groups (SHGs) in JTDP areas. The PDS is yet another beneficiary scheme of "Ministry of Consumer Affairs, Food and Public Distribution" of Indian government for providing food grains and other essential commodities at subsidized rates to marginalized groups. Although care must be taken in choice of technologies since tribal communities are distinctive from other peasant communities in terms of their cultural identities, governing systems, geographical locations, interests, practices, feeding habits, agricultural practices and productions (tribes produce for life sustenance), etc.

Agriculture and associated practices

Agronomic shifts to anticipated changes in average temperatures and precipitation adds complexity to already complex agricultural production models since volatile weather patterns are difficult to capture which further magnifies the complexity (IPCC, 2007). For developing countries the situation is likely to worsen since they heavily depend on agriculture, becoming relatively hotter, lack proper infrastructure and capital investments toward innovative adaptations (GIZ, 2011). India had been predicted to lose 5 percent reduction in gross domestic production (World Bank, 2009), therefore its poor who earn their livelihoods from agricultural farming are most likely to be severely hit by climatic shifts. Thus there remains immense need for appropriate technologies that would increase community resilience toward addressing agricultural food insecurity concerns. A broad range of agricultural management and production enhancement techniques are available namely use of high yield variety (HYV) seeds, use of organic manures such as vermicompost, system of rice intensification (SRI), alternative cropping for drought mitigation, etc. among many (FAO, 2009a). Field application of such technologies showed improvements in agricultural productivity in Jharkhand (Table III).

Sowing of HYV seeds of paddy, vegetables, legumes and pulses either solely or as part of alternative crop strategy resulted in production increases, with no major side effects either on lands or on agricultural productivity (Table III). In some cases where concerns were reported by the community, it was merely associated with increased use of fertilizers between two consecutive crops after sowing of HYV seeds. Further, it was beyond the scope of this study to measure/identify any evident ill-effects of HYV seeds, hence no such observations were made. Similarly, use of vermicompost decreased reliance on chemical fertilizers as well as improved soil nutrient contents. SRI proved to

Table III.
Perceived community responses on adaptive measures supported through JTDP agriculture interventions

SN	Particulars	Responses (%) (3) Yes	(2) Partially	(1) No
1.	Use of HYV seeds helped in an increase in paddy production	63.2	36.8	–
2.	Side effects on fields due to use of HYV seeds of paddy, vegetable, pulses, legumes etc.	26.3	–	63.2
3.	Efficiency of Vermicompost – has there been decreased need of manure application between two consecutive crops?	42.1	31.6	26.3
4.	Decreased use of chemical fertilizers after use of vermicompost	63.2	21.1	15.8
5.	Alternative cropping methods – use of drought resistance crops such as legumes and pulses increase resilience	26.3	52.6	21.1
6.	SRI is water efficient	68.4	26.3	5.3
7.	Metal seed bins are better compared to traditional straw bins	47.4	36.8	15.8
8.	Dissemination of agricultural information through coin operated telephones	26.3	21.1	52.6

Notes: HYV, high yield variety; SRI, system of rice intensification

be water efficient, however, only constraint observed (supported by 5.3 percent) was its greater dependency on irrigation/monsoon for on-time nursery development, failure to which resulted in crop losses (Table III). Beside crop management practices, metal seed bins were also promoted for proper seed storage, mainly due to unavailability/limited availability of traditional straw bins, which also had good adaptation successes. For dissemination of agricultural information among various program villages, coin-operated telephone boxes were distributed which had $\sim$50 percent adoption rates, determined by either partial or complete adoptions (Table III). Additionally, further enquiries revealed that widespread use and cheaper availability of mobile phones were slowly replacing coin operated telephone boxes. Besides online data access, mobile phones had also made the weather and other agriculture related information more viable. Additional survey reports also revealed adoption of available agricultural technologies from other schemes such as National Horticulture Mission which contributed to successful installation of green and poly houses at field sites, and its subsequent use for production of vegetable plantlets of improved varieties. It was notable that due to increased awareness people had also realized the need for soil testing for proper management of agricultural lands and consequently approached block as well as district government departments in particular, for benefiting from their schemes. Overall, agricultural interventions promoted among indigenous communities of Jharkhand showed greater prospects for managing trade-offs between food security and agricultural mitigation against the current challenges posed by climate change, in the form of inter as well as intra exchange of practices, ideas and knowledge. However, in absence of village seed banks and on-farm information technology centers, it would be difficult to promote sustainable adaptive measures.

Community adaptations supported through fishery interventions

Throughout globe fishery/fishing is not only an occupation and a way of life for indigenous people, but is also a significant part of their cultures since it defines and reinforces relationships between indigenous people, the animals and environment upon which they depend (Nuttall, 1992; FAO, 2009b). Previously indigenous people were

reported to lose vitality, health and personal well – being due to loss/unavailability of traditional foods due to a variety of reasons (Wein and Freeman, 1992). Climate change may further worsen local food and nutrition securities by undermining local modes of fish production, which may also affect livelihoods of concerned communities. Since global capture fishery resources are depleting, restocking/rehabilitation of natural as well as man-made water bodies becomes crucial for sustaining indigenous cultures and livelihoods.

Due to the obvious roles played by fishery stocking of hatchery raised carp polyculture were promoted in JTDP program areas since seeds obtained from local vendors were found to be of poor quality (Table IV). It is notable here that Indian Major Carps (*Labeo rohita, Catla catla* and *Cirrhinus cirrhosus*) were native to the area hence the species were easily accepted by tribal communities. However, community reported partial success of the activity due to various reasons such as lack of proper communication channels, lack of transport facility for carrying fish seed, absence of disaster/fish disease management services, etc. Nevertheless, majority of responses showed extra incomes earned from aquaculture activities. Additionally, successful culture of catfish *Magur (Clarius magur)* was also reported by communities at certain pockets which had resulted from learned experiences of carp culture. Integrated fish cum duck activity was also accepted by the communities which perceived it as an alternative income generating activity. Additionally, culture fishery interventions resulted in partial improvements of protein intake (fish, egg, meat) of house holds (HHs) (Table IV). Hence success of involvement of local community in culture fishery practices suggested indigenous knowledge and practices plays vital roles in sustaining tribal cultures (Dey and Sarkar, 2011). However, sustainability of inland culture fishery demands greater adoption of on-farm village as well as mobile hatcheries for easy availabilities of fish seed which is not only lacking, but also proving to be a roadblock.

Gender (women) related adaptations

The effect of climate change were predicted to be disproportionate among different regions, generations, age classes, income groups, occupations and gender (IPCC, 2007), hence adverse effects of climate change are not gender insensitive. Studies have shown that women accounts for 70 percent of the poor in developing countries, whose vulnerability is further accentuated by race, ethnicity and age (Parikh, 2007). Since rural women highly depend on natural resources for life sustaining activities such as, HH food security, income and employments, water and other energy needs, etc., their

SN	Particulars	Responses (%) (3) Yes	(2) Partially	(3) No
1.	Are all ponds in the village are stocked with hatchery raised fish seeds?	36.8	57.9	5.3
2.	Added incomes from fish farming	84.2	15.8	–
3.	Added incomes from integrated fish cum duck farming	84.2	15.8	–
4.	An increase in HH intake of egg/meat/fish in the diet	84.2	15.8	–
5.	High yielding *Khakhi campbell* duck survive better in changing climate compared to local breeds	63.2	21.1	15.8

Notes: HH, house hold; *Khakhi campbell*, improved breed of duck considered superior to local variety in terms of its egg laying capacity (annual 250-300 eggs)

Table IV. Perceived community responses on adaptive measures supported through JTDP fishery interventions

vulnerability would further increase, if they lack secure access over natural resources (land, water, livestock, trees) (Aguilar, 2004). Besides, a substantial part (35 percent) of rural Indian economy was reported to be contributed by female headed HHs (Centre for Policy Dialogue, 2000). Hence, gender analysts have recommended deployment of more gender friendly development projects, especially from food security and sustainable development perspectives (Skutch, 2002). However, gender focussed adaptation and mitigation mechanisms have not received much attention perhaps because community adaptations are still considered as social phenomena, which have its roots in local issues. Nonetheless, the present work attempted to evaluate women's resilience toward present climatic threats to various women's issues, since gender equality concerns were ingrained in program strategy of this particular tribal development program (JTDP). Few selective indirect indicators pertaining to the above mentioned interventions (land and water resource management, agriculture and fishery) were chosen as parameters, which may be considered as impacts of the various interventions.

Previously, staple diet of tribes of Jharkhand belonging to program areas were dominated by rice only with occasional inclusion of tubers, dried leaves, vegetables and meats. Findings of the present study associated with HH feeding habits showed improvements, as majority of women reported improvements in intake of grains/fruits/vegetables/pulses, etc. as a result of livelihood support of JTDP (Table V). Women reported decreases in drudgeries related to drinking water collection due to increased availability of the same, both for food and non-food consumptions (discussed in Table II). Similarly, agricultural related drudgeries were also reported to decrease due to various land husbandry practices. Women reported checks in migrations for work to a certain degree due to employment generation in the village itself. Similarly, women reported partial prevention against certain HH diseases (Table V). Thus women's participation in combating climate change is imperative, as their inclusion in policy decisions may support effective budgetary provisions for gender specific interventions of various projects. Documentation of women's knowledge in the context of community-specific adaptation may also serve as resources for effective policy formulations, and for handling issues on varied perspective of local governance.

Previously, developmental schemes of Indian government targeted toward women development had been confined to forming SHGs and thereby allocating micro finances for promoting various income generating activities. Alternative schemes had focussed on social and health issues of women namely education, sanitation, maternity and child development services, communicable and non-communicable diseases, etc.

Table V.
Perceived community responses on gender related adaptive measures supported through JTDP (indirect indicators resulting due to overall interventions)

SN	Particulars	Responses (%) (3) Yes	(2) Partially	(3) No
1.	An increase in HH intake of grains/fruits/vegetables/pulses, etc.	84.2	15.8	–
2.	Collection of drinking water made easy	78.9	21.1	–
3.	Sufficient water for other HH consumption (washing/bathing/livestock, etc.)	73.7	26.3	–
4.	Agriculture related works made easier due to land husbandry works	42.1	47.4	10.5
5.	Checks in migration for work	47.4	36.8	15.8
6.	Prevention against HH diseases (dengue/malaria/diarrhea, etc.)	26.3	52.6	21.1

However, for promoting holistic developmental practices, particularly in the context of climate change, increasing awareness among women folk regarding current probable threats to their ecosystems and associated livelihoods becomes imperative. Taking the example of JTDP, women's active participation and decision making should be encouraged for community driven planning of interventions, specifically targeted toward management of natural resources. Further, promotion of group activities through SHGs namely, development of village plant nurseries, collection and marketing of Non Timber Forest Produces, monitoring of LWM activities, reclamation of degraded lands through taking up plantations, integrated aquaculture, etc. had been few successful examples of JTDP that added toward increasing environmental awareness, rather than merely focussing on income generation. Cultivation of agricultural cash crops by women entrepreneurs by means of integrated crop management practices were yet another example. Further insights from FGDs revealed interesting observations since communities reported increased awareness and empowerment, resulting due to legal awareness campaigns organized at various occasions, on various societal issues including land mortgages. Thus, extending beyond societal patriarchy, formation of effective policies calls for implementation of holistic developmental approaches, for available natural resource optimization, as well as for increasing resilience of vulnerable rural women.

Conclusion

Degrading natural resources in the face of changing climates poses serious threats to associated rural communities by directly affecting their livelihoods and food securities. Indigenous people require special attention for developing resilience toward such changes, since they lack proper means and resources, in addition to their knowledge depravity and reluctance to new technologies. Although a variety of technologies are available today, various developmental programs fail to reach indigenous/tribal communities, many of which are at the verge of extinction. Since tribal communities have their own particular cultures and traditions, paternalistic developmental efforts projected toward mainstreaming these societies with others often remains unsuccessful. Hence well-dressed amalgamation of indigenous knowledge with current practices and technologies is required for promoting climate smart community developmental packages.

Out of five components of natural resources namely land, water, forest, animal and people, present study examined few selective NRM practices centered mainly on land, water and people. Innovative as well as previously tested participatory bottom-up planning and execution of selective adaptive measures, supported by means of tribal development program in Jharkhand (India) were found to be widely accepted among tribal communities. Watershed based area developmental approach, coupled with exclusive direct fund transfer to local communities, showed implications for water harvesting, increased agricultural productions, diversified livelihoods and increased gender resilience toward current climatic threats. Infinite freshwater – the basic form of life, was found to be effectively managed through rainwater harvesting by means of creation of rural assets through application of recommended engineering designs pertinent to various land types found in Jharkhand. Thus, rainwater harvesting strategy by addressing various land types proved to be crucial for supporting livelihoods and food securities. Similarly, agriculture development strategies not only addressed food demands, but also proved to be drought proofing irrespective of erratic rainfall patterns. Additionally, aquaculture promotion of native species showed prospects for livelihood diversification in agricultural sector. Formulation and inculcation of gender specific

strategies as well as promoting NRM activities through women SHGs showed positive societal improvements. Therefore, application of alternative, effective and innovative participatory bottom-up planning and management was found to be very useful for creating greater sense of ownership, fulfillment, and social security among grass-root communities.

However, in the context of watershed management, development of rural infrastructure needs particular attention in the direction of addressing various land types for increasing land fertility. Further, agricultural development requires consideration toward biodiversity conservation of native crop and animal species, since introduction of new and improved varieties poses the risk of either wiping out or polluting native breeds of plants and animals. Rehabilitation of local water bodies and sustainable management of forest produces namely Non Timber Forest Produces also requires formulation of effective strategies for sustaining rural livelihoods as well as for ecosystem conservation. Women's active participation in NRM activities is yet another domain that requires more research for promoting gender specific climate smart policies. Consequently, specific developmental policies targeted toward marginalized and deprived communities may require particular focus on NRM for ensuring livelihood and food securities, pertinent to the fact that high migration for work is also prevalent in rural areas. Hence, formulation of relevant policies through cross-sectoral amalgamation of various existing as well as prospective developmental programs could be an effective strategy for addressing various societal needs at one end, while at the other may also serve as tools for sustainable resource management.

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