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Agroforestry options, soil management and biodiversity conservation practices in some traditionally diverse shifting cultivation systems of Asia: a review.

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Abstract: *In this review paper, shifting cultivation and different related aspects and approaches are discussed elaborately with the data from research works carried on shifting cultivation practices in different regions of the Asia. In recent years, many modifications in the traditional shifting cultivation were developed by cultivators themselves which are sustainable and environmental friendly. Shifting cultivation is a primitive and traditional land resource management practice in which fields are shifted, mostly annually, in order to exploit the energy and nutrient capital of the natural vegetation and soil of the site. The operations involved in this practice are closely related with the religion, right and festival of the tribal people from the beginning and hence, it remained as a part and parcel of their socio-cultural life. About 500 million people, 3000 ethnic groups and approximately 2.9 billion hectares of land are under shifting cultivation practice in the world. An ever increasing population pressure caused shortening of fallow cycles, frequent deforestation, repeated burning and cleaning of vegetations from slope in hills. Such actions resulted to some ecological, environmental and soil related problems. Cleaning of vegetation cover from slope created problems like soil erosion, loss of biodiversity, forest and fall in soil productivity. Repeated burning and cropping in a short span of time has declined soil organic carbon, loss of soil structure, loosening of soil aggregation, reduced water holding capacity, nutrient loss and decline in biological rejuvenation processes. Shifting cultivation is surviving for centuries with optimum yield on a long term basis. It is possible to increase production without departing too much from traditional system. Therefore one of the approaches towards sustainable management of shifting cultivation may be to look into positive and also detrimental effect of each operation and take systematic management strategy accordingly.*

Keywords: *Shifting cultivation, ecological, environmental, productivity, modification sustainable etc*

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I. Introduction

Shifting cultivation is the most primitive form of agricultural practice. Conklin[1] defined shifting cultivation as “any continuing agricultural system in which impermanent cleanings are cropped for shorter periods in years, than they are fallowed. Pelzer [2] defined it as an agricultural system “which is characterized by a rotation of fields rather than crops, by short period of cropping (one to three years) alternating with long fallow periods (up to twenty or more years but often as short as six or eight years) and by cleaning by means of slash and burn”. A comprehensive definition of shifting cultivation was given by Okigbo [3] as “The term ‘Shifting’ refers to farming or agricultural system in which a short but variable cultivation phase of slash and burn cleared land alternatives with long, equally variable fallow periods”. This system of cultivation is known by various names like rotational agroforestry, slash and burn agriculture, swidden agriculture and Jhum cultivation in northeastern part of India. In India this system of cultivation is also practiced in different states and known by different names like as Vevar and dahiyaar in Bundelkhand and Deepa in Bastar district of Madhya Pradesh, Zara and Erka in southern states, Batra in south eastern Rajasthan, Podu in Andhra Pradesh, Kumari in hilly region of the western ghats of Kerala and Kaman, Vinga and Dhavi in Odisha. It is known as Milapa in Central America, Coamile in Maxico, Conuco in Venezuala, Poka in Brazil, Lavy in Madagascar, Taungya in Burma, Tamrain in Thiland, Ray in Indochina, Karen in Japan, Ladang in Indonesia, Hunals in Java, Diuma in Sumatra and Kaingin in the Philippines. This all confirm that shifting cultivation is a widely adopted agricultural practice in past and present. It is believed that shifting cultivation have originated in the Neolithic period around 7000 B C [4]. According to some scientists, it might have originated in Neolithic period between 13000 to 3000 B C [5].

The total area under this system of cultivation is difficult to assess because a diverse land use activities are associated with the practice. However in the mid 70s it covered about 30 percent of the worlds exploitable soils. During 1988 approximately 1 half of the lands in tropics and in 1994 the total area was estimated to be around 2.9 billion hectare globally. Due to differences in reports of the total number of people practicing shifting cultivation the exact figure is not known. Some reported it as about 300 to 500 millions in 1980s and few other reported as it is practiced by 400 million people in Asia alone. About 3000 ethnic groups [6] are involved in this agricultural practice worldwide. Shifting cultivation is now exclusively practiced in subtropical humid and humid tropics of Africa, Asia and Latin America. It was also common in temperate region of Mediterranean and northern Europe in 19th century and in south western and North America especially in north eastern pinewoods during 1940s [5, 7, 8].

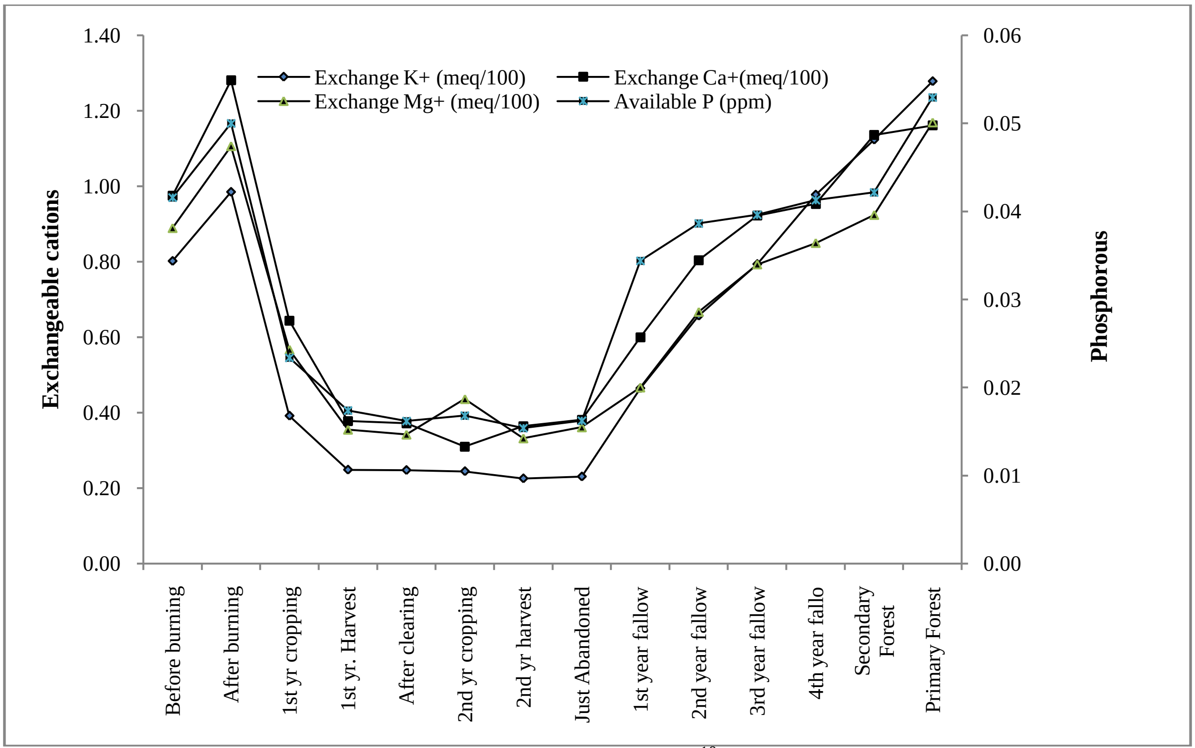
Shifting cultivation is mostly practiced by tribal people residing in hilly regions, ranging from moderately sloppy to steeply sloppy areas. Sometimes in almost flat lands near or in secondary forests, tropical moist forests to dry tropical forests, savannas, grasslands and also in low lying valleys even in seasonal flood plains. About 8.3% of the world's total tropical land areas *i.e*. 21% of the total tropical forest areas are affected by shifting cultivation. In north eastern hilly regions of India 25, 6083 sq km which accounts 7.76% of the country's total geographical area is under shifting cultivation. The emphasis on strategy and agro-eco-system dynamics makes shifting cultivation "neither a static nor necessarily stable system of agriculture" but one that is flexible in response to change [9].

II. Effect of shifting cultivation practice on soil properties

Shifting cultivation was earlier nature friendly and a viable practice. Shortening of fallow cycles and repeated burning and cleaning of vegetation has lead to some ecological, environmental and soil related problems. Frequent deforestation, cleaning of vegetation cover from slope created problems like soil erosion, loss of biodiversity, forest loss and fall in soil productivity in shifting cultivation lands. Repeated burning and cropping in a short span of time has declined soil organic carbon, loss of soil structure, aggregation, water holding capacity, nutrient loss and decline in biological rejuvenation processes. Therefore one of the approaches towards sustainable management of shifting cultivation may be to look into positive and also detrimental effect of each operation and take systematic management strategy accordingly.

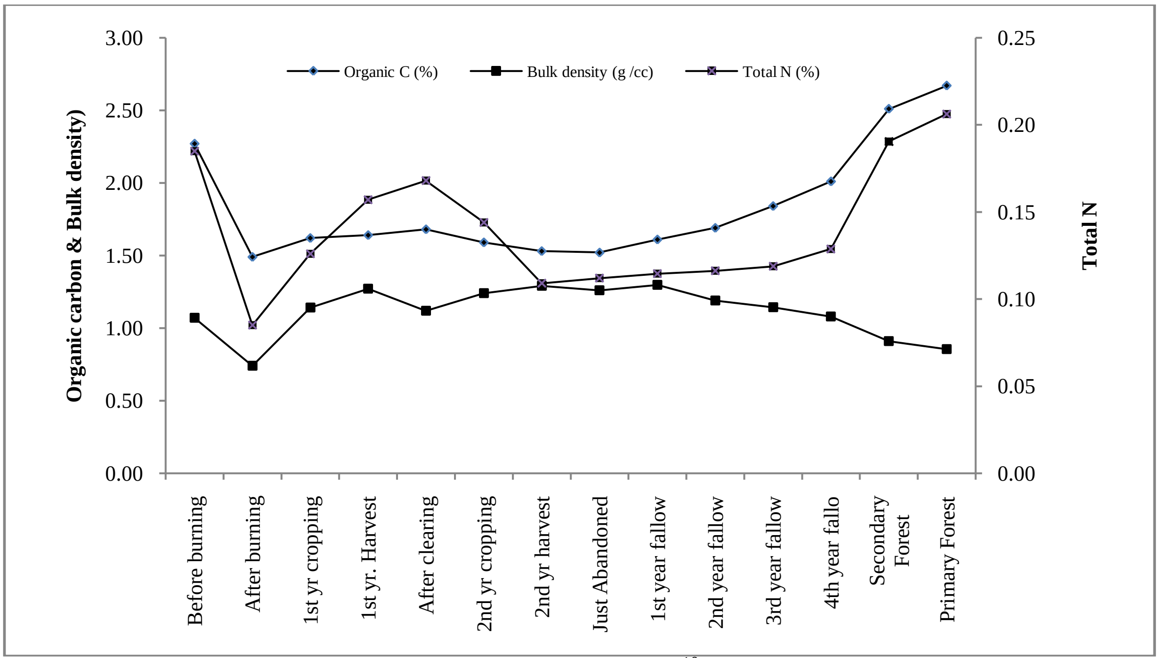
Researchers observed that the effect of burning on soils depends upon soil types. Soils rich in allophone clays (volcanic ash soils) and oxisols (highly weathered soils) are less affected by temperature change during burning whereas soils rich in humus and organic carbon are much altered during burning. There are also good affect of burning on soils, soil pH increases making most of the cations like Ca, Mg and K more available to plant (figure, 1). Ash contains phosphorous and potash in available forms. Burning causes loss of soil organic matter and makes soil compact resulting in high bulk density of soil up to 15 cm depth [10] (figure, 2). Soil nitrogen is converted into oxide forms and it escapes to atmosphere resulting in decreasing of soil available nitrogen after burning (figure, 2). Shifting cultivation is primarily practiced in hill slops. When burning operations are performed it eliminates most of the weeds, vegetation cover, organic carbon *etc.* exposing the finer section of soils and thus accelerates soil erosion which is mainly by splash and wash by rain water. The second year of cultivation cycle is comparatively more harmful as around 40 tons of soils per hectare can be eroded on an average [4]. Burning volatilize most of carbon, sulphur and nitrogen from the vegetations. Popenoe [11] Nye and Greenland [12] found that organic carbon and total nitrogen increases in soil after burning. The large amount of cations release after burning increases the soil pH which in turn may promote nitrification [13, 14]. After burning ash releases cations into the soil that neutralizes the level of soluble and exchangeable aluminum present in acid soils [15, 16]. Burning makes some nutrients available initially particularly phosphorous, potassium, calcium and magnesium [17] for the first cycle of crops plants in shifting cultivated soils of tropics. However productivity of soils and yields decline with the successive cropping cycles which are the prime reason behind for moving of cultivators from one forest to another.

Jacob and Chakraborty [18] conducted a study on species composition and density of litter micro fauna in shifting cultivated soils of Silonijan, Karbi Anglong district of Assam. It was observed that fallow areas like 1 year, 5 year, 10 year and 20 years showed wide species diversity. It was found that burning affected most of the micro faunal density.



Source: Singh *et al.* [10]

Figure: 1. Dynamics of soil available cations and phosphorous during shifting cultivation.



Source: Singh *et al.* [10]

Figure: 2. Dynamics of soil organic C, Bulk density and total N during shifting cultivation

III. Shifting cultivation versus deforestation, climate change and global warming

Shifting cultivators are often blamed for deforestation in tropical and subtropical regions but recent researches suggested that in reality it is more complex phenomenon as a variety of factors are also responsible. In fact they are not at all responsible for majority of deforestation or land degradation. Most traditional shifting cultivations are very much environment friendly, sustainable and frequently enhance biodiversity. They also adopt modern approaches. The techniques used by them are generally appropriate to their agro-ecological system. They have useful knowledge about resources, land fertility, production, land uses, and surrounding environment [19]. During land preparation for shifting cultivation forest vegetation is cleared, burned this contributes carbon dioxide and water vapour to the atmosphere which are the constituents of green house gas. Carbon dioxide constitutes almost 90% of green house gas found in a study conducted in Cameroon [20].

Shifting cultivation may be contributing carbon dioxide to atmosphere but there are other issues also like fossil fuel burning, industrial emission, urbanization *etc.* The current climate change and mitigation option has taken the debate on shifting cultivation to global level. Regarding green house gas (CO_2) emission from shifting cultivated fields some believe that it is smog. In a study in Thailand, Prasert [21]reported that burning of rotation fields is not a sole cause of climate change as the fields are burned only for 2-3 days for 1-2 hrs per day and that to once in a year or cropping cycle. In an another study it was found that carbon storage in the shifting cultivated lands covering an area of 236.16 ha was 17,348, while carbon dioxide emission from the burning was about 480 tons. Shifting cultivation cannot be considered a major cause for deforestation [22]. According to FAO, UNDP and UNEP, the main cause of deforestation and carbon emission is intensification of agriculture, direct conversion of forest land for urbanization, industrial development, highway developments *etc.* More carbon is sequestrated in areas under shifting cultivation than permanent cropping of seasonal plants or plantations. Since shifting cultivation is one form of agroforestry system. Above ground carbon stock in long fallow cycles of eight to ten years was found to be between 74 and 80 tons/ ha [23, 24] whereas under continuous annual cropping carbon stock was reported as 1-4 tons/ha. In Indonesia when rubber plantation is combined with shifting cultivation especially in landscape level they have above ground carbon stock of 90-116tons/ha.

IV. Shifting cultivation towards sustainability

As said earlier, shifting cultivators are mostly blamed for most challenging issues like deforestation, soil erosion, soil nutrient loss, loss of biodiversity *etc.* The continuous discrimination by some academics, government agencies on this practice has created a negative impact among most of the people. Shifting cultivation is practiced by some ethnic group of people this practice is closely intermingled with their food production, socio-economic, cultural and spiritual beliefs and life. They are not ready to give up their age old practice perhaps they would rather prefer to move deeper into the forest and be away from outside disturbances. So the strategy that could offer the greatest advantages and acceptance among the large number of shifting cultivators is to establish habit of making optimum use of their natural resources.

Some of the agricultural options are agroforestry, integrated nutrient management, on farm improvement, to and fro teaching and learning, improved traditional system by incorporation of green manuring crops/tree species in the system. Traditionally some of the leguminous trees like *Gliricidia sepium, Leucana leucacephala, Sesbania bispinosa*, *Tephrosia candida*, crops like *Mucuna pallida, Cajanus cajan*, creepers like *Mimosa,* Shrubs like *Crotalaria, Centrosem, Pueraria* can be grown in situ and incorporated in the field to increase the soil fertility and productivity. In a study done by Bora and Baruah [25] observed that incorporation of leguminous tree and shrubs leaf increased soil fertility as well as productivity (table 1 and 2).

Table: 1. Effect of green manure on NPK content of soil in shifting cultivation land

Treatments	Nitrogen(Kg/ha)				Phosphorus(Kg/ha)				Potassium(Kg/ha)			
	Before sowing		After harvesting		Before sowing		After harvesting		Before sowing		After harvesting	
	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.
T_1	462.2	450	373.92	361.3	36.96	33.64	14.34	14	507.36	499.62	252.17	248.57
T_2	454.72	441.4	329.28	318.6	34.93	32.62	14.32	13.4	490.56	472.5	236.17	234.2
T_3	403.2	392.75	345.84	334.76	32.37	29.73	14.3	13	412.44	402.1	228.7	212.2
T_0	362.88	358.72	279.2	265.1	27.51	26.42	14.3	12.8	319.2	312.8	177.4	162.8
SE (±)	1.99	1.65	1.99	1.68	0.07	0.4	0.22	0.17	1.88	1.3	1.43	1.29
CD (5%)	4.49	3.72	4.49	3.81	0.15	0.92	0.5	0.39	4.26	3	3.24	2.92

T_0- control, T_1- *Crotolaria pallida*, T_2-*Sesbania bispinosa*, T_3- *Cajanus cajan*

Source: Bora and Baruah [25]

Table: 2. Effect of green manure on productivity of rice and maize in shifting cultivation land

Treatments	Productivity of rice						Productivity of maize					
	Weight 1000grains(gm)		Grain(Kg/ha)		Straw(Kg/ha)		Weight 100grains(gm)		Grain(Kg/ha)		Stover(Kg/ha)	
	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.
T_1	20.67	19.85	2210	2140	3650	3320	23	22.7	2500	2270	2800	2520
T_2	19.67	18.72	1850	1795	3350	3030	22.6	22.5	2300	2092	2600	2315
T_3	19.28	18.23	1600	1490	3140	2830	21.5	21.3	2040	1865	2380	2140
T_0	17.33	17.14	1410	1380	2460	2240	20.4	20.2	1650	1510	1930	1740
SE (±)	0.37	0.42	3.72	2.98	2.1	2.4	0.52	0.32	2.49	2.05	0.53	1.42
CD (5%)	0.85	0.96	8.4	6.73	4.72	5.42	1.18	0.72	5.63	4.65	1.19	3.22

T_0- control, T_1- *Crotolaria pallida*, T_2-*Sesbania bispinosa*, T_3- *Cajanus cajan*

Source: Bora and Baruah [25]

Suitable crops need to be sown on shifting cultivation plots after the harvest in the second year [26]. Fast growing leguminous crops can provide thick material growth over the soil. This will not only fix atmospheric nitrogen in the soil but also prevent soil erosion and suppress the weeds. The point is that when shifting cultivation can survive for centuries with optimum yield on a long term basis, it is possible to increase production without departing too much from traditional system. An experiment was done for evaluating second year cropping on jhum fallows in Mizoram, north-eastern India on phytomass dynamics and primary productivity and found that if second year cropping is done, expanse of the forest land required for slashing and burning could be reduced significantly [27]. Economic yield from second year cropping in its traditional form (without any fertilizer treatment) was not less when compared with the first year, and can be improved further by manuring the soil.

In conditions where alley cropping have a chance of adoption, the rate of adoption can be increased by modifying designs to make more attractive to farmer for example, SALT (Sloping Agricultural Land Technology) which is basically a form of alley cropping that incorporate a variety of fruit, economically important crops along the hedge row plantation design [28]. 'Lisu people' of Huay Nam Rin village situated in Northern Thailand, plants legumes after corn. Originally they planted upland rice and opium and faced the problem of decline of yield and weed problem. With the practice of planting legumes after corn, they gained additional income and control over weeds to a certain extent [29]. Another example of sustainable swidden system that followed in Yunnan province of China is rattan and bamboo based and 'Jinuo' sustainable swidden. Both the system is evolved by shifting cultivators in response to their needs it also protecting their culture, tradition and is harmony with nature.

Shifting cultivators from Khonoma village of Nagaland, India, practice a cropping system that is distinct from others; they grow and manage alder trees (*Alnus nepalensis*) in their terraced crop and fallow fields. While planting no specific distance is maintained from one alder plant to another however, 6 x 6 meter is common. Alder trees has a fast growth rate, has extensive root system that fixes atmospheric nitrogen. Leaves are very good green manure, trees can with stand pollarding and frequent pruning of coppice. Young trees are pollarded when they reaches the bole size of 70-80 cm usually at about 6-10 years. Shifting cultivators reopen the fields after it is fallowed for two years. During the month of November they cut the vegetation underneath the alder trees and in December to January they cut the coppice flush from each alder tree completely. Leaves are removed from branches and the latter are then used as fire wood. They plant upland rice for the first year and secondary crops such as chilies; cucurbits, beans pumpkin, garlic *etc* are intercropped. In second year cultivation of crops like corn and pearl millet is also seen. Alder trees are again pollarded in end of second year cropping leaving only 5-6 coppice of the top and that are allowed to grow in next two years fallow periods, this helps in soil conservation, nitrogen fixation, weed suppression and rebuilding of soil organic matter. Recent studies point out the custodial role played by shifting cultivators in preserving forest, water harvesting, crop cultivation and fish rearing for e.g. 'Zabo system' of farming practiced by villagers of Kikruma, Nagaland. Government and national agencies has given top priorities to discouraging shifting cultivation and promotion of settled cultivation and agricultural intensification. Detailed study of Harold Conklin in Philippines pointed to its long history of sustainability. The study reflects on the indigenous knowledge accumulation through centuries of trial and error, agricultural biodiversity, intricate balance between product harvest and ecological resilience.

V. **Conclusion**

Lastly this paper can be concluded with the decisions taken in a workshop. A regional policy dialogue workshop was held in Shillong, Meghalaya, India during October 4-6, 2004. Participants from five different countries representing a broad spectrum of people like government agencies, farmers, international bodies NGOs, Research institutes, academicians, representatives from private sector met with a common interest and responsibility towards shifting cultivation. Outcome of this workshop is known as Shillong declaration on shifting cultivation in Eastern Himalayas which suggested that " The regional, national, and local policies for Shifting cultivation need to be reappraised and, where necessary reformulated''.

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