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Evaluation of Agricultural systems practiced in Upper Siang and Upper Dibang areas of Arunachal Pradesh in Northeast India

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Abstract

The study of agricultural systems includes *jhum*, valley and terrace cultivation available in Upper Siang and Upper Dibang areas of Arunachal Pradesh. Three types of *jhum* based on their previous forest vegetation types of terraces such as hill terrace and river basin terrace were used.The agricultural systems were evaluated in terms of productivity and economics. The trend of crop production was more or less similar in bamboo based- forest derived *jhum* and bamboo free forest derived *jhum*. Production of crops was high in the first year and it decreased with the increasing cropping years. But it showed quite different results in case of grassland derived *jhum* where production of crops for the first-year cropping was low and the next year was very high then it decreased with the increasing number of cropping years like the other *jhum* types. The highest yield was obtained at low elevation valley among all the agricultural systems. The bamboo free forest-derived *jhum* recorded the highest yield than that of other *jhum* types. The study suggested that management of grassland derived *jhum* was one of the best ethnic knowledge of land use practices and the valley cultivation of rice was tenable on both economic and ecologic considerations. The river basin terraces closer to the valleys eventually converted into valley lands were viable for longer duration.

In India, 80% of the population lives in villages and 70% of the people derive their livelihood from agriculture[1]. Recently, scientists have started looking at subsistence agriculture or traditional agriculture as one with high productive efficiency. Shifting cultivation made a revolutionary change in human societies from food gatherer to food producer. Series of studies[2-10] have shown that under the given conditions of high rainfall, low soil fertility and steep gradient, this is the only viable system of agriculture and all other alternatives based on modern agricultural terraced technique are untenable.It is the cheapest means of livelihood for the tribal people who have evolved this mode of cultivation in response to the most difficult terrain and topography under most inhospitable environment through centuries of struggle with nature. The high yields for subsistence agriculture that are often over looked by scientists are now receiving-more study[2,9,13,14]. The entire *jhum* operation involves efficient recycling of resources for optimizing the yield through the use of crop and weed residues as organic manure and also the residue from the agricultural system and animal husbandry[17]. Agro-Economics Research Centre, Jorhat conducted survey on *jhum* rice yields and concluded that the average yield of 800-900 kg ha^{-1} in the Garo hills, Mizorum and Arunachal Pradesh was comparable to the average rice yield of 1145 kg ha^{-1} for the country as a whole in 1971-72. On other hand, the rice yield under *jhum* in Tripura[11] was reported to be around 1200 kg ha^{-1}. The *jhum* rice yield was 853 kg ha^{-1} as compare to 3428 kg ha^{-1} under terracing at Burnihat in Meghalaya[26]. A more recent report of the Indian Council of Agriculture Research suggested an amazingly low yield of 190 kg ha^{-1} of rice under *jhum* compared to 1860 kg ha^{-1} under terrace[5]. Many workers have studied the monetary benefit from *jhum* cultivation in India. Output-input analysis of *jhum* under a 10-year cycle at lower elevation of Burnihat, Meghalaya was 1.83 and in upper elevation was 3.9, studied monetary benefit in 30-year, 10-year and 5-year *jhum* cycles and found the output-input ratio as 2.13, 1.83 and 1.88 respectively[12,17]. Although sparsely populated, the state of Arunachal Pradesh is deficient in food grain production. The tribal communities of Arunachal Pradeshwhose cultures and economies depend on traditional agricultural systems. They practice shifting agriculture (*jhum*), valley cultivation along with terrace cultivation. But the agricultural systems in Upper Siang and Upper Dibang region of Arunachal Pradesh have not so far been studied.Here shifting agricultural sub-systems shows variations based on previous vegeta-tiontypes of land and forests. They use only indigenous crops with long duration rice varieties in the irrigated terraces on the slope of the hills and in the river basins. There are so many gaps in our understanding of the agricultural systems in Upper Siang and Upper Dibang areas of Arunachal Pradesh dominated by the *Adis* and *Idus* respectively. Therefore, the present study was undertaken in Upper Siang and Upper Dibang area. Therefore, in the present study an attempt has been taken to the following aim and objective.

Aims & Objective :

- To evaluate the productivity of the agricul-tural systemsand
- To evaluate the economics of the agricul-tural systems.

The study on each system of agriculture was done during 2001 to 2003. *Jhum*plots with mixed cropping under 12-15year cycle for the *Adis* at 600-700m altitude; 7-10 year and 5–7-year cycles for the *Idus* at 1690-1836m altitude were identified. Monocropping of *Oryza sativa* in river basin terrace cultivation of the *Adis*, *Khamba* and *Membha* at 600-700m and *Idus* at1690-1836m altitudes was also studied. Terrace cultivation in hill slope at 600-700m altitude practiced by the *Adis* only was also included under the study. The evaluation of agricultural systems were made in terms of productivity and economics on the basis of data collected randomly from 15 village headmen and old farmers of the above area.

The yield of the crops was calculated on the basis of the yield obtained from the entire plot and converted into kg ha^{-1}. The economic yield as converted into rupees ha^{-1} on the basis of prevailing market prices (Table 1) of the inputs and outputs were analysed and presented. Labour charges for various works were calculated on the basis of prevailing daily rates of Rs.75 each per day during the study period (2001-2003). The monetary efficiency (output/input ratio) for each agriculture system was also estimated under this study.

Crops	**Value (Rs kg^{-1})**	**Crops**	**Value (Rs kg^{-1})**
Zea mays	1	*Capsicum* sp	11
Cucurbita maxima	2	*Cucumis sativus*	9
Colocasia esculenta	4	*Solanum tuberosum*	10
Monihot esculenta	5	*Zingiber officinalis*	11
Dioscorea sp.	6	*Coix lachrymal*	12
Ipomoea batatas	6	*Eleusine coracana*	12
Phaseolus mungo	7	*Pogostemon* sp.	12
Vigna umbellata	7	*Sechium edule*	12
Fagopyrum cymosum	8	*Chenopodium album*	13
Glycine max	8	*Oryza sativa*	15
Benincasa cerifera	2		

The yield of various crops grown in different agricultural systems in different study sites have been presented in the table 2 and 3. *Oryza sativa* produced 847 kg ha^{-1} grain yield during first year cropping in bamboo free forest-derived *jhum* which was higher than that of bamboo forest-derived *jhum* (750 kg ha^{-1}) in third year of cropping. It was very close to the rice yield data studied by Wadley[29] in West Kalimantan from 14 households in an Iban community on interview and classified fallow vegetation in very broad categories based on vegetation morphology rather than fallow age and thus a 20- year fallow on very poor sandy soil came in the same category as a 4- year fallow on a clay soil (young fallow of 3 to 20 years old gave average yield of 1042 $kgha^{-1}$, young secondary of 10-45 years old gave an average yield of 923 kg ha^{-1}, and old secondary/ mature forest of 20-70 years old gave 1187 kg ha^{-1}).

The yield of different crops declined markedly over the cropping years under different types of*jhums*. This was particularly evident in the case of *Zea mays* in all types of *jhums* of these areas [Table-2]. The results are in conformity with the findings of Arnason[4] who noticed decline in maize yield in Belize. The yield of *Zea mays* in bamboo forest-derived *jhum* was declined from 1280 kg ha^{-1} to 381 kg ha^{-1} in the second year and 126kg ha^{-1} in third year. The yield of *Oryza sativa* in bamboo free forest derived *jhum* was 847 kg ha^{-1} in first year but it was 750kg ha^{-1} under bamboo forest-derived *jhum* during the third year. The results corroborate the findings of Hansen[10] in Northern Thailand and Wey and Traore[21] in Guinea. One of the major causes for the low yield after first year cropping and onwards was the poor fertility builds up. This became more obvious during the third year of cropping in any type of *jhum* systems[1,22]. *Eupatorium* spp. and *Imperata cylindrica* were found as predominant weeds in the study sites. Freeman[6], Zinke *et al.*[31] and Ramakrishnan *et al.*[14] also noticed yield loss caused by *Imperata cylindrica* in Sarawak, *Eupatorium odoratum* in Thiland and these along with other weed species in North-Eastern India in different *jhum* systems. The yield increase was also evidence in grassland-derived *jhum* under this study. The yield increased markedly in the second and third year of cropping compared

Table 2. Yield of crops (kg ha^{-1}) in different *jhum* systems

Jhum types	**Low altitude**			**High altitude**					
	Bamboo free forest			**Bamboo forest**			**Grassland**		
Crops	**Iyr**	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**
Cereals									
Chenopodium album	15	20	12	-	35	25	-	41	28
Coix lachryma	-	391	-	-	117	77	-	53	25
Eleusine coracana	-	453	150	-	767	-	-	-	412
Fagopyrum cymosum	-	-	-	-	-	-	180	-	-
Oryza sativa	847	-	-	-	-	750	-	-	-
Zea mays	-	321	250	1280	381	126	-	230	112
Sub-total	**862**	**1185**	**412**	**1280**	**1300**	**978**	**180**	**324**	**577**
SD	±53.2	±96.1	±40.6	±107.8	±111.3	±93.9	±17.2	±30.1	±56.2
Pulses									
Glycine max	-	-	-	55	71	24	169	74	19
Phaseolus vulgaris	40	60	20	34	14		16	38	32
Vigna umbellata	38	48	18	73	25	45	65	50	67
Sub-total	**78**	**108**	**38**	**162**	**110**	**69**	**250**	**162**	**118**
SD	±3.9	±6.8	±5.6	±13.3	±10.4	±5.4	±16.4	±14.3	±9.8
Fruit vegetables									
Benincasa cerifera	645	307	200	-	-	-	-	-	-
Capsicum sp.	9	-	-	-	-	-	-	-	-
Cucumis sativus	683	352	75	122	76	26		70	43
Cucurbita maxima	621	312	180	158	224	108		224	124
Sechium edule	35	20		75	37			54	
Sub-total	**1993**	**991**	**455**	**654**	**337**	**134**	-	**348**	**117**
SD	±112	±87.2	±45.3	±51.2	±27.5	±12.1	-	±27.5	±8.8
Oil seeds									
Perilla ocimodes	-	35	25	-	21	45	-	23	42
SD	-	±3.3	±1.6	-	±1.8	±3.7	-	±2.1	±3.6
Tubers and rhizomes							-		
Colocasia esculenta	170	65	100	-	185	63	-	226	28
Dioscorea sp.	-	120	150	117	-	-	-	70	47
Ipomoea batatas	-	70	105	-	-	-	-	-	-
Monihot esculenta	-	420	525	-	-	-	-	-	-
Solanum tuberosum	-	-	-	-	-	-	-	860	-
Zinger officinalis	23	-	-	-	-	-	-	-	-
Sub-total	**193**	**675**	**880**	**117**	**185**	**63**	-	**1156**	**75**
SD	±13.9	±54.7	±55.7	±10.7	±15.0	±5.0	-	±66.3	±7.1
Total	**3126**	**2994**	**1810**	**2213**	**1953**	**1289**	**430**	**2013**	**979**

to that of the first year in grassland-derived *jhum* due to better crop management practices followed in second and third year under this system. The low yield of grassland-derived *jhum* during the first year was mainly due to use of the field for *Fagopyrum* and pulse crops for enriching the soil rather than getting high yield and prepared it for next year cropping of cereals and other crops [Table-2]. While the total yield of crops under grassland-derived *jhum* was markedly lower than that under wet cultivation system, the yield of individual crops obtained was dependent to a considerable extent on their proportionate area covered. Some tribals particularly the *Idus* use nitrogen-fixing non-legumes like *Alnus nepalensis* and *Castanopsis* sp. to improve the nitrogen economy of their *jhum* systems during cropping and fallow phases. Ramakrishnan and Toky[23] and Ramakrishnan[21] noticed that bamboo sprouts of the species like *Bambusa tulda, B. khasiana, Dendrocalamus hamiltonii* and *Neohouzeaua dulloa* in the bamboo forest derived *jhum* increased potassium content in soil when *jhum* cycles decline up to 5 years.

Terrace and valley cultivation, on the other hand, was the monoculture of *Oryza sativa* [Table-3]. The low elevation river basin terraces recorded the highest yield but the high elevation river basin terraces produced the lowest yield among the different types of terraces practiced in the study sites. The rice yield of the hill terrace was considerably higher than the yield of terrace cultivation practiced by the Sulung tribe (1172kg ha^{-1}) at Tabumah area in Arunachal Pradesh[7] and was more or less similar to that of the terrace cultivation practiced by Angami tribe (1600 kg ha^{-1}) of Nagaland[3]. The low elevation valley recorded the highest yield of rice (3575 to 3750 kg ha^{-1}), which was considerably higher than that of the high elevation valley (1800-2150 kg ha^{-1}). It also surpassed the productivity of the low elevation river basin terraces. The results are in conformity with the findings of Ramakrishnan in Meghalaya[14] and Singh and Bag[27] in Arunachal Pradesh who noted similar trend of rice yield at lower elevation valley systems.

The economics of the agricultural systems were also studied in terms of cost involved and benefit obtained. The labour input accountedfor the major portion of the cost followed by seeds in all types *jhum* cultivation [Table-4].

Table 3. Yield of crops (kg ha^{-1}) in different terrace and valley systems

	Low elevation						High elevation		
Agricultural system	**Hill terrace**			**River basin terrace**			**River basin terrace**		
	Iyr	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**
Terrace Cultivation									
Oryza sativa	2260	2300	2080	3000	2950	2875	1600	1490	1520
SD	±158.3	±176.8	±172.1	±252.1	±155.3	±201.6	±146.4	±121.8	±125.8
Valley cultivation	**Low elevation**						**High elevation**		
Oryza sativa	3575	3750	3625				2150	2025	1800
SD	**±132.3**	**±231.7**	**±258.8**				**±184.0**	**±158.1**	**±177.5**

Table 4. Labour cost of in different *jhum* systems (Rs. ha^{-1})

Jhum cultivation	Bamboo free forest-derived			Bamboo forest-derived			Grassland-derived		
	Iyr	IIyr	IIIyr	Iyr	IIyr	IIIyr	Iyr	IIyr	IIIyr
Jhum preparation	4725(63)	1350(18)	1350(18)	2475(33)	750(10)	900(12)	1275(17)	675(9)	750(10)
SD	±679.8	±183.7	±126.8	±289.1	±165.3	±188.0	±316.9	±144.5	±165.3
Crop management	6975(93)	5400(72)	3900(52)	5475(73)	3150(42)	2475(33)	6300(84)	3225(43)	2550(34)
SD	±578.2	±548.2	±397.9	±552.6	±335.4	±366.3	±451.8	±258.3	±455.3
Harvesting and processing	1500(20)	1200(16)	1125(15)	1275(17)	1200(16)	825(11)	750(10)	1350(18)	975 (13)
SD	±304.0	±206.4	±174.7	±217.7	±167.7	±160.4	±157.8	±212.1	±225.0
Total	13200(176)	7950(106)	6375(85)	9225(123)	5100(68)	4200(56)	8325(111)	5250(70)	4275(57)

*Figures in the parentheses indicate the number of labours required for different activities

Whereas total expenditure for labour in low elevation river basin was high in comparison with any other type of terrace system [Table-5]. The expenditure for labour in crop management was high any other type of activities. The lowest expenditure was incurred for harvesting and processing of crops. The valley cultivation recorded the highest expenditure for labours in comparison with any kind of agricultural systems [Table 6].

Table 5. Labour cost in different terrace systems (Rs. ha^{-1})

Terrace cultivation	Low elevation						Higher elevation		
	Hill terrace			River basin terrace			River basin terrace		
	Iyr	IIyr	IIIyr	Iyr	IIyr	IIIyr	Iyr	IIyr	IIIyr
Nursery bed	2775(37)	2850(38)	3075(41)	3000(40)	3150(42)	3000(40)			
SD	±391.8	±417.6	±357.5	±326.9	±315.7	±305.3			
Main field	7800(104)	7650(102)	7275(97)	8700(116)	8250(110)	8400(112)	7950(106)	7725(103)	7950(106)
SD	±611.3	±458.8	±690.9	±613.8	±571.2	±707.0	±661.8	±458.0	±604.0
Crop management	6000(80)	6975(93)	7950(106)	7875(105)	9000(120)	9450(126)	4650(62)	5475(73)	5775(77)
SD	±804.3	±810.3	±503.9	±554.0	±575.4	±789.2	±373.9	±694.4	±507.9
Harvesting and storing of crops	1050(14)	900(12)	900(12)	1125(15)	975(13)	1050(14)	1200(16)	1050(14)	900(12)
SD	±208.3	±216.8	±225	±247.1	±198.4	±198.4	±202.4	±170.1	±188.0
Total	17625(235)	18375(245)	19200(256)	20700(276)	21375(285)	21900(292)	13800(184)	14250(190)	14625(195)

*Figures in the parentheses indicate the number of labours required for different activities.

Table 6. Labour cost in different valley systems (Rs. ha^{-1})

Valley cultivation	Low elevation			High elevation		
	Iyr	IIyr	IIIyr	Iyr	IIyr	IIIyr
Nursery bed	3600(48)	3300(44)	3300(44)	-	-	-
SD	±542.3	±500.7	±602.0			
Main field	9075(121)	8850(118)	8250(110)	7200(96)	7500(100)	6900(92)
SD	±1022.5	±1284.7	±949.4	±1252.1	±1107	±1291.9
Crop management	8100(108)	10350(138)	10350(138)	5325(71)	6000(80)	6075(81)
SD	±973.4	±1112.1	±1579.4	±1653.2	±1283.5	±1231.1
Harvesting and storing of crops	1875(25)	1650(22)	1725(23)	1275(17)	1125(15)	1200(16)
SD	±372.9	±2886.3	±478.6	±325.7	±343.7	±291.9
Total	22650(302)	24150(322)	23625(315)	13800(184)	14625(195)	14175(189)

*Figures in the parentheses indicate the number of labours required for different activities.

The seed input was also considered an important input of the cultivated crops under different agricultural systems. The cost of seeds in different *jhums* wasvery low. The maximum money spent for cereal seeds in bamboo free forest-derived followed by bamboo forest-derived and grassland-derived *jhums*. Very low amount of money required for seeds of fruit vegetables, [Table-7].

Table 7. Seed cost of different crops in *jhum* systems (Rs ha^{-1})

***Jhum* types**	**Bamboo free forest-derived**			**Bamboo forest-derived**			**Grassland-derived**		
Crops	**Iyr**	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**
Cereals									
Sub-total	**212.0(14.5)**	**155.6(16.00)**	**22.6(3.7)**	**11(11.00)**	**115.9(13.3)**	**209.4(15.8)**	**44.00((5.5)**	**22.1(4.1)**	**65.4(6.8)**
SD	±46.9	±22.1	±6.3	±2.9	±31.5	±42.4	±13.4	±7.5	±14.5
Pulses									
Sub-total	**17.5(2.5)**	**24.2(3.45)**	**17.5(2.5)**	**32.5(4.5)**	**18.5(2.5)**	**22(3.0)**	**65.00(8.5)**	**45.00(5.1)**	**32.5(3.6)**
SD	±5.3	±9.2	±4.8	±10.1	±5.5	±5.2	±14.0	±11.2	±9.6
Fruit vegetables									
Sub-total	**1.80(0.46)**	**1.20(0.36)**	**0.88(0.38)**	**2.10(0.28)**	**1.50((0.1)**	**0.6(0.1)**	**-**	**2.1(0.28)**	**1.1(0.20)**
SD	±0.9	±0.5	±0.5	±1.1	±0.6	±0.2	-	±1.3	±0.4
Oil seeds									
Perilla ocimodes	**-**	**2.4(0.2)**	**2.4(0.2)**	**-**	**2.4(0.2)**	**6.0(0.5)**	**-**	**2.4(0.2)**	**6.0(0.5)**
SD	-	±1.1	±1.1	-	±1.1	±1.9		±0.8	±2.0
Tuber & Rhizome									
Sub-total	**46(08)**	**154.9(29.65)**	**219((42.00)**	**24(6.00)**	**26(6.5)**	**10(2.5)**	**-**	**533(59.5)**	**31(6.5)**
SD	±17.8	±21.1	±32.9	±6.2	±8.0	±3.3	-	±124.6	±12.6
Total	**277(25.46)**	**338(49.66)**	**262(48.78)**	**70(21.78)**	**164(22.6)**	**248(21.9)**	**109(14)**	**605(69.18)**	**136(17.6)**

*Figures in the parentheses indicate the quantity of seeds (kg) required for different crops

Expenditure on seeds in terrace cultivation was quite high.The maximum amount of money spent for seeds was in valley cultivation [Table-8].

Table 8. Seed cost of different crops in terrace and valley systems (Rs. ha^{-1})

Agricultural system	**Low elevation**						**High elevation**		
	Hill terrace			**River basin terrace**			**River basin terrace**		
	Iyr	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**
Terrace cultivation									
Oryza sativa	870(58)	900(60)	825(55)	930(62)	870(58)	840(56)	975(65)	930(62)	900(60)
SD	±76.7	±77.3	±115.4	±150.4	±154.6	±139.5	±160.4	±147.2	±138.9
Valley cultivation	**Low elevation**						**High elevation**		
Oryza sativa	960(64)	1080(72)	1020(68)				1200(80)	1125(75)	1200(80)
SD	±112.1	±189.9	±142.0				±217.4	±212.1	±233.8

*Figures in the parentheses indicate the quantity of seeds (kg) required.

Cereals accounted for major monetary output in the first and second year cropping of all types of *jhums* except in bamboo forest-derived *jhum* where fruit vegetables attained major monetary output during the first year. But in subsequent years of cropping, tubers and rhizomes recorded increase in monetary return all types of *jhums* [Table-9].

Table 9. Monetary out put in different *Jhum* systems (Rs. ha^{-1})

Jhum	Bamboo free forest			Bamboo forest			Grassland		
Crops	Iyr	IIyr	IIIyr	Iyr	IIyr	IIIyr	Iyr	IIyr	IIIyr
Cereals	**12900**	**10709**	**2206**	**1280**	**11447**	**12625**	**1440**	**1399**	**5720**
SD	±1111	±1398.5	±216.1	±153.3	±1010.5	±1591.3	±166.5	±138.8	±724.0
Pulses	**546**	**756**	**266**	**1189**	**841**	**505**	**1916**	**1208**	**847**
SD	±95.9	±121.7	±68.3	±113.1	±106.4	±78.3	±175.2	±147.6	±141.2
Fruit vegetables	**9204**	**4646**	**1435**	**2909**	**1574**	**455**	**-**	**1730**	**635**
SD	±956.6	±681.3	±156.6	±188.6	±145.8	±81.1	±183.2	±110.0	
Oil seeds	-	420	300	-	257	534	-	276	504
SD	-	±84.7	±70.8	-	±54.6	±113.3	-	±57.2	±98.4
Tuber and rhizomes	**933**	**3500**	**4555**	**702**	**738**	**250**	**-**	**9922**	**394**
SD	±127.2	±457.6	±578.8	±90.3	±68.5	±65.9	-	±1413.1	±47.1
Total	**23583**	**20031**	**8762**	**6080**	**14857**	**14369**	**3356**	**14535**	**8100**

The monetary output in river basin of low elevated terrace cultivation was high in compares with any kind of agricultural systems [Table-10].

Table 10. Monetary out put in terrace and valley systems (Rs ha^{-1})

Terrace cultivation	**Low elevation**						**High elevation**		
	Hill terrace			**River basin terrace**			**River basin terrace**		
	Iyr	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**	**Iyr**	**IIyr**	**IIIyr**
Oryza sativa	33900	34500	31200	45000	44250	43125	24000	22350	22800
SD	±2374.9	±2651.7	±2581.2	±3782	±2329.0	±3023.4	±2195.8	±1826.6	±1887
Valley cultivation	**Low elevation**						**High elevation**		
Oryza sativa	53625	54375	56250				32250	27000	30375
SD	±1984.3	±3474.7	±3881.6				±2759.3	±2371.7	±2663

The net return from the bamboo forest-derived *jhum* was negative in the first year of cropping (-Rs 3215 ha^{-1}) because of very low value of maize in this locality (Rs 1.0 Kg^{-1}). But in subsequent years the net return from the bamboo forest-derived *jhum* was positive and varied from Rs 9593-9921 ha^{-1}. The bamboo free forest-derived *jhum* recorded the net return of Rs 2125-11743 ha^{-1} in the different sites of this study. The net return from grassland-derived *jhum* was also negative (-Rs 5078 ha^{-1}) during the first year of cropping. The local tribes did not pay much attention in the first year cropping of grassland-derived *jhum*, but they considered the period for enriching the soil by growing of *Fagopyrum cymosum* and pulses for enriching soil and harvesting maximum yield in the subsequent years of cropping. But in subsequent years the net return from this *jhum* was positive and varied from Rs 3689-8680 ha^{-1} [Table-11].

The net return from hill terrace varied from Rs 11175-15405 ha^{-1} and was more than the net return from all types of *jhums*. The net return from low elevation river basin terrace was far more than that of any types of *jhums* during any year of cropping.

Table 11. Economic analysis of *jhum* types (Rs ha^{-1})

Agricultural systems	Year	Yield (kg ha^{-1})	Gross return (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1}) Labour	Seed	Total	Net return (Rs ha^{-1})	Benefit/ Cost ratio
Jhum								
Bamboo free forest-derived	Iyr	3126	23583	13200	277	13477	10106	0.75
	IIyr	2994	20031	7950	338	8288	11743	1.42
	IIIyr	1810	8762	6375	262	6637	2125	0.32
	SD	±591.71	±6318.13	±2917.83	±32.87	±2914.28	±4201.61	
Bamboo forest-derived	Iyr	2213	6080	9225	70	9295	-3215	-0.35
	IIyr	1953	14857	5100	164	5264	9593	1.82
	IIIyr	1289	14369	4200	248	4448	9921	2.23
	SD	±389.05	±4027.43	±2187.75	±72.71	±2118.92	±3086.83	
Grassland-derived	Iyr	430	3356	8325	109	8434	-5078	-0.60
	IIyr	2013	14535	5250	605	5855	8680	1.48
	IIIyr	979	8100	4275	136	4411	3689	0.84
	SD	±656.29	±4581.18	±1725.91	±227.72	±1664.03	±2103.27	

Table 12. Economic analyses of terrace and valley systems (Rs ha^{-1})

Agricultural systems	Year	Yield (Kg ha^{-1})	Gross return (Rs ha^{-1})	Cost of cultivation (Rs) Labour	Seed	Total	Net return	Benefit/ cost ratio
Terrace cultivation				**Low elevation**				
Hill terrace	Iyr	2260	33900	17625	870	18495	15405	0.83
	IIyr	2300	34500	18375	900	19275	15225	0.79
	IIIyr	2080	31200	19200	825	20025	11175	0.56
	SD	±95.68	±1435.27	±643.23	±30.82	±624.66	±1953	
River basin terrace								
	Iyr	3000	45000	20700	930	21630	23370	1.08
	IIyr	2950	44250	21375	870	22245	22005	0.99
	IIIyr	2875	43125	21900	840	22740	20385	0.90
	SD	±51.37	±770.55	±491.17	±37.42	±454.04	±1220.10	
River basin terrace				**High elevation**				
	Iyr	1600	24000	13800	975	14775	9225	0.62
	IIyr	1490	22350	14250	930	15180	7170	0.47
	IIIyr	1520	22800	14625	900	15525	7275	0.47
	SD	±46.43	±696.42	±337.27	±30.82	±306.51	±944.96	
Valley cultivation				**Low elevation**				
	Iyr	3575	53625	22650	960	23610	30015	1.27
	IIyr	3750	54375	24150	1080	25230	29145	1.16
	IIIyr	3625	56250	23625	1020	24645	31605	1.28
	SD	±73.60	±1103.97	±621.49	±48.99	±669.81	±1018.53	
Valley cultivation				**High elevation**				
	Iyr	2150	32250	13800	1200	15000	17250	1.15
	IIyr	2025	27000	14625	1125	15750	11250	0.71
	IIIyr	1800	30375	14175	1200	15375	15000	0.98
	SD	±144.82	±2172.27	±337.27	±35.36	±306.19	±2474.87	

The return per rupees invested [Table 12] was higher in low elevation valley cultivation (Rs.1.16 to 1.28) than that of the high elevation valley system (Rs 0.71 to 1.15). The return per rupees invested in bamboo free forest derived *jhum* was in the range of Rs 0.32 to 1.42. The bamboo forest-derived *jhum* showed a negative return per rupees invested (-Rs 0.35) during the first year of cropping because of very low local market value of *Zea mays* (Rs 1.0 Kg^{-1}) during the study period though its yield was quite high (1280 kg ha^{-1}). But it gave the highest income per rupees invested during the next two years (Rs 1.82 and 2.23) when compared with other types of agricultural systems or similar with that of the low elevation valley cultivation (Rs 1.16 to 1.28). The return per rupee invested under grassland-derived *jhum*was also low [Table 12]. It is also showed negative return per rupee invested in the first year. The lowest return per rupee invested was recorded in high elevation river basin terrace (Rs 0.47-0.62).

Cereal cultivation in *jhum* systems needs to be discouraged and may be replaced by tuber, rhizome, pulses, vegetables, fruits and other horticultural crops to protect the *jhum* land from further deterioration and better income generation. Cultivation of cereals particularly rice may be advocated at low elevation valley and to some extent at low elevation terrace due to high productivity from this agriculture system in spite of high cost. Both low elevation valleys and low elevation river basin terraces are viable for longer duration. Measure needs to be taken against weeds that pose a threat in terrace cultivation. Hill terrace cultivation may not be tenable from economic and ecological point of view in this region. These areas may be used for plantation and fruit crops.

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