Impact of Slash-And-Burn Agriculture on Forest Ecosystem in Garo Hills Landscape of Meghalaya, North-East India

P. K. Yadav1,2,*, Mohnish Kapoor3 and Kiranmay Sarma3

Abstract
Slash-and-burn (jhum) is one of the primary causes of deforestation in tropics. In North-East India, increasing human population density has resulted in the practice of unsustainable form of slash-and-burn that includes shortening of the fallow period as well as permanent conversion of forest to permanent agricultural expansions. This unsustainable form of slash-and-burn leads to soil degradation, soil erosion, loss of forest vegetation and threatens the survival of wild flora and fauna. Garo Hills has the richest reservoir of plant diversity of India and is one of the biodiversity hotspots of the world. There are numerous sacred forest patches in the Garo Hills. The prominent pressure to native forest biodiversity in the Garo Hills is the increasing anthropogenic conversion of mature and primary forest to jhum land. The decreasing fallow period has a deep impact on the life sustainability in Garo Hills and has reduced the quality of soil and thereby reducing the possibility of vegetative restoration at the locality. There was a tremendous increase in slash-and-burn land, i.e. 5.15 percentage in the year 2010 when compared to only 0.83 percentage in the year 1991. The overall reduction in the forest, mainly due to jhumming can severely affect a viable forest habitat of the endangered fauna like the Asian elephant and Hoolock Gibbon. The need to understand the effect of slash-and-burn cycle and to differentiate between the ecological sound traditional methods of jhum from the current unsustainable forms is most important.

Keywords: Slash-And-Burn; Garo hills; Soil degradation; Deforestation; Asian elephant; Hoolock gibbon

Introduction
Slash-and-burn agriculture is regarded as one of the traditional methods for cultivation in hilly areas of tropical regions in which forest vegetation is cut and burned on site (Figure 1 A and 1B). The site is cultivated for food crops and when the final crop is harvested; the site becomes fallow and is allowed to regain its natural forest cover [1]. World Resource Institute in 1996 [2] regarded slash-and-burn (also known as shifting cultivation, jhum agriculture and swidden agriculture) as one of the primary causes for deforestation in tropics. Deforestation by contrast and slash-burn normally causes large losses of CO2 and GHGs from soil and vegetation; leads to a change in runoff and local climate [3]. A recent study in Northern Thailand which aimed to assess the ecological footprint of a traditional shifting cultivation community found that shifting cultivation farms, including active and rehabilitating fields aged 1 to 10 years, have due to burning emitted 1745.33 tons of CO2 [4]. It is generally believed that about half of the deforestation in the tropics is the result of expansion of traditional agriculture, above all shifting cultivation [5]. Some studies suggest that slash-and-burn farming may also be associated with poor crop yields and rapid soil degradation [6,7]. Tropical forest felling and burning has significant local impacts on nutrient cycles and soil organisms, which can have long-term effects on quality and recovery of forest site [8].

The history of land use and agriculture in the forest landscapes of the greater Indian subcontinent and south Asia is strikingly diverse. Over the centuries, multiple overlapping cultures have occupied and tilled the forests of sal (Shorea robusta), teak (Tectona grandis), and hundreds of other evergreen, semi-evergreen, and deciduous tree species. In North-East India, the dense tropical forests were viewed as a major obstacle for agricultural expansion. Most of the arable land is being used either for settled permanent agriculture or jhumming, and other forest resource uses such as firewood extraction [9]. Today, however, it is human population density and its toll on soils and native forests of the region that have become an impediment to prosperity. These anthropogenic pressures are negatively affecting the native forest viability in North-East India. Increasing rates of shifting cultivation have led to increased fragmentation of intact, native forests and the implications of such changes in forest landscape patterns on native biota, including mammals like Asian elephants (Elephas maximus) and Hoolock Gibbons (Hoolock hoolock).

The main difference between shifting cultivation of current practices is that when compared to the past, there is an increase in the scale and shortening of fallow period. The practice of shifting cultivation is reported to account for 60 % forest losses worldwide each year [10]. About 0.45 millions families in North-East India annually cultivate 10,000 km2 of forest, whereas total area affected by jhumming is held to 44,000 km2 [11]. With a phenomenal increase in the human population, jhum cycle has decreased from 20-30 years to about 5-8 years [12]. Short jhum cycle makes the land unsuitable for agriculture and leads to considerable loss of soil nutrients through runoff and leaching [13,14].

Methodology
The present study “Impact of slash-and-burn agriculture on forest ecosystem in Garo Hills landscape of Meghalaya, north-east India” of

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Figure 1: (A) Burning of Forest land for Jhum and 1 (B) Burned forest land.
North-East India is conducted as preliminary survey in Garo Hills landscape. The relevant information and data for study were collected mainly from secondary sources available in publications and reports of various government departments and academic institutions. However, some information pertaining to Impact of slash-and-burn agriculture on soil, forest and wildlife, and their impact on forest ecosystem was also collected by conducting primary sample survey at village level. The details of data collection and compilation are given below:

Collection of data from Secondary sources

An extensive review of the available literatures on soil runoff, forest and wildlife was carried out by visiting different government departments, academic institutions and various libraries. Published and unpublished data pertaining to land and forest resources, and their various goods and services were collected from journals, theses and technical reports.

Generation of primary data

Garo Hills one of the biodiversity rich landscape of Meghalaya. Native Garo community is practicing Shifting cultivation (Jhum) for their livelihood from ancient time. There previous studies not documented the impact of shifting cultivation on the local biodiversity of landscape. However no more information is available on Impact of slash-and-burn agriculture on forest ecosystem. During present study primary survey was conducted to the find out the impact of slash-and-burn agriculture on soil degradation, runoff and wildlife habitat (Figure 2 and 3). Some information was also collected by interviewing of the endemic Garo community.

Study area

The study area is located between 90°07–91°E and 25°02-25°32N and with elevation ranges from 100 to 1500 m. The Garo Hills of Meghalaya have three district, viz., East Garo Hills, West Garo Hills and South Garo Hills. The total area of Garo Hills is 8,167 km², which is 36.4% of the total area of Meghalaya. The highest point of Garo Hills is the Nokrek peak with an altitude of above 1412 m. The Garo landscape contain four protected areas (PAs) and four reserved forests (RFs), which collectively comprise 15% of the total area and offering excellent prospect for conservation of native forest and the associated biodiversity of the region. The PAs include Balpakram National Park (200 km²), Nokrek National Park (47.48 km²), Siiju Wildlife Sanctuary (5.18 km²) and Baghmara Pitcher Plant Sanctuary (2.7 km²). The four Reserved forest are Baghamara Reserved Forest (44.29 km²), Rewak Reserved Forest (6.48 km²), Emangiri Reserved Forest (8.29 km²) and Angratoli Reserved Forest (30.11 km²) [15] (Figure 4).

Meghalaya is a small state in North-East India, is reported to have 3128 species of flowering plants including 1236 endemic species [16]. Sacred forest are rich in biodiversity with about 1886 plant species documented from the forest of Meghalaya [17]. Many endangered species of the state are confined to Garo Hills only and 111 species were reported from Garo hills, out of which 51 species were endemic [18]. Garo Hills has richest reservoir of plant diversity of India and is one of the biodiversity hotspots of the world. There are numerous sacred forest patches along the districts of Garo hills. Bamboo reserves dedicated to deities are also reported from Garo Hills. The Garo people traditionally perform ancestral worship in forest patches on ancient monoliths.

Results and Discussion

The most North East Indian forests are under the tremendous pressure of exploitation due to unplanned traditional forestry practices especially the widespread use of slash and burn shifting cultivation, in which native people clear and burn the old forest growth over a piece of land to get fertile land for raising agricultural crops for one or two years and then move on to clear fresh forest land. Yet its reputation as a causal factor for deforestation, land degradation and smog has remained alive; and for valid reasons. Indeed, the system might have been sustainable at one stage. But the rapidly increasing population pressure, migration, changing market dynamics, industrial development, and other significant changes
in the policy environment in the region, have increasingly caused transformation of one or other components of the shifting cultivation system in such manner as to destabilise the whole system at most places.

Impacts on soil

Burning forests is identified as one of the soil degrading practice that results in soil structural dilapidation. Although, shifting cultivation practices cause tremendous loss of nutrients [19] and degradation of natural vegetation [20]. The benefits of slash-and-burning in improving soil fertility by immediate release of concluded minerals nutrients for crop use seems to be short-lived due to its degenerate effective soil physical properties. In the farmer’s perception, this practice has clear benefits like: it consumes slash vegetation, increases field accessibility, provides a fertilizing layer of ash, improves soil structure and reduce weed tree composition as well as occurrence of pests and diseases [21]. After the cropping year farmers leave the crop land as fallow land and before the natural plants grow to cover the ground surface, the soil is exposed (Figure 5A and 5B) to climatic element of rainfall. Afterwards, soil aggregates are dispersed, pores are closed with particles and further result in much higher rates of runoff [22]. The level of soil alteration may be huge if the magnitude of trash is large and the resident time of burning is long or thin, dry litter is completely incinerated.

Meghalaya is the most wet place of the world and the average rain fall in Garo Hills is about 3000 mm. Slope and elevation are an important factors that affect soil erosion and Garo Hills have a high degree of variable slope and elevation characteristics. Forest reduced water caused erosion by intercepting rainfall, increasing water infiltration on associated “soil fertility” island, intercepting runoff at surface level and stabilizing soil with root [23]. Vegetation is one of the major factors controlling soil erosion, while most soil erosion occurrences are due to removal of vegetation and topsoil exposure to the air. Soil run-off and sedimentation processes at field and landscape scale can cause a net soil loss and can also affect spatial variability of soil fertility within a field and landscape [24]. Soil run-off mostly serve on sloping lands and occur mainly in the first year after burning, particularly if slash-and-burn followed by heavy rainfall [25]. Heavy rainfall in such areas (Figure 5A and 5B) may lead to sedimentation runoff from higher elevation and steep slopes (Figure 6). In future, this can lead to a severe soil erosion problem in those areas. The soil erosion may significantly affect any future revival of the vegetation. jhum cultivation plays a very big role in degradation of soil, forest and biodiversity fragmentation in that region. Survey of study sites (Figure 3, 5A and 5B) are presently upheld as an evidence of how the indigenous people have blindly destroyed their environment.

Forest loss

Meghalaya, including Garo Hills is one of the richest botanical regions of India [26] and one of the most diverse luxuriant tropical vegetation condition of the world [15]. Extensive cutting and burning activities during jhumming is the major biotic interferences in the Nokrek Biosphere Reserve [27]. This burning activity has directly and circuitously affected rich plant diversity and caused forest land degradation, habitat destruction and solely depleted the biodiversity of the Reserve [28]. Land use cover is an important component to understand global land status; it shows present as well as past status of the earth surface [29]. Status of land use changes of Garo hills is mentioned in Table 1 which shows dynamic degradation of forest cover. The study was conducted by Yadav in 2012 [30], as “Landscape Dynamics in Garo Hills of Meghalaya, North East India using Geospatial Technology” for master thesis (M.Sc. Biodiversity and Conservation) and submitted to Guru Gobind Singh Indraprastha University, New Delhi, India.

It was found that in entire period, a large area under open forest has been converted into non-forest area. The area of slash-and-burn land increased in whole time period continuously. Yadav in 2012 reported jhum as one of the drivers of deforestation in Garo Hills which increased tremendously (Table 1) during 1991 to 2010. The area of dense forest decreased in between 1991 to 2001 but increased in 2001 to 2010 period. This may be due to the effort put by Government and other organizations who are working for restoration of forest in Garo Hills.

The prominent pressure to native forest biodiversity in the Garo Hills is the increasing anthropogenic conversion of mature and primary forest to jhum land. From 1980 to 1990, more than 6% of worldwide tropical forests and 10% of Asian tropical forests were converted to shifting cultivation [2] (WRI, 1996). As per the 1979 report of the North Eastern Council in the Indian state of Meghalaya, a total of 4116 km² land was practised for jhumming, of which 760 km² was used at one point of time every year by 68000 jhummis, i.e. families involved in jhumming [31].Vegetation and land characteristics of Garo hills are heavily influenced by jhum activities which have greatly amplified in recent decades with increase in human population, resulting in several fragmentation of previously undamaged forest tracts. Reduction of native forest cover is a major impact of slash-and-burn. During 2000, a total of 7900 families (39,500 people) used 68 km² of land for jhumming at annual increase of 3.67% in South Garo Hills [32].

In Garo hills, native tribal communities have same permanent agricultural land, especially in western, southern and eastern parts bordering Bangladesh and Assam. Because of the hilly landscape,
settled cultivation is practiced only in small portion of the total cultivated land, mostly confined to the valleys. High labour cost and energy input involved in trace cultivation, and absence of other viable alternatives implies that the majority of population continues to depend on shifting cultivation for their livelihood.

Impact on wildlife

Large, wide-ranging mammals, especially herbivores such as Asian elephant, can act as useful indicators of overall landscape biodiversity because they use large, often heterogeneous landscape areas to find resources [33,34]. Elephants also provide vital ecological functions such as: creation and maintenance of forest paths and pools used in turn by many other species including ungulates; dispersal of fruits and seeds through dung deposition; alteration of vegetation composition and structure through browsing and trampling; and other functions [35-37]. Conserving elephants would also serve to conserve many other wildlife species; thus, elephants appropriately serve as an “umbrella species” [38].

In India, Asian elephants (Elephas maximus) are present in their highest densities and numbers in Garo Hills of Meghalaya [39]. Little quantitative work has been done on elephant-habitat relationships in this region where the species’ distribution is known to be highly fragmented [40]. If elephants and their habitat are to be conserved, particularly in Garo Hills, and elephant-human conflicts are to be reduced, the initial steps are to understand their spatial and temporal distributions, determine habitat conditions associated with elephant densities, identify key population stressors, and suggest conditions conducive to elephant population persistence. Much of the native forest cover used by elephants in Garo Hills has been greatly altered over recent decades, largely through accelerated short-cycle jhum activity. Such intensive land use has been previously concerned in the decline of elephant populations of the region [41]. There were total 1841, 1297, 1104 and 1285 elephant reported in the 1993, 1998, 2002 and 2008 censuses respectively and it was concluded that numbers in Garo Hills of Meghalaya [42]. There were total 1841, 1297, 1104 and 1285 elephant reported in the 1993, 1998, 2002 and 2008 censuses respectively and it was concluded that numbers in Garo Hills of Meghalaya [42].

Table 1: Area under different land use land cover classes in Garo Hills.

<table>
<thead>
<tr>
<th>Land use/cover (Classes)</th>
<th>Year 1991</th>
<th>Year 2001</th>
<th>Year 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area in km²</td>
<td>Area in %</td>
<td>Area in km²</td>
</tr>
<tr>
<td>Dense Forest</td>
<td>836</td>
<td>10.24</td>
<td>375</td>
</tr>
<tr>
<td>Open Forest</td>
<td>6649</td>
<td>81.41</td>
<td>6365</td>
</tr>
<tr>
<td>Slash-and-burn Land</td>
<td>68</td>
<td>0.83</td>
<td>172</td>
</tr>
<tr>
<td>Non Forest</td>
<td>614</td>
<td>7.52</td>
<td>1255</td>
</tr>
<tr>
<td>Total</td>
<td>8167</td>
<td>100</td>
<td>8167</td>
</tr>
</tbody>
</table>

Impact on physical environment including land use, land cover, biodiversity, and climate change and forest ecosystem. They also have negative impact for human health and on socio-economic system of affected region. The large-scale destruction and transformation of forest into degraded formations through logging and forest fragmentation and existing biotic pressure on forest in the form of logging, grazing and collection of non-timber forest products have rendered forest vulnerable to forest fire [44]. Increasing intensity of shifting of cultivation practices leads to low rainfall due to destruction of habitat which finally reduces biological diversity and causes extinction of previously undiscovered indigenous species too [45].

Conclusion

Like other forms of agriculture, slash-and-burn can be mismanaged and lead to severe environment degradation [46]. Continuously increasing human population and their demand for food, fodder and transportation leads to natural land cover degradation, resulting into habitat degradation, biodiversity loss, and ecological instability [47]. However, carefully designed and well managed slash-and-burn can serve as a sustainable food production system and provide benefits in the form of fuel, building materials and other income source. Historically, Slash-and-burn agriculture has been among the few truly ecologically sustainable agro ecosystems in the world because crop yields can be maintained without the use of non-renewable fossil energy resources for fertilizers, pesticides and irrigation [48] but shortening of the jhum cycle primarily to meet the demands of the ever growing human population has taken its toll on the environment.

The threats of soil degradation and soil erosion due to jhumming can affect the vitality of native vegetation due to loss of necessary nutrients and soil features needed for their natural survival. Ramakrishnan in 1992 [49] described a positive correlation between crop yields and length of the fallow period oeing the role of the fallow in controlling soil erosion. This relationship between food productivity and soil conditions provide a means of assessing the cost to humans of degrading the soil resource, but it also provides

![Figure 7: Burned forest cover (wildlife habitat) due to uncontrolled Slash-and-burn in Garo Hills.](image-url)
a means to assess the natural production potential of the soil, Garo hills landscape, being a wildlife hub is being negatively affected by unsustainable jhumming. The overall reduction in the forest, mainly due to jhumming can severely affect the habitat several of the endangered fauna like the Asian elephant and hoolock gibbon. Proper strategy and management of jhum in the Garo Hills is an immediate need to safeguard pristine habitats of wild flora and fauna in the area and also for sustainable food production for humans. Although there is lack of systematic analysis of the effect of social organisations and cultural values in shifting cultivation systems, there are enough anecdotal evidences which corroborate that these are important factors. There is a need for understanding determining factors, innovations and adoption of improved jhum management practices to conserve the continuously declining biodiversity of North-East Indian states.

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