Eco-technologies for agricultural and rural livelihoods in North East India

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About one-third of the total agricultural area in the Southeast Asia is under shifting cultivation. In North East India, where most of the populace comprises subsistence farmers largely depending on shifting agriculture, technologies in agricultural development that are based on high external inputs, become inappropriate and inaccessible. Technologies, therefore, need to adapt to local conditions based on the principles of low external input for sustainable agriculture and should also be pro-nature, pro-poor and pro-women-oriented. This article discusses about up-scaling of potential low-cost eco-technologies for improved crops yield in shifting agriculture, which continues to be a predominant livelihood for a majority of the upland communities in NE India and technological intervention as a possible entrepreneurship option for unemployed youths.

Keywords: Eco-technologies, entrepreneurship, rural livelihoods, shifting agriculture.

SHIFTING cultivation, a primary and often the only agricultural practice available to address the need for food security of the majority of the upland communities, is regarded to be the first step in transition from food-gathering and nomadic hunting to food production. The practice, believed to have originated in the Neolithic period around 7000–9000 BC (ref. 1), still continues to be the predominant land-use system and economic mainstay of the upland people in the South and Southeast Asian region. It consists of highly diverse land-use system in a wide range of distinct socio-economic and ecological conditions, from montane to lowland ecosystems and from tropical forests to grasslands[2]. Spencer[2] referred to the practice as 'jungle gardening' and suggested that this was a pioneering cropping system of early agriculturists in many forested regions of the world. About one-third of the total agricultural area in the Southeast Asia is under shifting cultivation[3]. About one billion people (22% of the population of the developing world in tropical and subtropical countries) belonging to at least 3000 different ethnic communities are estimated to rely directly or indirectly on some forms of shifting cultivation[4].

Shifting cultivation, commonly known as jhum in North East India, continues to be a predominant agricultural practice (Table 1), often being the only one available to address the need for food security of the inhabiting communities. This agro-ecosystem, once considered ecologically and economically sustainable, is gradually becoming untenable under increased anthropogenic and other pressures. However, this practice faceted with rich traditional ecological knowledge such as mixed cropping, traditional pest and insecticide management, weed management, soil conservation through zero tillage, and indigenous soil and water conservation practices is considered a candidate to arrest climate change if the farmers are able to maintain a longer fallow period through technological interventions[5–7]. Further, it is argued that unique resource ownership and utilization pattern of the shifting cultivators, make the system ecologically and economically sustainable[8,9], and efforts to wean farmers away from shifting agriculture and to replace it have not been successful. Such projects encroached the cultivable land, ultimately shortening the jhum cycles (fallow period)[10,11]. It is argued that the philosophy of shifting cultivation has been 'to create forest and not to destroy forest', because without forests the next jhum cannot be cultivated[12].

However, it is not to deny the fact that shifting cultivation in its distorted forms poses potential threat to the rich biodiversity of NE India[13], particularly to the unique faunal diversity[14]. Shifting agriculture is mostly found in tropical forests of NE India and changes in tropical habitats due to human-induced land-use practices are a major concern considering that the biodiversity-rich tropical rainforests are undergoing conversion to secondary habitats at a rapid rate[15]. Mature forest and late successional vegetation need to be maintained for conservation of several arboreal mammals[16]. Further, environmental

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Table 1. Area under shifting cultivation in different states of North East India

States	Abandoned Jhum (km^2)	Current jhum (km^2)	Total jhum land (km^2)	Total jhum land (km^2)	Per cent change in area
	2008–09			2005–06	Over 2005–06
Arunachal Pradesh	961.04	1078.52	2039.6	1531.5	+33
Assam	258.86	136.33	395.6	239.56	+65
Meghalaya	272.52	268.11	540.6	448.99	+20
Manipur	270.31	201.32	471.6	852.2	–45
Mizoram	612.71	1049.47	1662.1	2617.6	–37
Nagaland	1514.95	842.47	2357.4	2827.7	–17
Tripura	33.20	68.99	102.2	254.11	–60
Total	3923.59	3645.11	7568.7	8771.6	–13.7

Source: *Wasteland Atlas of India*, 2011 (http://doir.nic.in/wastelend_atlas.htm)

degradation obviously leads to poverty and reduces livelihood security[17]. There is a fair agreement that reduction in the length of the fallow phase in shifting cultivation cycle is a major challenge which needs to be addressed[18].

The economic development and improvement in livelihood conditions of the upland tribal communities of NE India are grossly dependent on shifting agricultural sustainability and efficient use of available natural resources[19]. This agro-ecosystem in the uplands of NE India, requires a concerted eco-technology backstopping (eco-technology development/modification, demonstration/dissemination, adoption/adaption and capacity building/capacity enhancement) to be sustainable, as access to technology in the region is grossly inadequate, given the constraints of terrain and limitations of prospective line departments[20]. Till date there is lack of viable simple and low-cost eco-technologies accessible to the practitioners to address this agro-ecosystem and make it more productive[21]. Technologies for this agro-ecosystem need to be adapted to local conditions and based on the principles of low external input for sustainable agriculture (LEISA). The technologies should also be based on locally available resources and be essentially simple, low-cost and appropriate so as to enhance sustainable agricultural production and generate employment opportunity by setting up entrepreneurships. Given the growing demand for both eco-technologies and capacity-building, a decentralized eco-technology backstopping system needs to be institutionalized in agricultural development in NE India. The mechanism is also to be utilized for feedback to facilitate eco-technology up-gradations without compromising on the basic principles of a particular eco-technology and for prioritizing location-specific technology needs at the grassroots, so that appropriate eco-technologies addressing the needs are developed and grassroots issues are incorporated in the research agenda. The technological intervention has to also keep in mind the gender perspectives, so that the quality of life of women in particular, is not challenged as they are the backbone of hill agriculture[22] that includes shifting agriculture. Further, appropriate eco-technological intervention in hill agriculture can be a deterrent to the fast-disappearing indigenous knowledge system[23,24] and climate change, which is visible across the Himalaya[25,26]. This article presents the outcome of up-scaling of potential low-cost eco-technologies for improved yield of crops in shifting agriculture, which continues to be the predominant livelihood for a majority of the upland communities in NE India.

Study area

The study area (Figure 1) is spread across NE India comprising five states, i.e. Assam, Manipur, Meghalaya, Mizoram and Tripura. The study was executed in partnership with 7 partner non-governmental organizations (PNGOs) covering 8 districts, 12 development blocks, 49 villages and more than 11 tribal communities. NE India occupies 7.7% of the total geographical area of the country and supports 50% of the flora (i.e. 8000 species), of which 31.58% is endemic[27,28]. It is a mega-biodiversity centre and a hotspot[29]. It harbours tropical rainforests to alpine scrubs, often called the ‘cradle of flowering plants’[30–32]. The region has the highest mammalian and avifaunal diversity in India, with around 250 and 900 species respectively[33]. Shifting agriculture in its present form with shortened fallow phase poses a serious threat to the rich biodiversity as it is prevalent in the NE India covering about 12% of the forest area in Arunachal Pradesh to 77% in Manipur[34].

Communities

The tribes covered in the present study include Boros, Hmars and Biete of Assam; Mao Naga/Liangmei Naga and Tangkhuls (Naga) tribes of Manipur; Mizos of Mizoram; Garos, Reangs, Debbarmas and Darlongs (Kukis) of Tripura, and Jaintias of Meghalaya. Agriculture is the subsistence livelihood of the studied communities, which is predominantly shifting agriculture, barring the Boro and Darlong tribes who are more or less settled agriculturists. Terrace cultivation is also a common practice in Manipur. Agricultural development in the region with inadequate access to technologies will be based on three critical imperatives – access to resources, credit and technology backstopping.

Methods

G.B. Pant Institute of Himalayan Environment & Development (GBPIHED), North East Unit was the Coordinating Agency for technology development, up-gradation, modification, demonstration and capacity-building. The PNGOs, who were trained by the Institute, had established Technology Demonstration Parks in their respective areas, so that such parks would become permanent Technology Demonstration and Dissemination Centres for the relevant state/district. The PNGOs demonstrated, disseminated and established on-farm demonstration sites of relevant technologies, appropriate to the needs of the farmers of their respective areas. Identification of technologies was need-based and demonstrated in selected villages, specifically sampled through survey and participatory rapid appraisal (PRA) exercises. The envisaged design, therefore, was three-tiered and functioned as a chain with a feedback loop using the same chain (Figure 2). It resulted in the establishment of an institutional network, where GBPIHED served as a 'Single Window'

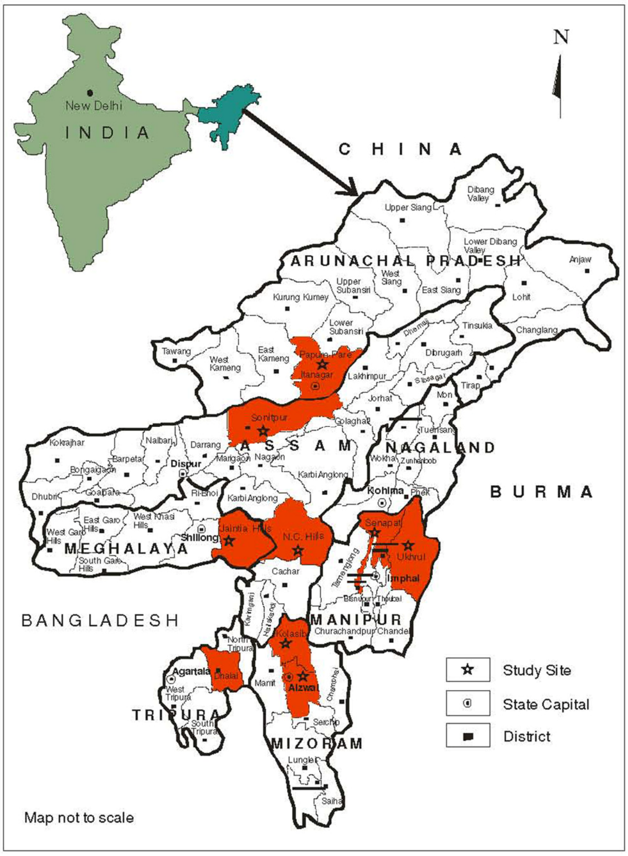

Figure 1. Location of the study area in the North East India.

Technology Dissemination and Up-gradation Centre, or a 'Technology Hub'. This was linked at the next level to localized NGOs, who have established Demonstration Centres. These are linked to lead farmers and on-farm demonstration sites, which are envisaged to be become 'Farmers' Schools'. Figure 2 is a flow diagram showing different links, roles and feedback mechanisms.

The PNGOs were trained in about 15 eco-technologies as follows:

(a) Production enhancement technologies: Weed/bio-composting, vermicomposting, liquid manuring, polyfilm technology, polyhouse, legume intercropping/mixed cropping, multi-tier cropping system and trellises.
(b) Soil erosion control technologies: Contour hedgerow technology (CHT), modified jhum.
(c) Water management technologies: Haandi (pitcher) irrigation.
(d) Post-harvest technologies: Zero-energy cool chamber.
(e) Energy/fuel-saving technology: Bio-briquetting technology.
(f) Nursery techniques: Bamboo propagation, cutting and grafting.

The PNGOs selected technologies based on the specific needs of their region for agriculture and entrepreneurship development (Table 2). A field manual on technologies prepared by GBPIHED was translated to local languages by the NGOs for effective adoption of technologies at the grassroots level by the target group in the respective states. The activities of the PNGOs were continuously monitored through field visits to project sites, obtaining progress information on quarterly basis using a questionnaire designed for this purpose, conduct of assessment-cum-monitoring workshops, guidance to PNGOs in consultative meetings, etc.

For monitoring the progress, the following indicators were identified:

- The number of NGOs imparting training (capacity-building of selected NGOs).
- Selection of relevant technologies by the NGOs.
- Selection of village clusters/villages.
- Number of demonstration centres/technologies established by the NGOs.
- On-farm demonstration sites established by the NGOs.
- Number of technologies adopted by the NGOs.
- Number of on-site training by the NGOs.
- Capacity-building of farmers/villagers (number of farmers trained).
- Number of farmers who adopted technologies.
- Validation/modification of technologies (technology validation/up-gradation)
- Surplus generated and income indicators.

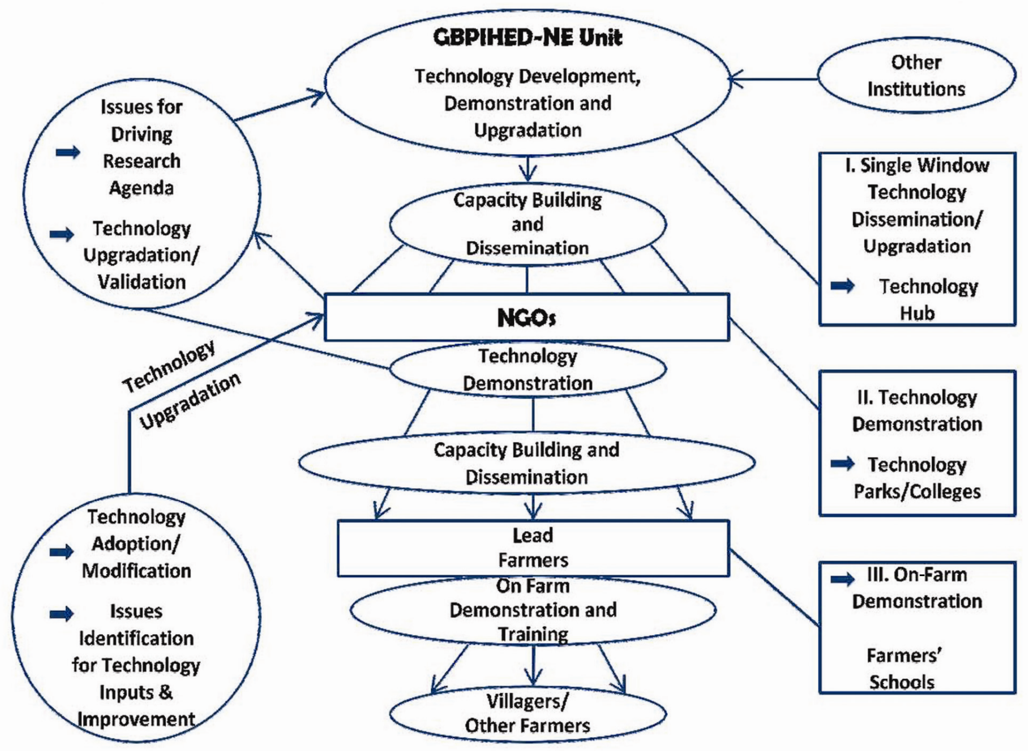

Figure 2. Flow diagram institutionalizing technology backstopping in NE India.

Table 2. Technologies promoted by PNGOs

PNGO	Technologies promoted
Institute of Integrated Resource Management (IIRM), Assam	Bio-composting, vermicomposting, trellises, haandi (pitcher) irrigation, polyfilm, legume inter-cropping and zero-energy cool chamber.
Centre for Environment Protection (CEP), Mizoram	Bio-composting, polyfilm, legume inter-cropping, contour hedgerow technology, zero-energy cool chamber and bio-briquetting
Nature and Motivation – Rural Human Empowerment Network Association (NAM-RHEN), Meghalaya	Bio-composting, bio-briquetting, vermicomposting, polyfilm, trellises, haandi (pitcher) irrigation and bamboo propagation.
N.C. Hills Hmar Cultural Organization (NCHHCO), Assam	Bio-composting, vermicomposting, modified jhum, polyfilm, haandi (pitcher) irrigation, trellises and bamboo propagation.
St Vincent's Welfare Society (SVWS), Tripura	Bio-composting, vermicomposting, liquid manuring, polyfilm, bamboo propagation, trellises, bio-briquetting and contour hedgerow technology.
Society for Sustainable Rural Development (SSRD), Manipur	Bio-composting, vermicomposting, liquid manuring, polyfilm, trellises, bio-briquetting, legume inter cropping, bamboo propagation and haandi irrigation.
Northern Integrated Development Association (NIDA), Manipur	Bio-composting, vermicomposting, liquid manuring, legume inter-cropping, bio-briquetting and modified jhum.

The Monitoring Committee drew its members from the Department of Science and Technology, Government of India, North Eastern Council, Central Universities; State Government Line Departments; State Institutions and subject experts.

Results and findings

The case study was people-centred and had in-built mechanisms such as integration of cultural landscape to ensure people's participation. In this case, as many as 3676 farmers were given training for capacity-building by the PNGOs on a number of technologies (Table 3). In the training and capacity-building, apart from focusing on tribal populace, gender perspectives were also given due consideration; more than 41% of the trainees were women. Further, to ensure sustained community participation, the PNGOs formed self-help groups (SHGs) and co-operatives like farmer's clubs. As many as 69 SHGs, 3 farmer's clubs, and 1 marketing committee were formed by the PNGOs for several entrepreneurships development. SHGs were involved in entrepreneurship development in

Table 3. Number of farmers trained in the case study

	People's participation/coverage			
PNGO	District	Villages covered	Communities covered	No. of farmers trained during 2008–2010
IIRM	Sonitpur	10	Boro	443
CEP	Aizawl, Kolasib	5	Mizo	1281
SSRD	Ukhrul	5	Tangkhuls	249
NIDA	Senapati	6	Mao Naga/Liangmei Naga	598
SVWS	Dhalai	10	Garos, Reangs, Debbarmas, Darlongs (Kukis)	369
NAM-RHEN	Jaintia Hills	8	Jaintias	482
NCHHCO	NC Hills	5	Hmar, Biete	254
Total	Eight	49	11	3676

Table 4. Technologies adopted by households

	Household-wise adoption of technologies in various NE states					
Technology	Assam	Mizoram	Meghalaya	Tripura	Manipur	Total
Bio-composting	93	23	20	35	89	260
Vermicomposting	75	–	5	09	10	99
Bio-briquetting	52	–	2	5	18	77
Polyfilm	30	11	–	–		41
Haandi irrigation	50	–	–	27	5	82
Trellises	380	–	20	15		415
Nursery techniques	–	–	–	12	20	32
Legume intercropping	–	23	2	250	104	379
Liquid manuring	–	–	–	42	10	52
Bamboo propagation	–	–	–	37		37
Modified jhum/contour hedgerow technology (CHT)	60	6	–	–		66
All technologies	740	63	49	432	256	1540

which lending their savings fund to their members was done so that the objectives and targets of the case were successfully achieved.

The level of adoption of various eco-technologies at household level across the study area revealed the practical application and impact of the case. More than 1500 households adopted one of the eco-technologies (Table 4) for enhancing shifting agricultural crop yield and entrepreneurship development. Trellises, legume intercropping and bio-composting had wider acceptance in comparison to others. However, large scale adoption of vermicomposting and bio-briquetting implied potential of the technologies as entrepreneurship option.

Increased crop yield

The average yield rate of major crops like rice, maize and wheat in shifting agricultural lands in NE India is about 1.15, 1.17 and 1.48 MT/ha respectively. The case revealed that use of technologies like bio-composting, vermicomposting, etc. noticeably enhanced the crop yield rates. The added advantage of the use of organic manure helped retain the region's tag as 'organic by default'. Consumption of chemical fertilizers and pesticides per hectare in the region is very low, e.g. it is 3 and below 0.006 kg per hectare respectively in Arunachal Pradesh, which is the lowest in the country[35].

Entrepreneurship development

Technologies such as vermicomposting, bio-briquetting, weed-composting were taken up by farmers for entrepreneurship development. A couple of households in Meghalaya have been using bio-briquettes for roasting of fish. The selling of roasted fish in the market has more than double return in terms of cash benefit and the whole mechanism can be considered as good entrepreneurship development. As observed, in the project villages, the income had increased by Rs 8000–10,000 annually, mostly for women entrepreneurs. In Assam, use of both bio-composting and vermicomposting enhanced crop yield, where surplus products were sold in the market. The farmers also sell the compost in the nearby market and supply to the nearby tea gardens. In the project villages in Manipur, bio-composting and vermicomposting provided fertilizer (compost) to the farmers, particularly for their mix-cropping system, thus enhancing crop yield and ensuring cash generation. Farmers could increase their income by Rs 10,000 per annum from mix-cropping in their home gardens through application of bio-composting.

It was interesting to observe that the farmers modified and adapted the technologies and practices according to their needs and requirements. Some of the technologies such as bio-briquetting, weed composting, liquid manuring, zero-energy cool chamber and haandi technology (pitcher irrigation) in their use pattern were modified by the NGOs/farmers without altering the basic principles of such technologies. Adaptation reflects a community's forward-looking drive to changes demanded by ecological conditions. Details of the farmer's modifications and the reasons were documented so as to make the technology up-gradations dynamic and incorporate farmers' concerns, thereby enhancing the acceptability of technologies among users. In the uplands of NE India, particularly in shifting cultivation systems, weeds form a critical input traditionally. Weed decomposition releases nutrients, which are then taken up by the crops. Mulching of weeds is a common practice among rural farmers. Based on this practice weed composting has been developed to allow low-cost, high-quality manure used as organic fertilizer. The mulched weeds are mixed with cow dung and allowed to decompose in pits constructed from bamboos. The conventional design is a three-chambered structure made up of bamboos with a perforated pipe placed vertically in the first and second chambers to allow aeration. The farmers have brought about changes in the conventional design of weed composting. In many villages, the traditional earthen pot used in haandi technology is replaced by plastic containers/bottles or bamboos. In principle, in haandi or pitcher drip irrigation system, earthen pitchers of 5 litres capacity are used as water containers in the crop beds. The pitchers are perforated carefully using nails to give less than a millimetre perforation in the 'belly region' of the pitcher. The perforations can be made in single rows or double rows, so as to allow the water to percolate at the root zone. The pitchers after perforation are buried in the soil in the crop beds up to the height of the pitcher neck. The pitchers are then filled with water and covered with lids to prevent evaporation and loss of water. Capillary action sucks out water from the pitchers into the soil, thereby increasing the moisture content of the soil in the root growth region. A 5 litre pitcher moistens an area of 0.5 m radius in two days. Depending on the dryness and relative humidity (precipitation through mist and dew), the water needs to be topped up every 7–10 days.

Policy impact

From the view of practical and policy impact, the eco-technologies described in this case are replicated in important programmes like International Fund for Agricultural Development by Meghalaya Rural Development Society (IFAD-MRDS), Meghalaya, and Watershed Development Programme of the Government of Arunachal Pradesh. The Inter-Ministerial National Task Force of the Ministry of Environment and Forests (now MoEF&CC), Government of India on rehabilitation of shifting cultivation areas has found the technologies appropriate for rehabilitation of jhum lands (shifting agricultural land). Transfer of low-cost sustainable eco-technologies to the upland farmers who are mostly marginalized has helped in improving crop production and thereby their livelihoods.

Conclusion

In NE India, technologies which are simple, low-cost and environment-friendly have a better and wider acceptance. Apart from enhancing production of shifting agricultural crops, the eco-technologies also have potential in capacity enhancement and entrepreneurship development. Up-scaling of eco-technologies could help address the issues associated with shifting agriculture, which are gradually becoming untenable under pressure from a number of factors and besieged with conflicting views with regard to degradation/conservation of the ecosystem. Considering the social and economic dependency of the ethnic communities on this agro-ecosystem that integrates both material and non-material culture[36], and the way of life for the upland communities of NE India, it is essential to make the practice ecologically and economically sustainable through simple and low-cost eco-technologies, which has been feasible in this case. Further, it is important to note that given the uniqueness of the shifting cultivation system, because of a combination of socio-cultural–legal and bio-physical characteristics of the locality, although replication of one model may not be appropriate to all localities, simple, low-cost ecotechnologies have the potential to be replicated and adapted. The agro-ecosystem being endowed with rich traditional ecological knowledge and practice has the potential to mitigate climate change impacts when it is made more productive using technologies and enhancing its fallow period.

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ACKNOWLEDGEMENTS. We thank the SEED Division, Department of Science and Technology, Government of India for financial support. The role of partner NGOs in propagating the technologies and the people of North East India in adopting the technologies is acknowledged. We also thank those involved in the various stages of implementation and monitoring of the case study, particularly Dr Dhrupad Choudhury (ICIMOD, Kathmandu) for initially contributing to the concept of the case study. The paper was submitted to North East Development Foundation for Competition for Scholl Research award.

Received 24 February 2015; revised accepted 18 July 2016

doi: 10.18520/cs/v111/i12/1929-1935