ROLE OF FOREST FRUITS IN SUSTAINING LIVELIHOODS OF FOREST MARGIN COMMUNITIES - CONTRIBUTION OF NON-TIMBER FOREST PRODUCTS TO INCOME OF THE ETHNIC GROUPS

Summary

A study was carried out to assess the livelihood of the forest margin communities and find their dependence on forest fruits at M.M.Hills. The study was carried out at Ponnachi, which is one of the villages at MMHills. About 10 per cent of the households of two ethnic groups (tribals and non-tribals) were considered for the study. The study revealed that the non-tribals dominate this area in number. The literacy is higher among the males. The non-tribals are dependent on the livestock to a greater extent than the tribals. The tribals relative to the non-tribals derive a larger share of their income from NTFP collection, especially from forest fruits, korai grass and bamboo. Major sources of income for both the ethnic group is derived from labour wages and agriculture. The per capita income of tribals is lesser compared to the non-tribals. The income derived from NTFPs over both the ethnic groups decreases with increase in wealth index (assest and the gross income). Based on factor and cluster analysis, there was distinct clustering of the households along the sources of income. We discuss these results in the light of the data from Kombudikki, another settlement at MM Hills and that reported from BR Hills by our earlier work (Hegde et al., 1996).

INTRODUCTION

Non Timber Forest Produce contributes to the livelihoods of the forest dwelling communities. In different situations NTFP contribute to household self-sufficiency, food security, income generation, and accumulation of savings and risk minimisation. NTFP based activities could be important in filling seasonal and other food or income gaps, can provide a buffer in times of hardship or emergency, be an activity of last resort, or can present an opportunity for improving household income and security (2). These communities often combine their agricultural production with collection of forest produce and make use of a multitude of such products as feed, food fuel and medicines. The forest products are also used in making of farm implements, as construction material, basket weaving and many other purposes, which indirectly contribute to food security. But the extent of dependence of the rural communities on forest products for food security or any other use to improve their economy is not very clear (1).

The changes in the dependence of the forest dwelling communities are much associated with the growing presence of market forces and opportunities. At the house hold level this transition is likely to be reflected in the impact on the importance and nature of NTFP activities of shifts in the balance between forest-based, agricultural and off-farm opportunities and sources of employment and income, and associated shifts in the availability and allocation of land and household labour.

Negative or limiting features associated with particular NTFP activities can also contribute to household decisions to discontinue them. These can include marginal returns, increasing costs and declining returns, poor working conditions, volatile markets, a weak marketing position, exploitative patron/labour relationships, and lack of access to inputs of capital or technology to overcome constraints of labour shortage or work stress (2).

The sustenance of millions of people depends on the resources of natural ecosystem for their livelihood and NTFP provides a substantial input to their

income. Sustainable extraction may ensure conservation of biological resources but not much is known about the exact quantity of extraction and impact of extraction of NTFP on conservation of biodiversity of the forests. Excessive extraction of NTFP like other exogenous disturbance will affect the structure and function of forests, resulting in the gradual loss of the growing species in course of time.

The number of people in India who rely on forest fruits is assumed to be approximately 50 million, but there is little information on the extent to which these people derive their annual income from the forest sources (4).

The main objectives of our study are to find:

- The portfolio of livelihood activities that exists within the community and how these are differentiated by human capital endowments.
- The range of income sources and their importance in the household economy with special reference to forest fruits.

Although millions of people extract non-timber forest products worth billions of dollars through out the tropics, little is known about the impact of extraction on local, regional or national economies. The assumption linking the extraction of non-timber forest products to an increase in rural income, to participation of local communities in conservation, and to overall conservation of bio-diversity are largely untested and require rigorous examination.

Moreover, local communities can be involved in conservation because of the economic stake they are likely to have in preserving the resource base (3).

MATERIAL AND METHODS

Study Area

Malé Mahadeshwara Reserve Forests is located between 11°55 to 12°15 north and 77°45 to 77°25 east from east in Kollegal taluk of Chamarajangar district of Karnataka state. The area enjoys a mild, equable climate throughout the year but in recent years the temperature has risen. Deforestation and reduction of the forest, quality wise, may be the reason for the gradual warming. It receives rainfall from Northeast monsoon as well as southwest monsoons. The bulk of the rain is derived from the Northeast monsoon and falls during September and October. The driest months are January–March. The total area of M.M. Hills is 434.80-sq. km. Ponnachi, a settlement that includes tribal and non-tribal population has been considered for the study. The demographic details are in the table 1.

Table 1: Demographic details of Ponnachi

Demographic details of Ponnachi	1991 Census	% of total population
Area (in hectares)	1587.07	
Total Population	5562	100.00
Male Population	2939	52.84
Female Population	2623	47.16
SC-Male	512	9.21
SC-Female	429	7.71
ST-Male	514	9.24
ST-Female	475	8.54
Non SC or ST male	1913	34.39
Non SC or ST female	1719	30.91
Literate-Male	674	12.12
Literate-Female	173	3.11
Illiterate-Male	2265	40.72
Illiterate-Female	2450	44.05

(Source data: Kollegal taluk census data1991).

Sampling Design

The study to understand the livelihood pattern of the forest communities was undertaken during September to December 2000 at Ponnachi. A sample size of 90 households comprising of 59 non-tribal and 31 tribal (approximately representing 10 per cent of the respective populations at Ponnachi) was administered the questionnaire (see appendix 1).

The data was collected on the following: Size of the family, Percentage of dependents, Percentage of educated, Area of land owned and number of livestock owned. Besides these, the income from various sources, number of

days spent for each, the NTFPs collected (quantity, number of days spent for each) was also obtained per household.

Analyses

Tabular analysis was done to identify the various variables influencing the income of the household and to identify the portfolio of livelihood activities that exist within the non-tribal and tribal community.

Wealth Index was calculated for the sample households using the following: Area of land owned, number of livestock owned, type of house, access to electricity and the total gross income of the households. These variables were normalized (all the values were expressed in 0-1 scale) and then the mean index per household was calculated and regressed against the proportion of income contributed by NTFP to the total household income.

Multiple linear regression was carried out to examine the variables that influence the income from NTFP at a household level. This was employed for the non-tribal and tribal communities individually and for the communities as a whole.

The independent variables used in the analysis were

A. Household variables

1. Family size
2. Percentage of dependents (individuals aged below 10 and above 60 years)
3. Percentage of educated people
4. Area of land owned.
5. Value of Livestock owned
6. Value of agriculture produce

B. All sources of Income

7. Income from Agriculture and tree crops
8. Value of consumed agriculture produce
9. Value of Livestock owned
10. Income from Daily wage labour
11. Income from Livestock
12. Income from working in Quarry
13. Income from forest fruits
14. Income from forest products
15. Income from Korai grass
16. Income from Bamboo
17. Income from Factory/Government jobs
18. Income from masonry work
19. Income from various allied sources.

The analyses were carried out with the following dependent and independent variables.

Dependent variable	Independent variable
Income from Forest fruits	Household variables and sources of income
Income from NTFPs	Household variables
Income from NTFPs	Household variables and income from Non-NTFPs
Per capita income	Household variables and sources of Income
Per capita income from NTFP	Household variables and income from Non-NTFPs
Total gross income	Household variables

Factor analysis and ***Cluster analysis*** was performed to examine if the households cluster into different groups based on the ethnicity. The analysis

was done using various sources of income and household variables independently and together.

RESULTS:

Household details of Ponnachi:

The average family size is approximately 6 to 9 and 6 to 8 individuals among non-tribals and tribals respectively, of which the males and females are almost equal in number (though the number of males are slightly higher in the family, there is no much variation in the proportion). Though the dependence of females is more when in comparison with the male population, the variation is not very much (Table 2). The literacy level is higher among males than among females. The percent literacy is greater among non-tribals than the tribals (Table 3). The two communities differ significantly different with respect to male illiteracy.

Table 2: Household details of Ponnachi

Household details of Ponnachi	Non tribals		Tribals		T test	Pooled	
	Average	Stdevp	Average	Stdevp	P-value	Average	Stdevp
Total female	3.03	±1.76	2.00	±0.98	0.9457	2.97	±1.57
Dependents female	0.93	±0.99	0.87	±1.01	0.556	0.97	±0.97
Independents female	2.10	±1.15	2.87	±1.13	0.3844	2.00	±1.05
Total male	3.32	±1.78	1.92	±1.09	0.815	3.26	±1.68
Dependents male	0.86	±0.98	1.48	±1.52	0.9115	0.87	±0.99
Independents male	2.46	±1.47	3.03	±1.53	0.4718	2.39	±1.41
Total dependent	1.80	±1.45	1.87	±1.34	0.74	1.82	±1.41

Total independent	4.56	±2.27	4.00	±1.81	0.363	4.37	±2.14
No.of illiterates female	2.05	±1.59	2.00	±0.98	0.6031	2.03	±1.41
No.of literates female	1.02	±1.13	0.87	±1.01	0.6539	0.97	±1.09
Total no female	3.07	±1.80	2.87	±1.13	0.9762	3.00	±1.61
No.of illiterates male	1.29	±1.25	1.92	±1.09	0.3052	1.48	±1.24
No.of literates male	2.03	±1.66	1.48	±1.52	0.1235	1.84	±1.63
Total no male	3.32	±1.78	3.03	±1.53	0.7602	3.22	±1.70
Total no.of illiterates	3.36	±2.50	3.55	±1.95	0.4467	3.43	±2.34
Total no.of literates	3.02	±2.39	2.32	±1.71	0.1568	2.79	±2.20
Total no of individuals	6.37	±3.12	5.87	±1.83	0.8550	6.22	±2.79
Land owned in acres	3.50	±4.04	3.53	±3.62		3.51	± 3.94

Table 3: Literacy status of Ponnachi

Literacy status of Ponnachi	Non-tribals		Tribals		Pooled	
	Percentage	Total	Percentage	Total	Percentage	Total
Illiterate female	66.85	121	69.66	62	32.68	182
Literate female	33.15	60	30.34	27	15.54	87
Females	48.01	181	48.63	89	48.21	269
Illiterate male	38.78	76	51.06	48	22.14	124
Literate male	61.22	120	48.94	46	29.64	165
Males	51.99	196	51.37	94	51.79	289
Total illiterate	52.25	198	60.44	110	55.18	309
Total literate	47.75	178	39.56	72	44.82	251
Total individuals		376		182		558

Livestock details of Ponnachi

The non-tribals own a larger livestock population in comparison to tribals (Table 4). We observe that the non tribals and tribals are significantly different in the ownership of livestock when compared. The non-tribals are more dependent on livestock for their livelihood and derive a greater share of their income from livestock than the tribals.

Table 4: Livestock details of Ponnachi (Total number owned)

Livestock details of Ponnachi (Total number owned)	Non tribal livestock	Tribal livestock	*T test*	Pooled livestock
Livestock	Average	Average	P-value	Average
Buffalo	0.85 ± 1.68	0.13 ± 0.60	0.0207	0.60 ± 1.44
Chicken	0.42 ± 2.15	1.00 ± 0.62	0.1718	0.62 ± 2.29
Cows	6.12 ± 12.55	2.45 ± 4.86	0.3532	4.86 ± 10.60
Donkeys	0.27 ± 2.07	0.00 ± 0.18	0.0000	0.18 ± 1.68
Goats	0.88 ± 3.05	0.48 ± 0.74	0.8994	0.74 ± 2.58
Sheep	0.02 ± 0.13	0.65 ± 0.23	0.9016	0.23 ± 2.10
Grand Total	8.56 ± 13.95	4.71 ± 7.23	0.3806	7.23 ± 12.01

Table 4a: Livestock details of Ponnachi (Total number in their care)

Livestock details of Ponnachi (Total of number total)	Non tribal livestock	Tribal livestock	*T test*	Pooled livestock
Livestock	Average	Average	P-value	Average
Buffalo	1.76 ±6.56	0.13 ±0.55	0.0000	1.20 ±5.38
Chicken	0.42 ±2.15	1.00 ±2.49	0.1125	0.62 ±2.29
Cows	6.69 ±12.61	6.03 ±10.74	0.8446	6.47 ±12.00
Donkeys	0.27 ±2.07	0.00 ±0.00	0.0000	0.18 ±1.68

Goats	1.73	±7.03	1.52	±3.93	0.4289	1.66	±6.14
Sheep	0.02	±0.13	0.65	±3.53	0.4298	0.23	±2.10
Grand Total	10.90	±16.47	9.32	±13.12	0.9801	10.36	±15.42

Sources of income (with outliers): The non-tribals derive a meagre part of their income from NTFPs, which is negligible when compared to the dependence of the tribals on NTFPs. The tribals derive the income from NTFPs by collecting forest fruits, Korai grass, bamboo and other forest products; but the non-tribals are dependent only on fruits. Tribals derive a major share of their income from labour work, which is also the case with the non-tribals. Agriculture is the next important source of income for both the communities. The non-tribals derive income from a wide range of jobs (Barber, begging, bidi making, petty business, carpenter, dhobi, driver, fencing, granite dealer, hotel worker, house rent, lorry cleaner, painter, pension, petty shop, priest, ration shop, selling of land, supported by the others in the family, tailor, tailoring, trader). A reasonable share of their income is from quarries (Table 5 and 6). We observe a significant difference in the dependence on NTFPs and non-NTFPs among the two communities. The quarries that were operational earlier at Ponnachi have stopped functioning now; which used to be a major source of income. Probably this is the reason for the dependence on quarries to a great extent as they are familiar with the work.

Table 5: Sources of income

	Tribal	Non tribal	T test	Pooled
(Table with outliers)	Average	Average	P-value	Average
Total Of total	16970.98 ± 12806.36	28248.91 ± 33371.44	0.4420	22373.71 ± 20621.69
Gross total of all the incomes	22535.49 ± 15593.85	35450.48 ± 53817.58	0.2313	27105.15 ± 21411.08
Sum of Total value of the produce	5661.28 ± 6053.57	7404.96 ± 24661.30	0.2808	4782.58 ± 5385.90
Agriculture + tree crops	1582.61 ± 2973.56	5270.52 ± 22159.08	0.4923	2154.79 ± 4151.10
Bamboo	1047.73 ± 2195.24	0.00 ± 0.00	0.0000	369.09 ± 1395.74
Daily wage labour	7711.13 ± 10520.24	5153.56 ± 7433.57	0.0460	6162.56 ± 8763.84
Factory/government employee	598.06 ± 2209.97	2312.54 ± 8345.44	0.7934	1761.14 ± 7001.79
Forest fruits	775.32 ± 1823.12	38.56 ± 142.74	0.0031	298.98 ± 1143.64
Forest product*	258.39 ± 847.47	0.00 ± 0.00	0.0000	91.02 ± 517.92
Korai grass	29.03 ± 110.55	0.00 ± 0.00	0.0000	10.23 ± 67.06
Live stock	586.77 ± 1236.60	2065.25 ± 6091.92	0.5623	1111.82 ± 2632.17
Quarry	2235.48 ± 3986.39	3094.92 ± 7350.37	0.7857	2862.50 ± 6466.05
Others**	2146.45 ± 6541.92	10313.56 ± 22698.15	0.0242	7551.59 ± 19368.99
Income from NTFPs***	2110.47 ± 3409.00	38.56 ± 142.74	<0.0001	769.31 ± 2255.15

Income from non NTFPs	14860.52 ± 12580.70	28210.35 ± 33381.15	0.0002	21604.39 ± 20793.72
Gross income from non NTFPs	20521.80 ± 15261.83	35615.31 ± 53718.52	0.1385	26386.98 ± 21493.41

*Includes all the forest products excluding Korai grass, Bamboo and forest fruits.

**Includes Barber, begging, bidi making, petty business, carpenter, dhobi, driver, fencing, granite dealer, hotel worker, house rent, lorry cleaner, pain ter, pension, petty shop, priest, ration shop, selling of land, supported by the others in the family, tailor, tailoring, trader.

***Includes all forest products including Korai grass, Bamboo and fruits.

When we remove the outliers we observe a significant difference in the total and gross incomes between the two communities.

Table 5a: Sources of income (Without outliers)

Sources of income in rupees	Tribal	Non tribal	*T test*	Pooled
(Table without outliers)	Average	Average	P-value	Average
Total Of total	16970.98 ± 12806.36	25312.03 ± 23298.71	0.0525	22373.71 ± 20621.69
Gross total of all the incomes	22535.49 ± 15593.85	29590.41 ± 23621.51	0.2181	27105.15 ± 21411.08
Sum of Total value of the produce	5661.28 ± 6053.57	4304.69 ± 4919.93	0.2642	4782.58 ± 5385.90
Agriculture + tree crops	1582.61 ± 2973.56	2465.98 ± 4638.91	0.5218	2154.79 ± 4151.10
Bamboo	1047.73 ± 2195.24	0.00 ± 0.00	0.0000	369.09 ± 1395.74
Daily wage labour	7711.13 ± 10520.24	5320.35 ± 7508.04	0.0633	6162.56 ± 8763.84
Factory/government employee	598.06 ± 2209.97	2393.68 ± 8479.14	0.76	1761.14 ± 7001.79
Forest fruits	775.32 ± 1823.12	39.91 ± 145.04	0.0037	298.98 ± 1143.64

Forest product*	258.39	± 847.47	0.00	± 0.00	0.0000	91.02	± 517.92
Korai grass	29.03	± 110.55	0.00	± 0.00	0.0000	10.23	± 67.06
Live stock	586.77	± 1236.60	1397.37	± 3103.74	0.6219	1111.82	± 2632.17
Quarry	2235.48	± 3986.39	3203.51	± 7454.92	0.8416	2862.50	± 6466.05
Others**	2146.45	± 6541.92	10491.23	± 23051.79	0.0254	7551.59	± 19368.99
Income from NTFPs***	2110.47	± 3409.00	39.91	± 145.04	<0.0001	769.31	± 2255.15
Income from non NTFPs	14860.52	± 12580.70	25272.12	± 23308.07	0.0049	21604.39	± 20793.72
Gross income from non NTFPs	20521.80	± 15261.83	29576.81	± 23614.62	0.0504	26386.98	± 21493.41

*Includes all the forest products excluding Korai grass, Bamboo and forest fruits.

**Includes Barber, begging, bidi making, petty business, carpenter, dhobi, driver, fencing, granite dealer, hotel worker, house rent, lorry clea ner, painter, pension, petty shop, priest, ration shop, selling of land, supported by the others in the family, tailor, tailoring, trader.

***Includes all forest products including Korai grass, Bamboo and fruits.

Table 6: Percentage sources of income (With outliers)

Percentage sources of income	Tribal	Non tribal	T test	Pooled
(Table with outliers)	Average	Average	p-value	Average
Agriculture + tree crops	11.47 ± 19.23	12.27 ± 21.31	0.7394	11.36 ± 19.49
Bamboo	8.09 ± 19.62	0.00 ± 0.00	0.0000	2.85 ± 12.27
Daily wage labour	44.83 ± 33.40	31.70 ± 39.06	0.0565	36.97 ± 37.82
Factory/government employee	5.28 ± 15.98	7.11 ± 19.72	0.8205	6.63 ± 18.72
Forest fruits	4.53 ± 9.55	0.28 ± 0.96	0.0029	1.78 ± 6.07
Forest product	0.89 ± 2.66	0.00 ± 0.00	0.0000	0.32 ± 1.64
Korai grass	0.15 ± 0.56	0.00 ± 0.00	0.0000	0.05 ± 0.34
Live stock	5.31 ± 11.87	7.97 ± 15.78	0.6567	6.99 ± 14.69
Quarry	9.72 ± 18.10	12.23 ± 25.55	0.8565	11.62 ± 23.49
Others	9.72 ± 23.53	26.75 ± 36.79	0.0274	20.30 ± 33.24
Income from NTFPs	13.66 ± 22.39	0.28 ± 0.96	<0.0001	5.00 ± 14.77
Income from non NTFPs	86.34 ± 22.39	98.03 ± 12.91	<0.0001	93.87 ± 17.86

Table 6a: Percentage sources of income (Without outliers)

Percentage sources of income	Tribal	Non tribal	T test	Pooled
(Table without outliers)	Average	Average	P-value	Average
Agriculture and tree crops	11.47 ± 19.23	11.30 ± 19.63	0.7822	11.36 ± 19.49
Bamboo	8.09 ± 19.62	0.00 ± 0.00	0.0775	2.85 ± 12.27
Daily wage labour	44.83 ± 33.40	32.69 ± 39.37	0.7875	36.97 ± 37.82
Factory/government employee	5.28 ± 15.98	7.36 ± 20.02	0.7672	6.63 ± 18.72
Forest fruits	4.53 ± 9.55	0.29 ± 0.97	0.0033	1.78 ± 6.07

Forest product	0.89	± 2.66	0.00	± 0.00	0.0000	0.32	± 1.64
Korai grass	0.15	± 0.56	0.00	± 0.00	0.0000	0.05	± 0.34
Live stock	5.31	± 11.87	7.90	± 15.95	0.6893	6.99	± 14.69
Quarry	9.72	± 18.10	12.66	± 25.89	0.9151	11.62	± 23.49
Others	9.72	± 23.53	26.06	± 36.20	0.0308	20.30	± 33.24
Income from NTFPs	13.66	± 22.39	0.29	± 0.97	<0.0001	5.00	± 14.77
Income from non NTFPs	86.34	± 22.39	97.96	± 13.13	<0.0001	93.87	± 17.86

Per capita sources of income (With outliers):

The per capita income of the tribals is much lesser than that of the non-tribals. There is not much variation in the per capita income among the tribals while there is a large variation among the non-tribals (Table 7). There is a wide variation in the per capita income as a few extreme cases were sampled. When these outliers were removed we observe that there is no much variation in the per capita income among the non-tribals (Table 7a).

Table 7: Per capita sources of income (With outliers)

Per capita sources of income	Tribal		Non tribal		T test	Pooled	
(Table with outliers)	Average		Average		P value	Average	
Gross total of all the incomes	3902.12	± 2387.02	6636.60	± 10883.28	0.2697	4904.55	± 4245.44
Value of the produce	978.33	± 965.54	1349.97	± 4907.48	0.2659	814.45	± 835.07
Total of total	2937.61	± 1924.08	5315.23	± 6920.22	0.1163	4099.23	± 4245.24
Agriculture + tree crops	316.92	± 541.13	1164.51	± 4617.70	0.6148	505.12	± 1374.97
Bamboo	167.02	± 340.06	0.00	± 0.00	0.0000	58.83	± 217.03
Daily wage labour	1343.15	± 1719.87	959.97	± 1479.37	0.0483	1115.63	± 1586.80
Factory/government employee	115.81	± 438.76	323.08	± 1085.56	0.8002	257.41	± 930.78
Forest fruits	115.86	± 231.07	6.40	± 19.69	0.0036	45.11	± 147.62
Forest product	39.84	± 126.59	0.00	± 0.00	0.0000	14.03	± 77.50
Korai grass	4.03	± 15.68	0.00	± 0.00	0.0000	1.42	± 9.50
Live stock	101.36	± 221.97	357.47	± 1148.30	0.5258	179.47	± 386.04
Quarry	357.49	± 662.84	631.34	± 1957.43	0.7169	549.22	± 1653.56
Others	376.14	± 972.39	1872.47	± 4441.89	0.0326	1372.99	± 3749.30
Income from NTFPs	326.75	± 505.33	6.40	± 19.69	<0.0001	119.40	± 337.04
Income from non NTFPs	2610.86	± 1911.60	5308.83	± 6922.34	0.0217	3979.83	± 4278.46
Gross income from non NTFPs	3589.20	± 2364.29	6658.80	± 10871.18	0.0781	4794.28	± 4269.45

Table 7a: Per capita sources of income (Without outliers)

Per capita sources of income	Tribal	Non tribal	*T-test*	Pooled
(Table without outliers)	Average	Average	p-value	Average
Gross total of all the incomes	3902.12 ± 2387.02	5449.73 ± 4887.08	0.0525	4904.55 ± 4245.44
Value of the produce	978.33 ± 965.54	725.32 ± 739.61	0.2188	814.45 ± 835.07
Total of total	2937.61 ± 1924.08	4730.99 ± 4967.61	0.2964	4099.23 ± 4245.24
Agriculture + tree crops	316.92 ± 541.13	607.47 ± 1652.20	0.5218	505.12 ± 1374.97
Bamboo	167.02 ± 340.06	0.00 ± 0.00	0.0000	58.83 ± 217.03
Daily wage labour	1343.15 ± 1719.87	991.90 ± 1495.04	0.0633	1115.63 ± 1586.80
Factory/government employee	115.81 ± 438.76	334.42 ± 1102.72	0.76	257.41 ± 930.78
Forest fruits	115.86 ± 231.07	6.63 ± 20.00	0.0037	45.11 ± 147.62
Forest product	39.84 ± 126.59	0.00 ± 0.00	0.0000	14.03 ± 77.50
Korai grass	4.03 ± 15.68	0.00 ± 0.00	0.0000	1.42 ± 9.50
Live stock	101.36 ± 221.97	221.95 ± 445.15	0.6219	179.47 ± 386.04
Quarry	357.49 ± 662.84	653.49 ± 1987.84	0.8416	549.22 ± 1653.56
Others	376.14 ± 972.39	1915.14 ± 4511.52	0.0254	1372.99 ± 3749.30
Income from NTFPs	326.75 ± 505.33	6.63 ± 20.00	<0.0001	119.40 ± 337.04
Income from non NTFPs	2610.86 ± 1911.60	4724.36 ± 4969.88	0.0049	3979.83 ± 4278.46
Gross income from non NTFPs	3589.20 ± 2364.29	5449.68 ± 4886.96	0.0504	4794.28 ± 4269.45

When we compare the per capita and percentage income derived from various sources we observe that there is a significant variation between the two communities with respect to income from forest fruits, various sources of income, income from NTFPs, income from non-NTFPs and the gross income. The difference in the dependence of the two communities on various sources for their livelihood is evident.

NTFPs details:

In general the tribals are more dependent on forest products for their livelihood. There is a very wide variation in the number of people dependent and average number of days spent on collection. The quantity extracted and the income derived are also highly varying. Only tribals depend on Arale, Antwala, Korai grass, Sige and Tamarind while non-tribals do not depend on these. Both the communities extract Magali, Nelli, Honne and bamboo.

Table 8: Details of NTFP collection at Ponnachi.

NTFP	Community	No of collector families	No.of days/collector	Avg.qty/collector	Total qty collected	Units of quantity
Antwala(*Sapindus emarginatus*)	Non tribal	Non collector	0.00 ±0.00	0.00 ±0.00	0	Tins
	Tribal	1	15.00 ±0.00	2 ±0.00	2	
	P value	0				
	Pooled	1	15.00 ±0	2 ±0.00	2	
Arale (*Terminalia chebula*)	Non tribal	1	1.00 ±0	1 ±0.00	1	Tins
	Tribal	11	6.45 ±3.7	12.36 ±11.82	136	
	P value	0				
	Pooled	12	6.00 ±3.8	11.42 ±11.74	137	
Bamboo (*Dendrocalamus strictus*)	Non tribal	1	2.00 ±0	0.00 ±0.00	0	Poles
	Tribal	6	18.00 ±21	205 ±196.3	1230	
	P value	0				
	Pooled	7	15.71 ±20	205 ±196.3	1230	
Honne (*Cassia spp.*)	Non tribal	1	3.00 ±0	6 ±0	6	
	Tribal	1	4.00 ±0	120 ±0	120	
	P value	0				
	Pooled	2	3.50 ±0.5	63 ±57	126	
Korai grass (*Phoenix spp.*)	Non tribal	Non collector	0.00 ±0.00	0.00 ±0.00	0	Bundles
	Tribal	2	15.00 ±0	450 ±0	450	
	P value	0				
	Pooled	2	15.00 ±0	450 ±0	450	
Magali (*Decalepis hamiltonii*)	Non tribal	Non collector	0.00 ±0.00	0.00 ±0.00	0	Kilograms
	Tribal	2	11.50 ±3.5	325 ±275	650	
	P value	0				
	Pooled	2	11.50 ±3.5	325 ±275	650	
Nelli	Non tribal	11	3.36 ±2.1	25.41 ±45.8	279.5	Kilograms

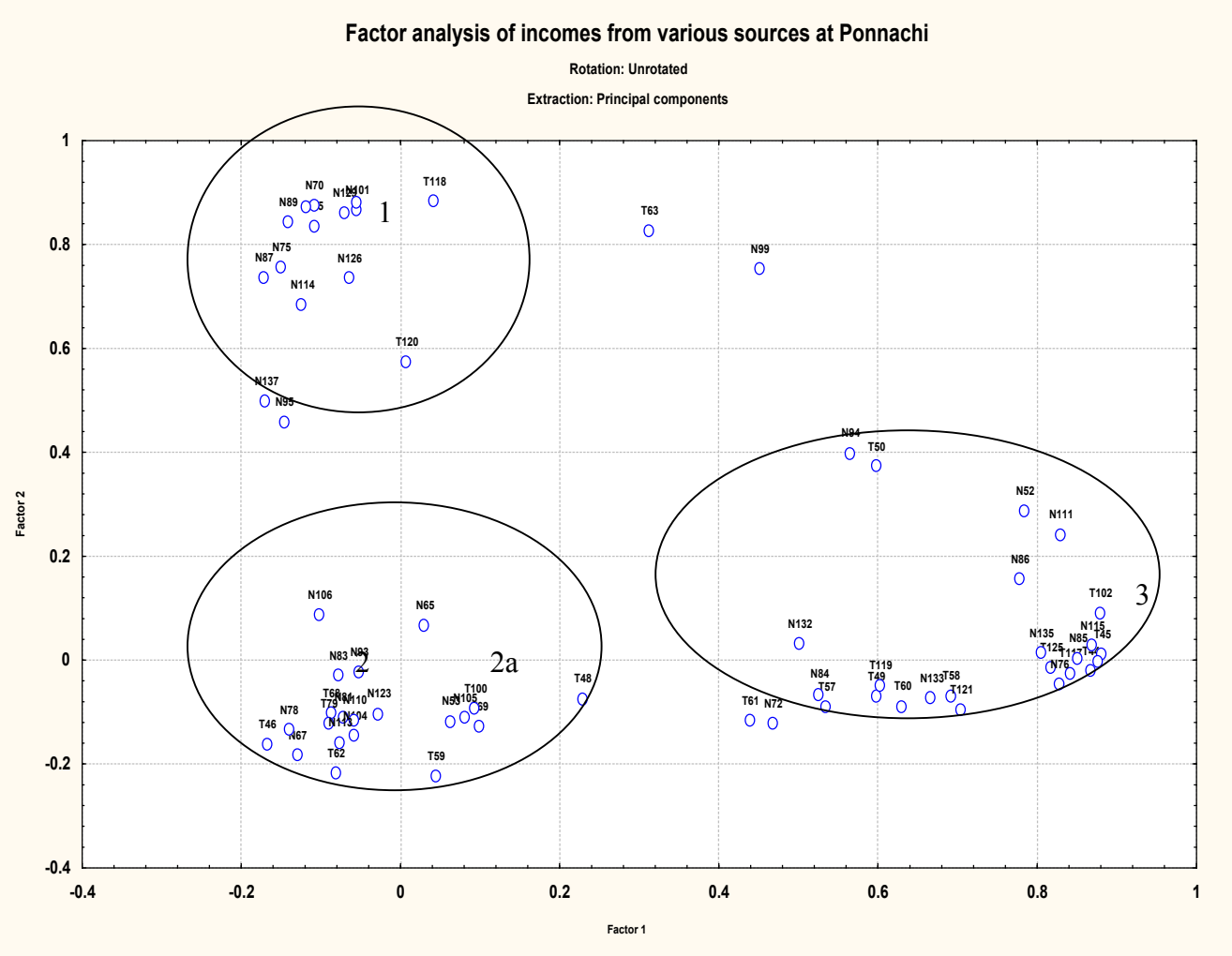
(*Phyllanthus emblica* & *P.indofischeri*)	**Tribal**	15	10.53	±8.4	321.4	±384.3	4821	
	P value	0.0107	T value	±2.8			5100.5	
	Pooled	28	7.50	±7.4	196.2	±327.8		
Sige (*Acacia concinna*)	**Non tribal**	Non collector	0.00	±0.00	0.00	±0.00	0	Tins
	Tribal	1	3.00	±0	3	±0	3	
	P value	0						
	Pooled	1	3.00	±0	3	±0	3	
Tamarind (*Tamarindus indicus*)	**Non tribal**	Non collector	0.00	±0.00	0.00	±0.00	0	Kilograms
	Tribal	5	13.40	±10	34.75	±49.27	139	Dry weight
	P value	0						
	Pooled	5	13.40	±10	34.75	±49.27	139	

Factor analysis:

The factor analysis indicated a clear clustering of the individual households based on the sources of income (Figure 1). Group 1 comprised of households, which primarily obtained their income from bamboo, forest products or Korai grass. Income derived from NTFPs is less. Most of them have a high annual income. The group 2 includes the households that do not depend on forest products or Korai grass for their livelihood. Most of these households derive a major share of their income from agriculture. They do not derive a major percentage of their income from daily waged labour or other means. This set of households includes non-dependants of forest products, korai grass and the other sources of income. Only a small percentage of income is derived from bamboo in one of the families. Group 3 includes of those households, which derive a major share of their income from daily waged labour. They do not depend on bamboo, factory or korai grass for their livelihood. But there are a few households, which derive a major share of income from NTFP collection. The clustering of the people dependent on NTFP is not clear.

The factor loadings are in Appendix 3.

Figure1: Factor analysis of various sources of income at Ponnachi.



Cluster analysis:

Sources of income

Based on the sources of income, two distinct clusters are evident (I, II). Cluster I is composed of households that mainly depend on various sources of income categorised as other sources of income. This cluster splits into two smaller groups. Group 1 consists of those families that derive almost all of their income from "various sources of income". Group 2 also comprises of those households that derive a major share of their income from various

sources of income but at the same time are dependent on other sources such as livestock and agriculture.

Cluster II consists of two groups 3 and 4. The group 3 could be further nested in group 3a and 3b. 3a include the households, which derive a major share of their income from quarries. A subset of these households also depends on daily waged labour work for their livelihood. 3b again splits into two distinct clusters 3b1 and 3b2. 3b1 includes households dependent on factories to a great extent and agriculture to a smaller extent. 3b2 is further comprised of two groups, 3b1 and 3b2 includes households, which depend mainly on NTFPs and to a lesser extent on daily waged labour.. 3b2 consist of subsets, which depend on agriculture and livestock, daily waged labour and agriculture, daily waged labour and factory or exclusively depends on bamboo. Cluster 4 mainly depends on daily wage labour for their livelihood.

We examined the stratification by ethnicity in the different clusters by performing a goodness of fit test. The expected values for the two ethnic groups were calculated by the taking their original proportions in the population.

Table 9: Cluster analysis: Sources of income.

Clusters	Main sources of income	Non tribal number	Tribal number	P value
I	Various sources of income	17	2	0.0223
3a	Quarries, wage labour	18	7	0.4256
3b	factory, agriculture, wage labour, NTFPs	12	17	0.0068
4	Wage labour	9	5	0.9949

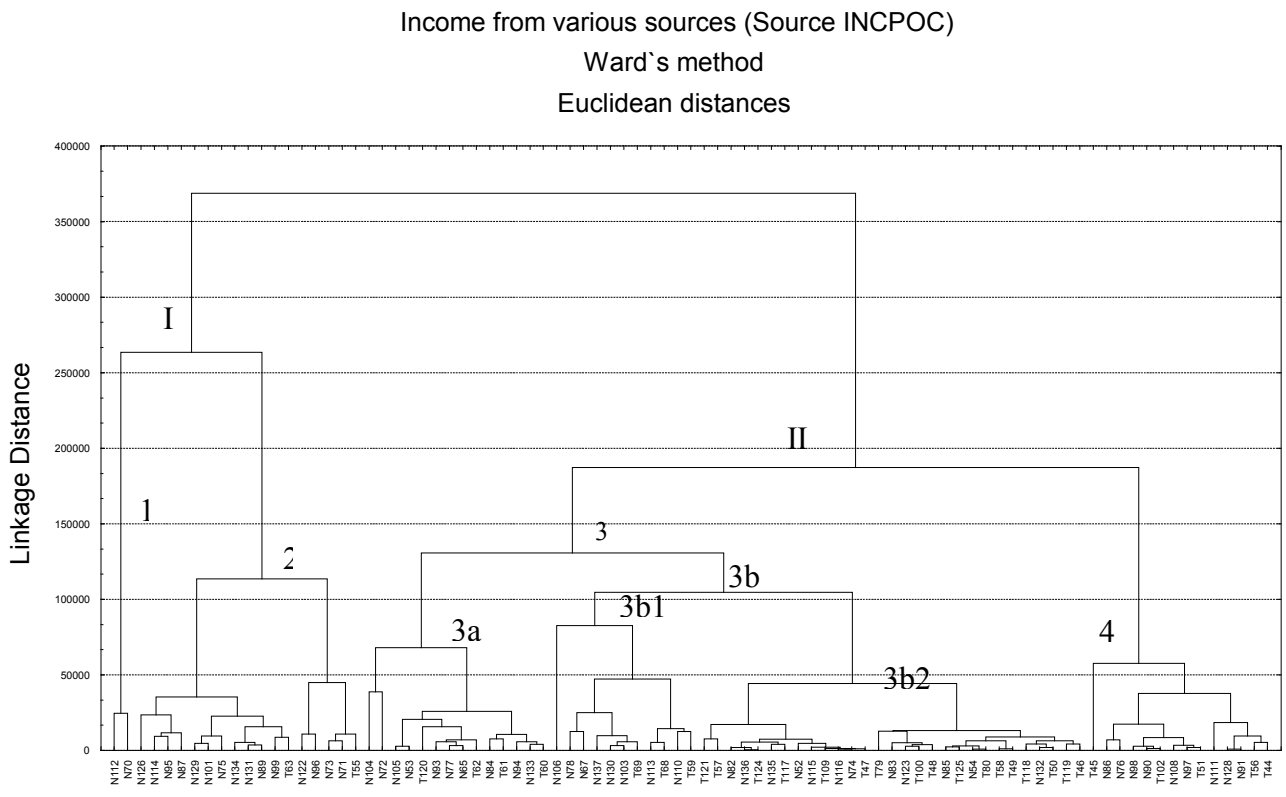


Figure 2: Cluster analysis of sources of income at Ponnachi.

Household variables: We see two main clusters and three distinct clusters in the two clusters that are present. There is a bifurcation of the two clusters as the two are different in the household composition. The main difference between the two clusters is the education status. The first cluster (I) consists of households with 50 to 100 percent literates while the second cluster (II) consists of households with a lower literacy level of zero to 67 percent with most of them ranging from zero to 40.

The first group (1) consists of those households with 50 to 100 percent independents and 50 to 100 percent literates. In this group we see two smaller group, which are slightly different in characters. The first (1a) and second small (1b) group have 50 to 100 percent and 60 to 88 percent independents and 75 to 100 and 50 to 83 percent literates respectively. The second main cluster (II) consists of two smaller groups (2,3). Group 2 consists

of households with similar dependency level and family size, which ranges from 33 to 67 percent and 4 to 9 individuals respectively. In group 2 we have two smaller clusters, which are different in the literacy percentage per family. Groups 3 have are similar in the dependency. Most of the households here consist of 70 to 100 independents. This group is split into two smaller groups (3a, 3b). These two clusters are different in the literacy level of the household, which ranges from zero to 14 percent in 3a and zero to 57 in 3b.
When the different clusters were considered and a chi square test was done we observe that there is no significant difference between the two communities in the household parameters.

Table 10: Cluster analysis of houshold variables.

Clusters	House hold variable responsible for the clustering	Non tribal number	Tribal number	P value
1a	Percent independents (50 –100), literates (75-100)	9	3	0.4911
1b	Percent independents (60 –88), literates (50-83)	17	5	0.2475
2a	Family size (4-9), Dependence (33-67), literates (0-25)	8	8	0.1904
2b	Family size (4-9), Dependence (33-67), literates (60-70)	7	8	0.1237
3a	Independents (70-100), Literacy (0-14)	6	3	0.9441
3b	Independents (70-100), Literacy (0-57)	12	4	0.4266

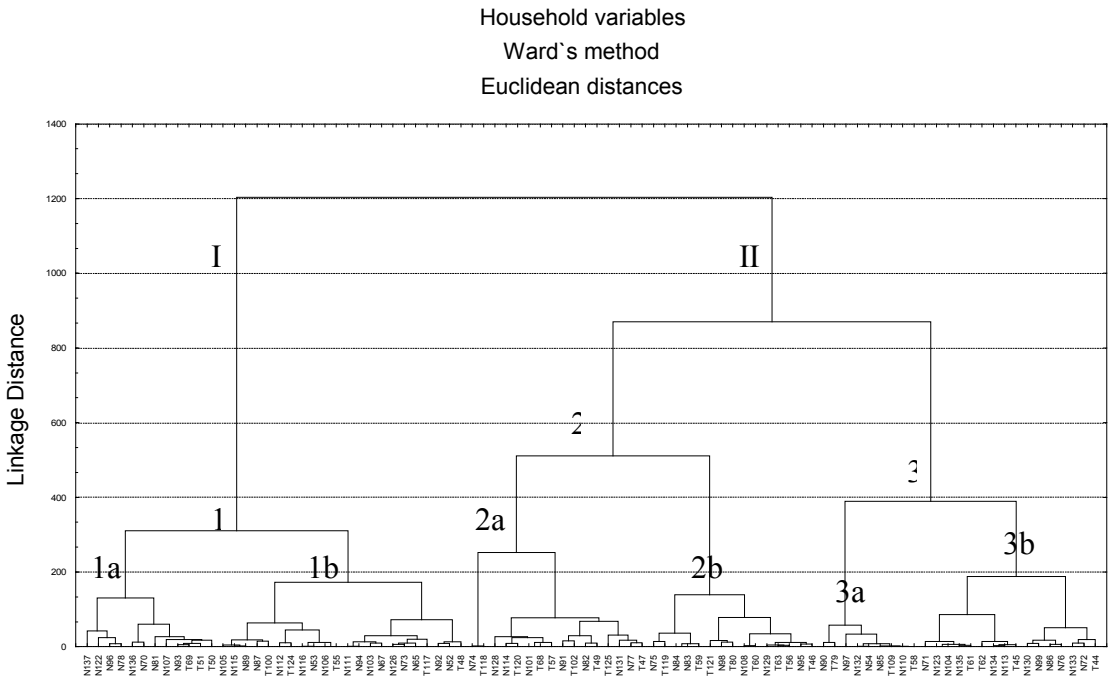


Figure 3: Cluster analysis of household variables of Ponnachi.

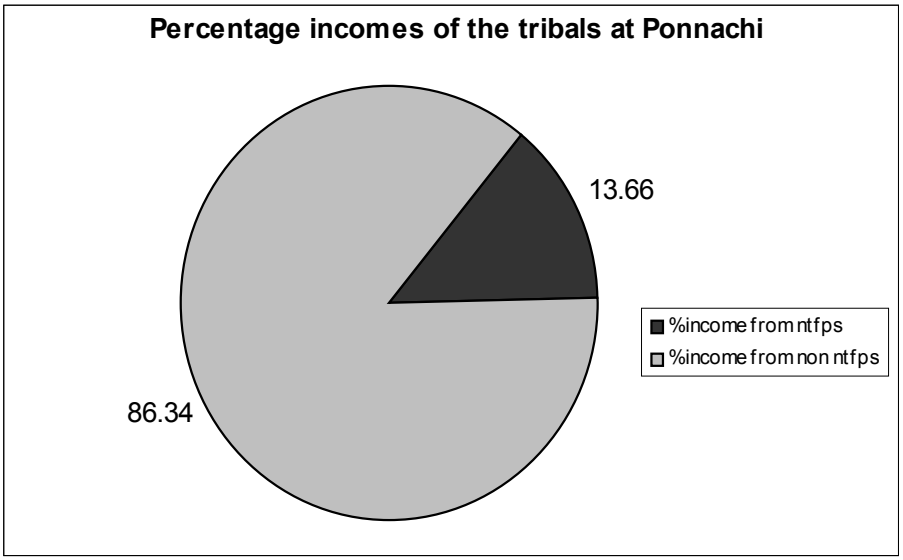


Figure 4: Percentage of incomes from NTFP and non-NTFPs of tribals at Ponnachi

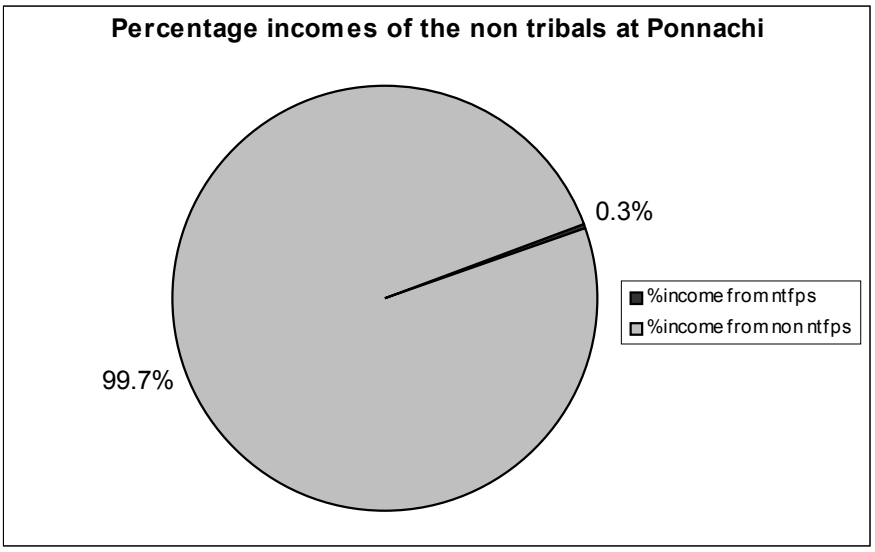


Figure 5: Percentage of incomes from NTFP and non-NTFPs of non-tribals at Ponnachi

From the pie charts we see that the tribals and nontribals obtain a major share of their income from non-NTFP sources. Among the two we observe that the non-tribals derive a very small percentage of their income from NTFPs.

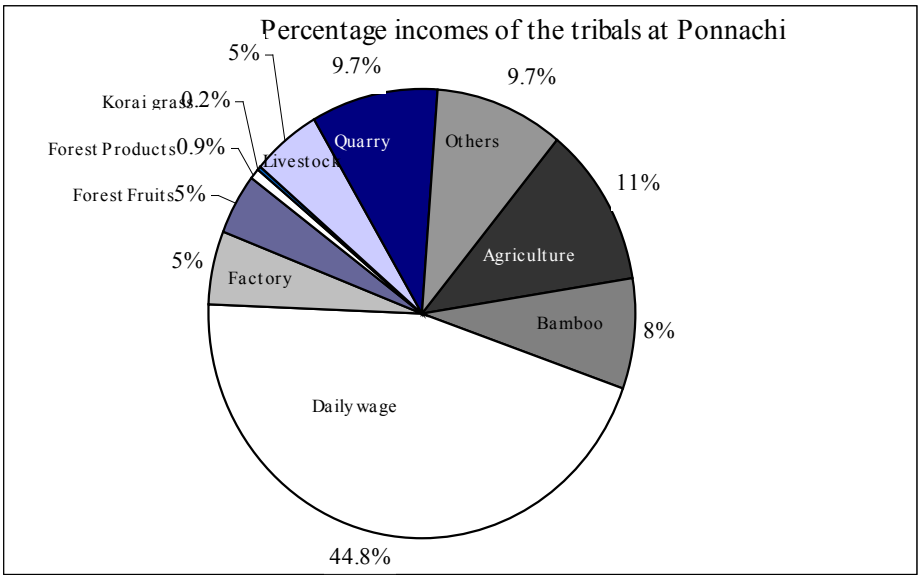


Figure 6: Percentage of incomes from all sources of tribals at Ponnachi

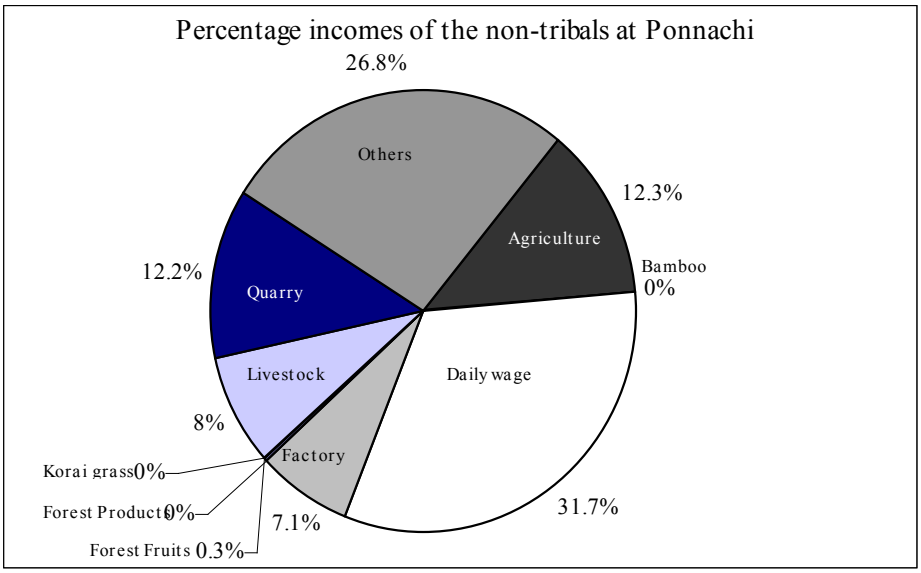


Figure 7: Percentage of incomes from all sources of non-tribals at Ponnachi

The two-pie charts show that the tribals and the non tribals derive a major share of their incomes from labour work. Agriculture is also an important source of income. Non tribals are not dependent on bamboo unlike tribals. The non tribals derive a major share of income from other sources of income.

Figure 8: Wealth index using income from non NTFPs against assets at Ponnachi

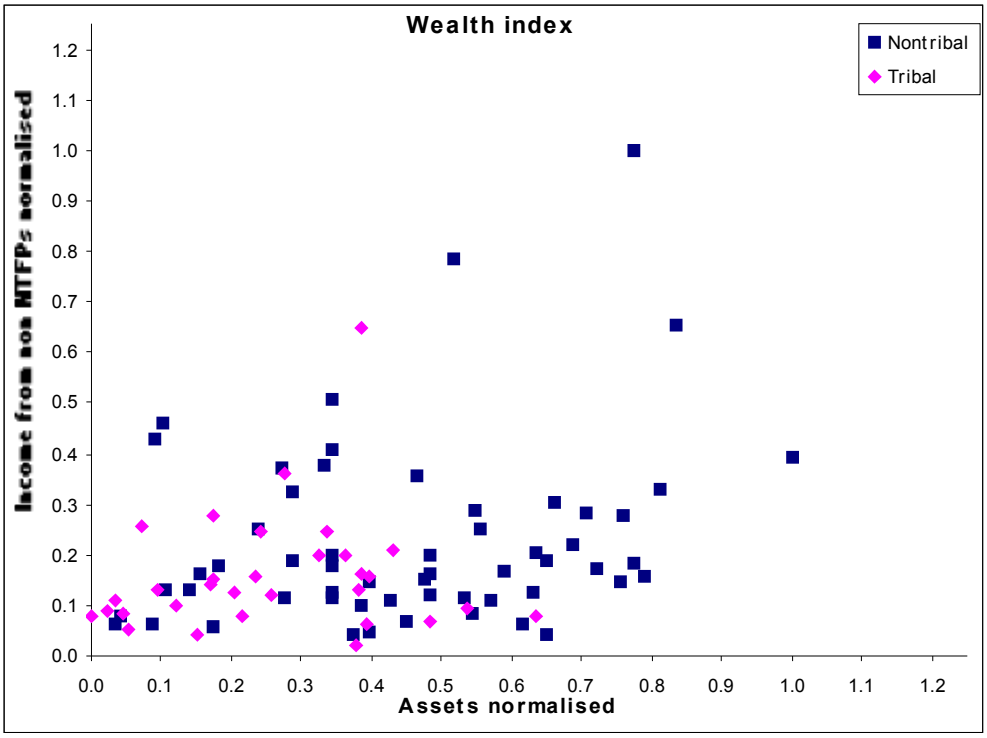


Figure 9: Wealth index using income against assets from NTFPs at Ponnachi

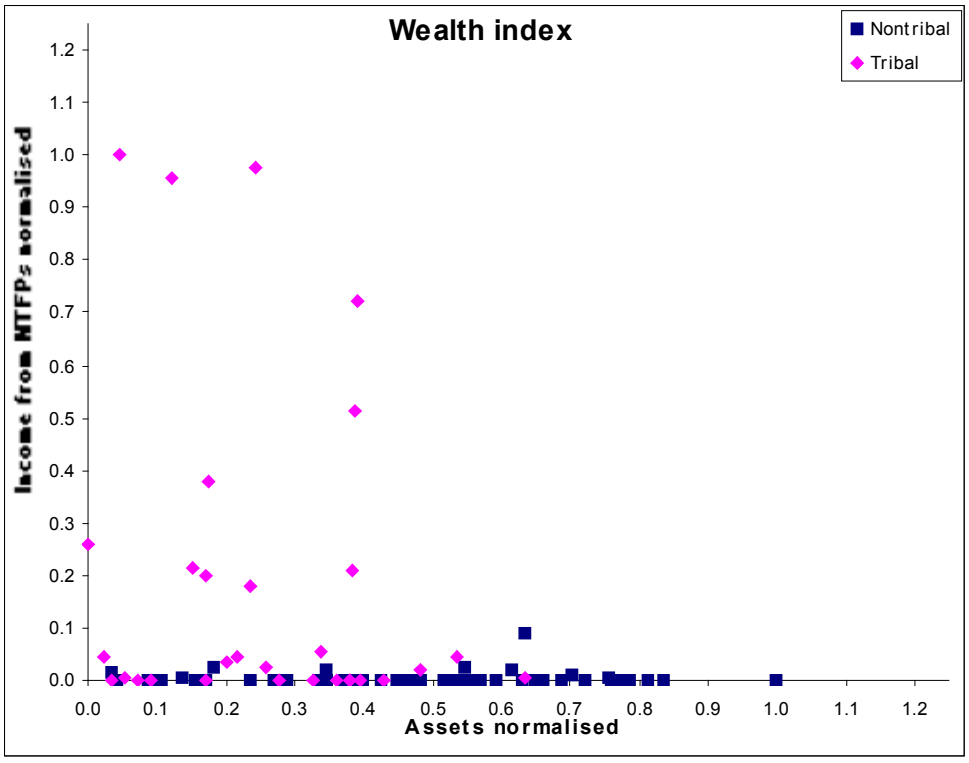
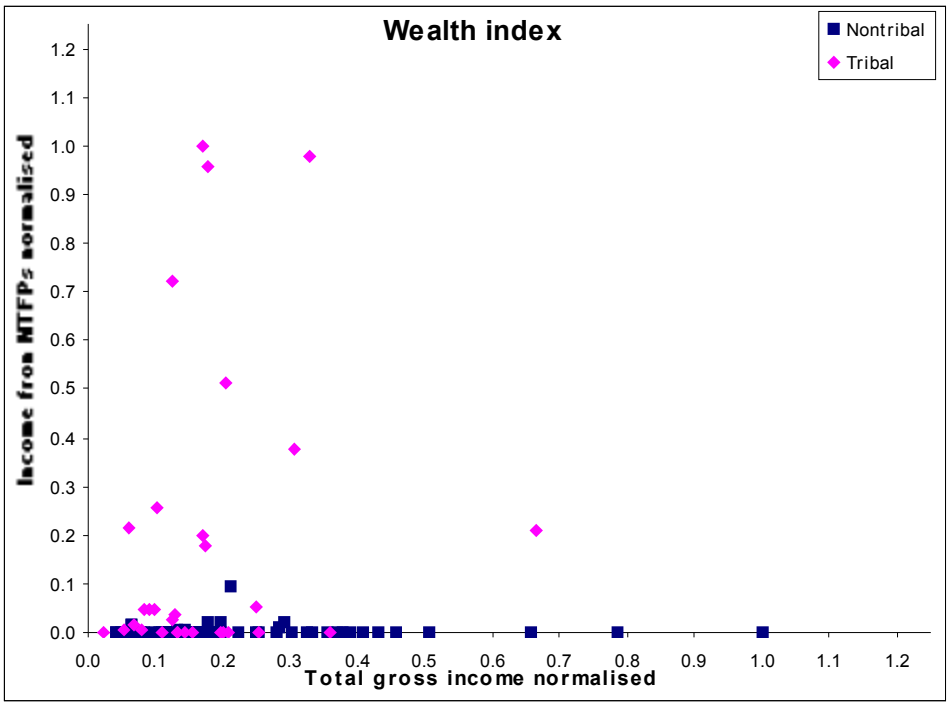


Figure 10: Wealth index using income from NTFPs against gross income at Ponnachi



Wealth index:

We examined the relation between wealth index of the households with their percentage dependence on income from NTFPs and non-NTFPs. It is hypothesised that as wealth index increases the dependence on the NTFPs as a source of income will decrease. Our results indicate that with increase in wealth index the dependence on NTFPs decreases for the tribal population. The wealth index of the non-tribals is larger than the tribals and they do not depend on the NTFPs as a source of income. This pattern was also clear from the relation between the per cent dependence on NTFPs and the total gross income.

Summary of MLR analysis:

The multiple linear analysis was carried out to find the influence of the household variables and sources of income mainly on the dependence of NTFPs. The significant result are explained in form of a table below. The income from forest fruits has a positive relationship with the gross income of the non-tribals. We also see that there is an increase in the gross income of the tribals as the dependence on NTFPs increases. The per capita income decreases with an increase in the size of the family in both the cases. A similar situation is noticed when the number of dependants in the family increases. Probably the households with a large family size have more dependants. The per capita income from NTFPs increases as the income from forest fruits increases. The details of the results are in tables in Appendix 2.

Table11: Summery of Multiple linear regression with various variables.

Ethnic group	Dependent variable	Significant variables (Positively)	Significant variables (Negatively)
Non tribals	Per capita gross income	Value of consumed agricultural produce, Income from agriculture +tree crops, Value of Income from livestock, Income from waged labour, Income from quarry, Income from other sources, and Income from factory, Income from livestock, Income from forest fruits.	Family size.
Non tribals	Gross income	Percent literate, Land area, Value of Income from livestock, Value of consumed agricultural produce, Income from agriculture +tree crops, Income from waged labour, Income from livestock, Income from quarry, Income from other sources, Income from factory, Income from forest fruits	
Non tribals	Per capita gross income from non	Percent literate, Land area, Value of Income from livestock	Family size

	NTFPs		
Tribals	Gross income	Value of consumed, agricultural produce, Income from agriculture +tree crops, Income from bamboo, Income from waged labour, Income from livestock, Income from NTFPs, Income from quarry, Income from other means, Income from factory, Income from forest fruits	Percent dependent
Tribals	Per capita gross income	Value of consumed, agricultural produce, Income from agriculture +tree crops, Income from waged labour, Income from quarry, Income from other means, Income from factory	Percent dependent, Family size
Tribal	Gross per capita income from non NTFPs		Percent dependent
Tribal	Per capita income from forest fruits	Income from agriculture +tree crops, Income from korai grass	
Tribal	Gross income from non NTFPs		Percent dependent
Tribal	Per capita income from NTFPs	Income from agriculture +tree crops, Income from road or masonry work	Family size
Pooled	Gross income	Percent literate, Land area, Value of consumed agricultural produce, Income from agriculture +tree crops, Income from bamboo, Income from waged labour, Income from livestock, Income from NTFPs, Income from quarry, Income from other means, Income from factory, Income from forest fruits, Income from korai grass	
Pooled	Per capita gross income	Percent literate, Land area, Value of consumed, agricultural produce, Income from agriculture +tree crops, Income from waged labour, Income from quarry, Income from other means, Income from factory	Family size

Pooled	Per capita income from NTFPs	Income from forest fruits	
Pooled	Per capita gross income from non-NTFP	Percent literate, Land area, Value of livestock	Family size
Pooled	Per capita income from forest fruits	Income from bamboo, Income from korai grass	

Conclusions:

- We see that the tribals are more dependent on NTFPs when compared to the non tribals. The non tribals are not dependent on Bamboo, korai grass or other NTFPs. Though the non tribals are dependent on forest fruits there is a significant difference in their dependence. Most collectors depend on *Phyllanthus emblica , P.indofischeri* and *Terminalia chebula* than on any other NTFP. This could be due to the abundance in the availability of these three species. Very few people in this region are NTFP collectors as the returns from the same is less as the quantity is less and the money paid by the contractors is low. Though Korai grass is in abundance in this area the people do not derive much from it as outsiders are hired to do the collection and bundling which require skill. Based on Ravi Hegde's work we see that there is a difference in the dependence on NTFPs.
- There is no variation in the family size or male and female ratio.
- The non-tribals are more dependent on livestock for their livelihood than the tribals. There is a variation in the ownership of Buffaloes in this region.

Comparison of Ponnachi and Kombudikki:

When the two settlements are compared we see that

- The population of Ponnachi (5562) is very much greater than that of Kombudikki (442). At Kombudikki the tribal population is only 13 % of the total population while it is 17% at Ponnachi.
- At Ponnachi the tribal number of dependents per household is much greater that at Kombudikki, but it is just the opposite in case of non-tribal.
- The average no of literates per household is greater at Ponnachi.
- The average livestock number per household among non-tribals is higher at Kombudikki than at Ponnachi and vice versa among tribals. In general the average number of livestock owned by people at Kombudikki is more than at Ponnachi. Kombudikki has a better forest with more trees. Hence the fodder for the cattle is more abundant here, which could be the reason for the difference in the variation in the cattle population.
- At Kombudikki the tribals are very much dependent on basket making while at Ponnachi the dependence on the same is not very high. This could be due to the difference in resource availability.
- The tribals of Ponnachi are more dependent on daily wage labour. Agricultural land is more, income from NTFP is low, livestock population is low and the only available means of income during all seasons is waged labour.
- Quarry is an important source of income at Kombudikki and Ponnachi. Ponnachi is a place with a number of quarries, which are not functional now. Hence these trained labourers still prefer to go to places where such jobs are available.
- At Ponnachi people especially non-tribals are more versatile in their jobs. They do all kinds of odd jobs, as any particular job is not available uniformly through out the year.

- At Kombudikki the income from NTFP is much greater when compared to Ponnachi This could be because the forests are less disturbed and hence more productive at Kombudikki and people at Ponnachi have opted to other means of income, which is seen from the income they earn from various sources.
- Korai grass is an important source of income at Kombudikki while it is not so important at Ponnachi. The people of Ponnachi are not familiar with the bundling technique, which is unique and requires skill.
- At both places non-tribals are more dependent on livestock compared to tribal.

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Appendix 2: Results of Multiple linear regression with various household and income variables

NON TRIBALS			
Dependent variables	Independent variables	y/n	Positive /negative
Per capita gross income	Percent dependent	n	
	Percent literate	n	
	Family size	y	n
	Land area	n	
	Value of consumed agricultural produce	y	p
	Income from agriculture+tree crops	y	p
	Income from waged labour	y	p
	Income from Income from livestock	n	
	Income from Income from quarry	y	p
	Income from road or masonrywork	n	
	Income from other sources	y	p
	Income from factory	y	p
	Income from forest fruits	n	
Per capita gross income	Percent dependent	n	
	Percent literate	n	
	Family size	y	n
	Land area	n	
	Value of Income from livestock	n	
	Value of consumed agricultural product	n	
	Income from agriculture+tree crops	y	p
	Income from waged labour	y	p
	Income from livestock	n	

	Income from quarry	y	p
	Income from road and masonrywork	n	
	Income from other sources	y	p
	Income from factory	y	p
	Income from forest fruits	n	
Per capita gross income from non NTFPs	Percent dependent	n	
	Percent literate	y	p
	Family size	y	n
	Land area	y	p
	Value of Income from livestock	y	p
	Income from forest fruits	n	
Gross income	Percent dependent	n	
	Percent literate	y	p
	Family size	n	
	Land area	y	p
	Value of Income from livestock	y	p
Per capita gross income from non NTFPs	Percent dependent	n	
	Percent literate	y	p
	Family size	y	n
	Land area	y	p
	Value of Income from livestock	y	p
Gross income	Percent dependent	n	
	Percent literate	y	p
	Family size	n	
	Land area	y	p
Per capita gross income	Percent dependent	n	
	Percent literate	y	p
	Family size	y	n
	Land area	y	p

Per capita gross income	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of Income from livestock	n	
	Value of consumed agricultural product	y	p
	Income from agriculture+tree crops	y	p
	Income from waged labour	y	p
	Income from livestock	y	p
	Income from quarry	y	p
	Income from road and masonry work	n	
	Income from other sources	y	p
	Income from factory	y	p
	Income from forest fruits	y	p
Per capita gross income	Percent dependent		
	Percent literate		
	Family size		
	Land area		
	Value of Income from livestock		
	Value of consumed agricultural product		
	Income from agriculture+tree crops		
	Income from waged labour		
	Income from livestock		
	Income from quarry		
	Income from road and masonry work		
	Income from other sources		
	Income from factory		

Gross income	Percent dependent		
	Percent literate		
	Family size		
	Land area		
	Value of Income from livestock		
	Income from forest fruits		
Per capita gross income	Percent dependent		
	Percent literate		
	Family size		
	Land area		
	Value of Income from livestock		
Per capita gross income from non NTFPs	Percent dependent		
	Percent literate		
	Family size		
	Land area		
	Value of Income from livestock		
	Income from forest fruits		
Gross income	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of consumed agricultural produce	y	p
	Income from agriculture+tree crops	y	p
	Income from waged labour	y	p
	Income from Income from livestock	y	p

	Income from Income from quarry	y	p
	Income from road or masonrywork	n	
	Income from other sources	y	p
	Income from factory	y	p
	Income from forest fruits	y	p
Gross income	Percent dependent	n	
	Percent literate	y	p
	Family size	n	
	Land area	y	p
	Value of Income from livestock	y	p

Dependent variable: Per capita gross income (Non tribal)		
r value	0.9889	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0466	0.0575
Percent literate	0.0070	0.7906
Family size	-0.2122	0.0000
Land area	0.0102	0.7450
Value of consumed agricultural produce	0.2370	0.0352
Income from agriculture +tree crops	0.6564	0.0000
Income from waged labour	0.1057	0.0010
Income from Income from livestock	0.0531	0.3445
Income from Income from quarry	0.1496	0.0000
Income from road or masonry work	0.0206	0.4852
Income from other sources	0.3730	0.0000
Income from factory	0.1081	0.0001
Income from forest fruits	-0.0082	0.7215

Dependent variable: Gross income (Non tribal)

r value	1.0000	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0001	0.8320
Percent literate	-0.0004	0.5676
Family size	0.0005	0.3834
Land area	-0.0005	0.4806
Value of consumed agricultural produce	0.4569	0.0000
Income from agriculture +tree crops	0.4134	0.0000
Income from waged labour	0.1378	0.0000
Income from livestock	0.1135	0.0000
Income from quarry	0.1367	0.0000
Income from road or masonry work	0.0001	0.8598
Income from other sources	0.4228	0.0000
Income from factory	0.1552	0.0000
Income from forest fruits	0.0028	0.0000

Dependent variable: Per capita gross income (Non tribal)		
r value	0.9889	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0464	0.0612
Percent literate	0.0070	0.7924
Family size	-0.2126	0.0000
Land area	0.0098	0.7583
Value of Income from livestock	0.0251	0.7262
Value of consumed agricultural product	0.2190	0.0780
Income from agriculture + tree crops	0.6653	0.0000
Income from waged labour	0.1056	0.0011
Income from livestock	0.0387	0.5791
Income from quarry	0.1495	0.0000
Income from road and masonry work	0.0205	0.4922

Income from other sources	0.3727	0.0000
Income from factory	0.1093	0.0001
Income from forest fruits	-0.0070	0.7675

Dependent variable: Per capita gross income from non NTFPs (Non tribal)		
r value	0.8361	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0880	0.2642
Percent literate	0.1591	0.0458
Family size	-0.2285	0.0052
Land area	0.2775	0.0053
Value of Income from livestock	0.5760	0.0000
Income from forest fruits	-0.0144	0.8519

Dependent variable: Gross income (Non tribal)		
r value	0.8477	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.1273	0.0938
Percent literate	0.1686	0.0275
Family size	0.0137	0.8552
Land area	0.2575	0.0066
Value of Income from livestock	0.6237	0.0000

Per capita gross income from non NTFPs (Non tribal)		
r value	0.8360	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0885	0.2564

Percent literate	0.1598	0.0427
Family size	-0.2292	0.0046
Land area	0.2761	0.0050
Value of Income from livestock	0.5777	0.0000

Dependent variable: Gross income (Non tribal)		
r value	0.6888	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0813	0.4222
Percent literate	0.2470	0.0161
Family size	-0.0125	0.9024
Land area	0.6259	0.0000

Dependent variable: Per capita gross income (Non tribal)		
r value	0.6998	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0459	0.6450
Percent literate	0.2324	0.0213
Family size	-0.2536	0.0140
Land area	0.6175	0.0000

Dependent variable: Per capita gross income (Non tribal)		
r value	1.0000	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0001	0.8472

Percent literate	-0.0004	0.5698
Family size	0.0005	0.4023
Land area	-0.0005	0.4645
Value of Income from livestock	0.0013	0.4507
Value of consumed agricultural product	0.4559	0.0000
Income from agriculture + tree crops	0.4138	0.0000
Income from waged labour	0.1378	0.0000
Income from livestock	0.1128	0.0000
Income from quarry	0.1367	0.0000
Income from road and masonry work	0.0001	0.8675
Income from other sources	0.4228	0.0000
Income from factory	0.1553	0.0000
Income from forest fruits	0.0029	0.0000

Dependent variable: Per capita gross income (Non tribal)		
r value	0.2853	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0321	0.8358
Percent literate	0.0301	0.8585
Family size	-0.0163	0.9196
Land area	0.1274	0.5281
Value of Income from livestock	-0.4067	0.3705
Value of consumed agricultural product	0.3890	0.6177
Income from agriculture + tree crops	-0.2014	0.7385
Income from waged labour	-0.0304	0.8755

Income from livestock	0.0446	0.9199
Income from quarry	-0.1823	0.2945
Income from road and masonry work	0.1975	0.2927
Income from other sources	-0.1103	0.5076
Income from factory	-0.1473	0.3528

Dependent variable: Gross income (Non tribal)		
r value	0.8478	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.1271	0.0976
Percent literate	0.1684	0.0294
Family size	0.0139	0.8550
Land area	0.2578	0.0072
Value of Income from livestock	0.6232	0.0000
Income from forest fruits	-0.0061	0.9345

Dependent variable: Per capita gross income (Non tribal)		
r value	0.8361	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0884	0.2568
Percent literate	0.1597	0.0427
Family size	-0.2294	0.0046
Land area	0.2763	0.0049
Value of Income from livestock	0.5775	0.0000

Dependent variable: Per capita gross income from non NTFPs (Non tribal)		
r value	0.8361	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0880	0.2642
Percent literate	0.1591	0.0458
Family size	-0.2285	0.0052
Land area	0.2775	0.0053
Value of Income from livestock	0.5760	0.0000
Income from forest fruits	-0.0144	0.8519

TRIBALS			
Dependent variables	Independent variables	y/n	Positive /negative
Gross income	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of consumed agricultural produce	y	p
	Income from agriculture+tree crops	y	p
	Income frm bamboo	y	p
	Income from waged labour	y	p
	Income from livestock	y	p
	Income from NTFPs	y	p
	Income from quarry	y	p
	Income from road or masonrywork	n	
	Income from other means	y	p
	Income from factory	y	p
	Income from forest fruits	y	p

	Income from korai grass	n	
Per capita gross income	Percent dependent	y	n
	Percent literate	n	
	Family size	n	
	Land area	n	
Gross income	Percent dependent	y	n
	Percent literate	n	
	Family size	n	
	Land area	n	
Per capita gross income	Percent dependent	y	n
	Percent literate	n	
	Family size	y	n
	Land area	n	
	Value of consumed agricultural produce	y	p
	Income from agriculture+tree crops	y	p
	Income frm bamboo	n	
	Income from waged labour	y	p
	Income from livestock	n	
	Income from NTFPs	n	
	Income from quarry	y	p
	Income from road or masonrywork	n	
	Income from other means	y	p
	Income from factory	y	p
	Income from forest fruits	n	
	Income from korai grass	n	
Gross income	Percent dependent	n	
	Percent illiterate	n	
	Family size	n	
	Land area	n	
	Value of livestock	n	

	Value of consumed agricultural produce	n	
	Income from agriculture+tree crops	y	p
	Income frm bamboo	y	p
	Income from waged labour	y	p
	Income from livestock	y	p
	Income from NTFPs	y	p
	Income from quarry	y	p
	Income from road or masonrywork	n	
	Income from other means	y	p
	Income from factory	y	p
	Income from forest fruits	y	p
	Income from korai grass	n	
Per capita gross income	Percent dependent	n	
	Percent illiterate	n	
	Family size	y	n
	Land area	n	
	Value of livestock	n	
	Value of consumed agricultural produce	y	p
	Income from agriculture+tree crops	y	p
	Income frm bamboo	n	
	Income from waged labour	y	p
	Income from livestock	n	
	Income from NTFPs	n	
	Income from quarry	y	p
	Income from road or masonrywork	n	
	Income from other means	y	p
	Income from factory	y	p
	Income from forest fruits	n	
	Income from korai grass	n	

Per capita income from forest fruits	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of livestock	n	
Gross per capita income from non NTFPs	Percent dependent	y	n
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of livestock	n	
Per capita income from forest fruits	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of livestock	n	
	Value of consumed agricultural produce	n	
	Income from agriculture+tree crops	y	p
	Income frm bamboo	n	
	Income from waged labour	n	
	Income from livestock	n	
	Income from NTFPs	n	
	Income from quarry	n	
	Income from road or masonrywork	n	
	Income from other means	n	
	Income from factory	n	
	Income from korai grass	y	p
Gross per capita income from non NTFPs	Percent dependent	y	n
	Percent illiterate	n	

	Family size	n	
	Land area	n	
	Value of livestock	n	
Gross income from non NTFPs	Percent dependent	y	n
	Percent literate	n	
	Family size	n	
	Land area	n	
	Intercpt	n	
Gross income	Percent dependent	y	n
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of livestock	n	
Gross Per capita income	Percent dependent	y	n
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of livestock	n	
Per capita income from NTFPs	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of livestock	n	
Gross per capita income from non NTFPs	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of livestock	n	
	Income frm bamboo	n	
	Income from NTFPs	n	

	Income from forest fruits	n	
	Income from korai grass	n	
Per capita income from NTFPs	Percent dependent	n	
	Percent literate	n	
	Family size	y	p
	Land area	n	
	Value of livestock	n	
	Value of consumed agricultural produce	n	
	Income from agriculture+tree crops	y	p
	Income from waged labour	n	
	Income from livestock	n	
	Income from quarry	n	
	Income from road or masonrywork	y	p
	Income from other means	n	
	Income from factory	n	
Gross per capita non NTFP	Percent dependent	y	n
	Percent literate	n	
	Family size	n	
	Land area	n	

Dependent variable: Gross income (Tribal)		
r value	0.9990	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0152	0.3517
Percent literate	0.0128	0.4397
Family size	-0.0174	0.3278
Land area	0.0000	0.9990
Value of consumed agricultural produce	0.4031	0.0000

Income from agriculture +tree crops	0.1853	0.0000
Income from bamboo	0.1536	0.0000
Income from waged labour	0.6864	0.0000
Income from livestock	0.0796	0.0032
Income from NTFPs	0.0522	0.0116
Income from quarry	0.2418	0.0000
Income from road or masonry work	-0.0068	0.7164
Income from other means	0.4352	0.0000
Income from factory	0.1418	0.0000
Income from forest fruits	0.1071	0.0041
Income from korai grass	0.0285	0.4072

Dependent variable: Per capita gross income (Tribal)		
r value	0.4443	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.4531	0.0232
Percent literate	0.0880	0.6392
Family size	-0.1887	0.3230
Land area	-0.1376	0.4764

Dependent variable: Gross income (Tribal)		
r value	0 .51997354	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.3707	0.0485
Percent literate	0.1389	0.4393
Family size	0.2526	0.1691
Land area	-0.1568	0.3957

Dependent variable: Per capita gross income (Tribal)		
r value	0.9927	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0955	0.0436
Percent literate	-0.0515	0.2617
Family size	-0.4461	0.0000
Land area	0.0064	0.8734
Value of consumed agricultural produce	0.4471	0.0000
Income from agriculture +tree crops	0.2636	0.0005
Income from bamboo	0.1105	0.0649
Income from waged labour	0.7156	0.0000
Income from livestock	0.0133	0.8309
Income from NTFPs	-0.0372	0.4619
Income from quarry	0.2726	0.0001
Income from road or masonry work	-0.0023	0.9638
Income from other means	0.3877	0.0000
Income from factory	0.1511	0.0016
Income from forest fruits	0.0674	0.4440
Income from korai grass	0.0957	0.3114

Dependent variable: Gross income (Tribal)		
r value	0.9990	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0146	0.3888
Percent illiterate	-0.0154	0.4386
Family size	-0.0179	0.3340
Land area	-0.0047	0.8414
Value of livestock	0.0081	0.7917
Value of consumed agricultural produce	0.4035	0.0000
Income from agriculture +tree crops	0.1841	0.0000

Income from bamboo	0.1541	0.0000
Income from waged labour	0.6864	0.0000
Income from livestock	0.0746	0.0260
Income from NTFPs	0.0516	0.0162
Income from quarry	0.2417	0.0000
Income from road or masonry work	-0.0087	0.6751
Income from other means	0.4349	0.0000
Income from factory	0.1413	0.0000
Income from forest fruits	0.1071	0.0056
Income from korai grass	0.0289	0.4169
Dependent variable: Per capita gross income (Tribal)		
r value	0.9927	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0960	0.0524
Percent illiterate	0.0488	0.3736
Family size	-0.4467	0.0000
Land area	0.0017	0.9792
Value of livestock	0.0081	0.9228
Value of consumed agricultural produce	0.4476	0.0000
Income from agriculture +tree crops	0.2623	0.0010
Income from bamboo	0.1110	0.0754
Income from waged labour	0.7156	0.0000
Income from livestock	0.0083	0.9203
Income from NTFPs	-0.0377	0.4750
Income from quarry	0.2726	0.0001
Income from road or masonry work	-0.0042	0.9409
Income from other means	0.3873	0.0000
Income from factory	0.1506	0.0025
Income from forest fruits	0.0673	0.4616
Income from korai grass	0.0962	0.3281

Dependent variable: Per capita income from forest fruits (Tribal)		
r value	0.2862	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0533	0.7969
Percent literate	-0.0824	0.6931
Family size	0.2427	0.2460
Land area	0.1259	0.6377
Value of livestock	-0.2098	0.4074

Dependent variable: Gross per capita income from non NTFPs (Tribal)		
r value	0.5267	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.4860	0.0131
Percent literate	0.1387	0.4559
Family size	-0.2373	0.2025
Land area	-0.3273	0.1745
Value of livestock	0.2985	0.1886

Dependent variable: Per capita income from forest fruits (Tribal)		
r value	0.9342	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.1379	0.2916
Percent literate	0.1021	0.5038
Family size	0.0331	0.8121
Land area	0.0248	0.8926
Value of livestock	-0.0704	0.7697
Value of consumed agricultural produce	0.1749	0.2689
Income from agriculture +tree crops	0.4063	0.0213

Income from bamboo	-0.1476	0.3649
Income from waged labour	-0.2276	0.0857
Income from livestock	-0.4014	0.0779
Income from NTFPs	-0.0826	0.5801
Income from quarry	0.1892	0.1989
Income from road or masonry work	-0.0383	0.8076
Income from other means	-0.1686	0.1811
Income from factory	-0.0408	0.7271
Income from korai grass	0.9145	0.0000

Dependent variable: Gross per capita income from non NTFPs (Tribal)		
r value	0.5267	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.4860	0.0131
Percent illiterate	-0.1387	0.4559
Family size	-0.2373	0.2025
Land area	-0.3273	0.1745
Value of livestock	0.2985	0.1886

Dependent variable: Gross income from non NTFPs (Tribal)		
r value	0.5038	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.3943	0.0387
Percent literate	0.1637	0.3683
Family size	0.1821	0.3227
Land area	-0.1607	0.3895

Dependent variable: Gross income (Tribal)		
r value	0.5591	

Independent variables	Beta coefficients	P-value
Percent dependent	-0.3822	0.0411
Percent literate	0.1831	0.3150
Family size	0.2517	0.1670
Land area	-0.3315	0.1591
Value of livestock	0.2669	0.2268

Dependent variable: Gross Per capita income (Tribal)		
r value	0.4875	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.4643	0.0200
Percent literate	0.1312	0.4919
Family size	-0.1897	0.3181
Land area	-0.3083	0.2118
Value of livestock	0.2608	0.2612

Dependent variable: Per capita income from NTFPs (Tribal)		
r value	0.2615	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0848	0.6849
Percent literate	-0.0302	0.8857
Family size	0.2160	0.3040
Land area	0.0779	0.7720
Value of livestock	-0.1671	0.5113

Dependent variable: Gross per capita income from non NTFPs (Tribal)		
r value	0.5613	

Independent variables	Beta coefficients	P-value
Percent dependent	-0.3791	0.1006
Percent literate	0.1444	0.4784
Family size	-0.2175	0.3030
Land area	-0.2765	0.2999
Value of livestock	0.2708	0.2750
Income from bamboo	-0.0498	0.8007
Income from NTFPs	0.1851	0.3859
Income from forest fruits	-0.0333	0.9201
Income from korai grass	-0.0382	0.9093

Dependent variable: Per capita income from NTFPs (Tribal)		
r value	0.8434	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0047	0.9771
Percent literate	-0.2639	0.1754
Family size	0.3866	0.0227
Land area	0.2157	0.3784
Value of livestock	-0.2549	0.4314
Value of consumed agricultural produce	0.1461	0.4793
Income from agriculture +tree crops	0.6458	0.0013
Income from waged labour	-0.0914	0.5451
Income from livestock	-0.3848	0.1732
Income from quarry	0.0570	0.7258
Income from road or masonry work	0.6152	0.0011
Income from other means	-0.1243	0.4167
Income from factory	0.1262	0.4246

Dependent variable: Per capita gross income from non NTFPs (Tribal)		
r value	0.4739	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.4732	0.0165
Percent literate	0.0892	0.6287
Family size	-0.2362	0.2109
Land area	-0.1320	0.4871

Pooled

POOLED			
Dependent variables	Independent variables	y/n	Positive /negative
Gross income	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Land area	n	
	Value of consumed agricultural produce	y	p
	Income from agriculture+tree crops	y	p
	Income frm bamboo	y	p
	Income from waged labour	y	p
	Income from livestock	y	p
	Income from NTFPs	y	p
	Income from quarry	y	p
	Income from road or masonrywork	n	
	Income from other means	y	p
	Income from factory	y	p
	Income from forest fruits	y	p

	Income from korai grass	y	p
Per capita gross income	Percent dependent	n	
	Percent literate	n	
	Family size	y	n
	Land area	n	
	Value of consumed agricultural produce	y	p
	Income from agriculture+tree crops	y	p
	Income from waged labour	y	p
	Income from livestock	n	
	Income from quarry	y	p
	Income from road or masonrywork	n	
	Income from other means	y	p
	Income from factory	y	p
	Income from forest fruits	n	
	Income from factory	n	
	Income from forest fruits	n	
	Income from korai grass	n	
Gross income	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Value of livestock	n	
	Land area	n	
	Value of consumed agricultural produce	y	p
	Income from agriculture+tree crops	y	p
	Income frm bamboo	y	p
	Income from waged labour	y	p
	Income from livestock	y	p
	Income from NTFPs	y	p
	Income from quarry	y	p

	Income from road or masonrywork	n	
	Income from other means	y	p
	Income from factory	y	p
	Income from forest fruits	y	p
	Income from korai grass	y	p
Per capita income from NTFPs	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Value of livestock	n	
	Land area	n	
	Value of consumed agricultural produce	n	
	Income from agriculture+tree crops	n	
	Income from waged labour	n	
	Income from livestock	n	
	Income from quarry	n	
	Income from road or masonrywork	n	
	Income from other means	n	
	Income from factory	n	
	Income from forest fruits	y	p
Per capita gross income	Percent dependent	n	
	Percent literate	y	p
	Family size	y	n
	Land area	y	p
Gross income	Percent dependent	n	
	Percent literate	y	p
	Family size	n	
	Land area	y	p
Per capita gross income	Percent dependent	n	
	Percent literate	n	
	Family size	y	n

	Value of livestock	n	
	Land area	n	
	Value of consumed agricultural produce	y	p
	Income from agriculture+tree crops	y	p
	Income frm bamboo	n	
	Income from waged labour	y	p
	Income from livestock	n	
	Income from NTFPs	n	
	Income from quarry	y	p
	Income from road or masonrywork	n	
	Income from other means	y	p
	Income from factory	y	p
	Income from forest fruits	n	
	Income from korai grass	n	
Per capita gross income from non NTFPs	Percent dependent	n	
	Percent literate	y	p
	Family size	y	n
	Value of livestock	y	p
	Land area	y	p
	Income frm bamboo	n	
	Income from NTFPs	n	
	Income from forest fruits	n	
	Income from korai grass	n	
Per capita income from forest fruits	Percent dependent	n	
	Percent literate	n	
	Family size	n	
	Value of livestock	n	
	Land area	n	
	Value of consumed agricultural	n	

	produce		
	Income from agriculture+tree crops	n	
	Income frm bamboo	y	p
	Income from waged labour	n	
	Income from livestock	n	
	Income from NTFPs	n	
	Income from quarry	n	
	Income from road or masonrywork	n	
	Income from other means	n	
	Income from factory	n	
	Income from korai grass	y	p

Dependent variable: Gross income (Pooled)		
r value	0.9999	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0006	0.6536
Percent literate	0.0010	0.4782
Family size	-0.0007	0.6183
Value of livestock	-0.0002	0.9568
Land area	-0.0008	0.6406
Value of consumed agricultural produce	0.4540	0.0000
Income from agriculture +tree crops	0.4019	0.0000

Income from bamboo	0.0319	0.0000
Income from waged labour	0.1960	0.0000
Income from livestock	0.1118	0.0000
Income from NTFPs	0.0080	0.0000
Income from quarry	0.1426	0.0000
Income from road or masonry work	-0.0005	0.7418
Income from other means	0.4276	0.0000
Income from factory	0.1546	0.0000
Income from forest fruits	0.0208	0.0000
Income from korai grass	0.0064	0.0067

Dependent variable: Per capita gross income (Pooled)		
r value	0.9889	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0466	0.0575
Percent literate	0.0070	0.7906
Family size	-0.2122	0.0000
Land area	0.0102	0.7450
Value of consumed agricultural produce	0.2370	0.0352
Income from agriculture +tree crops	0.6564	0.0000
Income from waged labour	0.1057	0.0010
Income from livestock	0.0531	0.3445
Income from quarry	0.1496	0.0000
Income from road or masonry work	0.0206	0.4852
Income from other means	0.3730	0.0000
Income from factory	0.1081	0.0001
Income from forest fruits	-0.0082	0.7215
Income from factory	0.1751	0.0000

Income from forest fruits	0.0093	0.8679
Income from korai grass	0.0312	0.5706

Dependent variable: Per capita income from NTFPs (Pooled)		
r value	0.7280	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0652	0.4356
Percent literate	0.0212	0.8103
Family size	-0.0499	0.5677
Value of livestock	-0.0218	0.9260
Land area	0.0030	0.9764
Value of consumed agricultural produce	0.2803	0.4013
Income from agriculture +tree crops	-0.0588	0.8262
Income from waged labour	0.0578	0.5321
Income from livestock	-0.2293	0.3354
Income from quarry	-0.0160	0.8616
Income from road or masonry work	-0.0304	0.7417
Income from other means	-0.0413	0.6419
Income from factory	-0.0100	0.9069
Income from forest fruits	0.6914	0.0000

Dependent variable: Per capita gross income (Pooled)		
r value	0.6119	
Independent variables	Beta coefficients	P-value
Percent literate	0.2022	0.0228
Family size	-0.2120	0.0172
Land area	0.5288	0.0000

Dependent variable: Gross income (Pooled)		
r value	0.6004	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0748	0.3959
Percent literate	0.2133	0.0177
Family size	0.0327	0.7119
Land area	0.5291	0.0000

Dependent variable: Per capita gross income (Pooled)		
r value	0.9874	
Independent variables	Beta coefficients	P-value
Percent dependent	0.0171	0.4012
Percent literate	0.0091	0.6639
Family size	-0.2157	0.0000
Value of livestock	0.0110	0.8432
Land area	0.0097	0.6915
Value of consumed agricultural produce	0.2983	0.0004
Income from agriculture +tree crops	0.5904	0.0000
Income from bamboo	0.0102	0.6261
Income from waged labour	0.1625	0.0000
Income from livestock	0.0407	0.4717
Income from NTFPs	-0.0020	0.9259
Income from quarry	0.1549	0.0000
Income from road or masonry work	0.0168	0.4483
Income from other means	0.3783	0.0000

Income from factory	0.1072	0.0000
Income from forest fruits	0.0060	0.8617
Income from korai grass	0.0218	0.5186

Dependent variable: Per capita gross income from non NTFPs (Pooled)		
r value	0.8127	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.1024	0.1402
Percent literate	0.1450	0.0350
Family size	-0.2076	0.0026
Value of livestock	0.6369	0.0000
Land area	0.1814	0.0250
Income from bamboo	-0.0308	0.6677
Income from NTFPs	0.0290	0.6733
Income from forest fruits	-0.0567	0.6268
Income from korai grass	0.0747	0.5164

Dependent variable: Per capita income from forest fruits (Pooled)		
r value	0.8395	
Independent variables	Beta coefficients	P-value
Percent dependent	-0.0315	0.6494
Percent literate	0.0575	0.4212
Family size	0.0028	0.9681
Value of livestock	-0.0773	0.6821
Land area	0.0767	0.3551
Value of consumed agricultural	0.2058	0.4490

produce		
Income from agriculture +tree crops	-0.0857	0.6949
Income from bamboo	0.2034	0.0050
Income from waged labour	-0.1045	0.1900
Income from livestock	-0.1351	0.4827
Income from NTFPs	0.1219	0.0963
Income from quarry	0.0086	0.9095
Income from road or masonry work	0.0214	0.7774
Income from other means	-0.0712	0.3202
Income from factory	-0.0529	0.4409
Income from korai grass	0.7319	0.0000

Appendix 3: Factor loadings of various sources of income at Ponnachi

Factor Loadings (Unrotated) (incpoc~1.sta)		
Extraction: Principal components		
(Marked loadings are > .700000)		
	Factor	Factor
	1	2
T44	0.866785	-0.0207
T45	0.880993	0.011484
T46	-0.16789	-0.1622
T47	0.879521	0.017666
T48	0.228373	-0.07388
T49	0.597099	-0.06939
T50	0.597331	0.372687
T51	0.88315	0.01953
T55	-0.10848	0.836048
T56	0.87626	-0.0017
T57	0.534977	-0.0897
T58	0.691167	-0.06872

T59	0.044092	-0.2226
T60	0.630257	-0.0884
T61	0.438812	-0.1167
T62	-0.08147	-0.21763
T63	0.312033	0.826969
T68	-0.08725	-0.10185
T69	0.098986	-0.12772
T79	-0.0902	-0.12102
T80	0.880252	0.007331
T100	0.093415	-0.09327
T102	0.87845	0.091048
T109	0.878552	0.009205
T117	0.84061	-0.02455
T118	0.041707	0.883217
T119	0.602131	-0.04799
T120	0.006736	0.574906
T121	0.703647	-0.09526
T124	0.882225	0.018633
T125	0.816642	-0.01459
N52	0.784238	0.286997
N53	0.062821	-0.11726
N54	0.88312	0.022142
N65	0.030063	0.067589
N67	-0.1299	-0.18287
N70	-0.10894	0.874898
N71	-0.11114	0.880759
N72	0.467623	-0.12234
N73	-0.10549	0.87799
N74	0.882344	0.017038
N75	-0.15033	0.755997
N76	0.827371	-0.04627

N77	0.092287	-0.11619
N78	-0.14042	-0.13395
N81	-0.07222	-0.10999
N82	0.882853	0.024668
N83	-0.07872	-0.0298
N84	0.525912	-0.06546
N85	0.850755	0.003997
N86	0.777614	0.15634
N87	-0.17234	0.735824
N89	-0.14173	0.842439
N90	0.882853	0.024668
N91	0.882853	0.024668
N92	0.882853	0.024668
N93	-0.05237	-0.02247
N94	0.564644	0.398633
N95	-0.14644	0.458236
N96	-0.11826	0.872259
N97	0.875919	0.007114
N98	0.877688	0.017688
N99	0.450816	0.752917
N101	-0.05547	0.867084
N103	-0.17	-0.16019
N104	-0.05817	-0.14539
N105	0.080035	-0.11084
N106	-0.10258	0.087603
N108	0.845988	-0.01414
N110	-0.05854	-0.11543
N111	0.828728	0.241782
N112	-0.10577	0.877155
N113	-0.07663	-0.1583
N114	-0.12431	0.683841

N115	0.868455	0.028415
N116	0.882967	0.01875
N122	-0.10953	0.874085
N123	-0.0282	-0.10272
N126	-0.06504	0.735073
N128	0.882853	0.024668
N129	-0.07102	0.861297
N130	-0.13905	-0.12865
N131	-0.11603	0.881234
N132	0.50068	0.030797
N133	0.666386	-0.07265
N134	-0.05524	0.882549
N135	0.804327	0.013496
N136	0.881457	0.022311
N137	-0.16957	0.498417
Expl.Var	27.55352	14.97064
Prp.Totl	0.30959	0.168209

Eigenvalues (incpoc~1.sta)				
Extraction: Principal components				
		% total	Cumul.	Cumul.
	Eigenval	Variance	Eigenval	%
1	27.55352	30.95901	27.55352	30.95901
2	14.97064	16.82094	42.52416	47.77995

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Role of forest fruits in sustaining livelihoods of forest margin communities – indigenous knowledge of the ethnic groups on the forest with special reference to fruits.

Summary

The study was carried out to assess the traditional knowledge of the communities regarding various ecological aspects at M.M.Hills and B. R. Hills. The two communities (tribals and non-tribals) were assessed for their knowledge regarding forest fruits (mainly *Phyllanthus emblica, Phyllanthus indofischeri and Terminalia chebula*) and forest conditions. The communities differed in their perspective on a few aspects such change in production of non-timber forest product species, spatial location of the trees and the method of harvesting. Besides these aspects, it was observed that *Phyllanthus emblica* was the most common species known by the communities. There exists a difference in their views on promotion of regeneration. The analysis carried out for all the other aspects dealt with did not show much variation between the communities. These were assessed to have a better idea on their understanding of the forest processes, which could later be used for the conservation of these resources.

Introduction

Science–based societies have tended to overuse and simplify complex ecological systems, resulting in a whole series of problems of resources exhaustion and environmental degradation. It is, in this context that the knowledge of indigenous societies accumulated over historical time is of significance. The view of humans as a part of the natural world is of value for evolving sustainable relations with the natural resource base. Not all pre-scientific societies have necessarily lived harmoniously with the natural world and not all-indigenous peoples, outside industrial societies do so today. For example, some nomadic hunter-gatherers who are not tied to any specific resource base and without well-defined territories may gain little from prudent resource use. Self-regulatory mechanisms tend to evolve in societies when they are faced with resource limitation. As several major studies point out, indigenous knowledge or traditional ecological knowledge is of significance from a conservation perspective and an attribute of societies with continuity in resource use practices (1)

Indigenous knowledge is herein defined as a cumulative body of knowledge and beliefs handed down through generations by cultural transmissions about the relationship of living beings (including humans) with one another and with their environment.

Biological resource conservation is necessary to ensure human survival and well - being. The local / indigenous communities had knowledge systems and a culture that conserved life forms and the physical environment. Such knowledge systems and culture have become eroded due to external influences. There still exists as a rich, latent pool of indigenous knowledge within local communities, which can be tapped for the recovery of ecosystems. Though indigenous knowledge has great potential for such a recovery, it

should be augmented with modern conservation management techniques. This is necessary because the scale of present day human activities and its effect on ecosystems is different when compared with the time of development of these indigenous knowledge systems. It is thus obvious that biological resources of the village community can be managed successfully, only if the local people develop appropriate ecological management systems themselves. (2)

Judicious harvesting and processing of NTFPs can enhance rural incomes and can contribute to gross national product without degrading forests. Moreover, local communities can be involved in conservation because of the economic stake they are likely to have in preserving the resource base. (3)

The objectives of the study are to assess the indigenous knowledge of the people regarding the ecological aspects of forest fruits mainly *Phyllanthus emblica, Phyllanthus indofischeri and Terminalia chebula*, and the changes in the general forest conditions. The issues discussed are the spatial distribution of trees, method of harvesting, changes in the fruit productivity, regeneration, influence of the parasites on the trees, pollination and dispersal, effect of weeds on regeneration and the forest conditions. This was done to observe whether there was a variation in the traditional knowledge of the ethnic groups (tribals and non-tribals) in the study area. Further, this study seeks to address the following issues:

a. Whether there is a difference in the ecological knowledge of people working within a self governed management mode (such as the LAMP society in B. R. Hills) and those working on a commercial basis (such as the sale of forest fruits via a contractor in MM Hills).

b. Whether there is a change in ecological knowledge as one moves from the core of the forested area to the periphery, the assumption being that the people of the periphery are more prone to outside influences.

c. Whether there is a difference in the ecological knowledge between two ethnic groups, i.e. the tribals, who are known to depend more on forest benefits, and the non- tribals (Lingayats).

Study Area

Malé Mahadeshwara Reserve Forests is located between 11°55 to 12°15 north and 77°45 to 77°25 east from east in Kollegal taluk of Chamarajangar district of Karnataka state. The area enjoys a mild, equable climate throughout the year but in recent years the temperature has risen. Deforestation and reduction of the forest, quality wise, may be the reason for the gradual warming. It receives rainfall from Northeast monsoon as well as southwest monsoons. The bulk of the rain is derived from the Northeast monsoon and falls during September and October. The driest months are January–March. The total area of M.M. Hills is 434.80 sq. km. The forest type comprises of Scrub, Dry deciduous, Moist deciduous and Evergreen. Three villages, namely Asthur, Marur and Ponnachi, were selected in the Ponnachi cluster, which has dry deciduous, bamboo and shola forests (altitude of 1514 M).

Biligiri Rangaswamy Temple Wildlife Sanctuary (BRTWLS) (77^0-$77^0$16'E and $11^0$47'-$12^0$9'N) gets the name "Biligiri" from the white cliff on which the temple of Lord Rangaswamy is situated. The sanctuary is located to the east (rain shadow) of the Western Ghats in Karnataka State. It was declared as a Wildlife Sanctuary in 1987 and covers an area of about 540 km^2. Altitude ranges from 600 to 1800 m above msl. Temperature ranges from 10^0 to 25^0 c and rainfall is around 600 mm at the base and 3000 mm at hilltop per year. This wide range of climatic conditions along with the altitudinal variations within the small area of the sanctuary have translated it into a highly heterogeneous forest of various vegetation types – scrub, deciduous, riparian, evergreen, sholas and grasslands. The BRT WLS is inhabited by indigenous

people called Soligas. These tribes were hunter-gatherers and used to practice shifting-cultivation. Although the area was declared as a wildlife sanctuary in 1976, collection of non timber forest products is still carried out. 21 villages (see appendix) were chosen from the BR Hills area, out of which 12 were considered as core and 9 as periphery (Fig x).

Both tribal and the non-tribals occupy these villages. The tribal population in MM Hills is concentrated in 15 tribal settlements situated inside these villages of which 13 are at Ponnachi. Ponnachi cluster has the maximum population of both the tribal and non-tribal. The non-tribals constitute the major population in the study area. In BR Hills there are only one tribal group, the Soligas.

Methodology

The study to assess the ecological knowledge of the people in the study area was carried out between September and December 2000 in MM Hills and between April and June 2001 in BR Hills. This study was conducted in three villages of Ponnachi cluster with a sample of 90 households (59-Non tribal; 31- Tribal) and 21 villages of BR Hills with a sample of 52 households (25-Core, 27-Periphery). A questionnaire survey was conducted to assess the traditional knowledge of the people that included aspects relating to phenology, production and area of collection, pollination and regeneration of *Phyllanthus emblica*, *Phyllanthus indofischeri* and *Terminalia chebula*. Questions relating to forest changes were also included. The specific questions in each and the possible responses have been listed in Appendix 1.

Results

Ecological Knowledge of the people of Ponnachi

The percentage of collectors is greater among the tribals when compared to the non-tribals. Therefore, the two communities differ in their dependency on the forest. The nontribals are not as dependent as the tribals on income generated from the harvesting of non timbr forest products. However, the non-tribals are more aware of the need to promote regeneration when compared to the tribals.

With respect to specific questions regarding the ecological knowledge of the four NTFP species, there were very little difference in the responses of the tribals and the non tribals. However, as most of the tribals are collectors in Ponnachi, differences arose in harvest method, extent of harvest and quality importance. The most dominant form of collection involved either beating or breaking branches. Tribals also claimed to collect all or most of the fruit yield in a tree, which is expected considering that they are more dependent on the harvest of these fruits.

A substantial number of people of both tribals as well as non tribals did not attach any importance to the quality of the fruit collected, preferring rather to collect fruits based on the contractor. There was also a decided preference against collecting diseased fruits presumably because the contractor would reject the sample. The responses described above are fairly typical for all NTFP species with the exception of *Acacia concinna*, which is harvested only sparingly as the species is very less in number and is found at a considerable distance from the settlements.

Ecological Knowledge of the people of BR Hills

At BR Hills, there is a substantial dependence on the forest by the tribals for their livelihood. The people residing towards the centre of the sanctuary have a better awareness regarding the pollinators. There is no significant difference in the responses regarding the two species *Phyllanthus emblica* and *Phyllanthus indofischeri.* Irrespective of the location of the settler, all of them are dependent on the forests for their livelihood as these two species are distributed throughout the forest. *Terminalia chebula* is lesser abundant when in comparison with *Phyllanthus spp.* Hence, the dependence on the same is lesser when compared to the *Phyllanthus spp.* Most of the tribals from the periphery of the sanctuary are not dependent on *Acacia concinna.* Hence the people from the periphery are less aware about the same species. This could be due to the distribution of the species towards the core of the sanctuary, as the species prefers sholas and similar habitat conditions. All the sholas are found in the core of the sanctuary.

There is a difference in the response regarding the productivity as measured by the number of fruits during the current year (all four species) in the two areas ie, core and periphery; productivity is low towards the core while there are varied responses towards the outside of the sanctuary. Most are aware that they should not harvest all the fruits from the tree, as some need to be left behind for regeneration and the animals.

Ecological Knowledge of the people of MM Hills compared with those of BR Hills

When the responses of the two settlements are considered we see that there is a significant difference in the responses given by the two populations in every aspect. The people of BRT take measures towards regeneration unlike

the people of MM Hills. At BR Hills, all are forest dependent, while the people of MM Hills are not as dependent. There is a varied response regarding the forest changes in the two areas and some responses are specific to the particular settlement, probably because of the difference in the forest type. The people of BR Hills are more aware regarding the habitat preferences of the four species and the effects of the parasitic plant parasite, *Loranthus*. There is a significant difference in the method of harvesting these fruits. The people of MM Hills are less dependent on *Terminalia chebula* and *Acacia concinna* because of the sparse distribution of the two in this region. Hence their knowledge regarding these species is less.

Discussion

Between two market regimes

Though there is a significant difference in the responses of the tribals working in the self governed management mode (such as the LAMP society in B. R. Hills) and those working on a commercial basis (such as the sale of forest fruits via a contractor in MM Hills), it is difficult to attribute this difference solely to the marketing strategies of the two areas. BR Hills is also subject to a variety of educational extension programmes run by VGKK, SAS and ATREE along with the Karnataka forest department. These programmes serve to enhance the traditional knowledge of the tribals with respect to forest and forest functions. Therefore, it is possible that the tribals of BR Hills are generally more aware than their MM Hills counterparts where such programmes are nonexistent. To add to this, the management regime in BR Hills is more conducive towards sustainable harvest of the NTFPs as the collectors are locally resident and have a stake in the eventual profits. In contrast, collectors in MM Hills may be resident or may be brought in by the

contractor from outside. These collectors may be considered to have little or no stake in the long-term viability of the forest fruit population. The further difference is that while all the people interviewed are collectors in BR Hills, the proportion of non-collectors to collectors is greater in MM Hills. This could represent a gradual shift away from forest dependency among the people of MM Hills, further suggesting that the collectors may not retain their traditional knowledge regarding the NTFP species. With such an erosion in knowledge, it is expected that there is a corresponding increase in the stress placed on the NTFP populations.

Between two locations

People residing on the outskirts of BR Hills can be considered to be more prone to influences than those living within the sanctuary. The sampling strategy was designed to test this hypothesis. However, our data shows that, overall, there is no difference in the responses of the two locations with significant exceptions such as pollination and productivity. People living at the core claimed that productivity was high whereas people at the periphery claimed that it was low for all NTFP species, as a whole. This difference can be attributed to the type of spatial distribution of the species themselves, rather than on the location per se. For example, knowledge about Acacia concinna and its distribution was much higher in the core areas as opposed to the periphery, merely because Acacia is found mainly in the sholas that occur near the core of the sanctuary.

Between two ethnic groups

In MM Hills, in the Ponnachi settlement, we compared the ecological knowledge between tribals and non-tribals. While most of the tribals are collectors, very few non tribal collect NTFPs, of which the majority is forest fruits. As the dependence on the forest decreases, one would expect the ecological knowledge to decrease as well. But this is not the case in Ponnachi.

Despite the fact that non tribals are by and large non collectors, there more aware of the need to promote regeneration. The differences were mainly in harvest methods and strategies, knowledge of which would have diminished in the non tribals.

Tables and graphs are in the appendix.

Patterns of distribution and productivity of forest fruits at Ponnachi settlement, MM Hills reserve forest.

Summary

Harvesting of non-timber forest products (NTFP) is an important source of income for many communities that live in or around forested areas. While, in the past, these products (mostly forest fruits) were harvested on a subsistence level, of late, with increase in access to markets, forest dwelling communities get a substantial monetary benefit from the sale of these products. In this paper, we assess the patterns of distribution and productivity of selected forest fruits: *Phyllanthus emblica, Phyllanthus indofischeri and Terminalia chebula.* The study was carried out in the Ponnachi settlement of the MM Hills reserve forest, Karnataka. The questions we address are as follows:

Can the populations of these forest fruit species sustain, given the rate of extraction in the area?

What are the factors that influence the spatial distribution of these species?

We discuss these results with emphasis on the role of forest fruits in the livelihoods of the dependent community and in the context of long term use of these resources.

Introduction

Fruits are one of the major non-timber forest products on which the forest dwellers depend. Non timber forest products (NTFPs) are receiving increasing attention from the scientific community for two main reasons: 1. It is hoped first that the promotion of extraction and trade of NTFPs will improve the livelihood of low-income farmers. 2. The measurable economic value of NTFPs will constitute an important reason for preserving forests from destructive uses or conversion to other land uses. Extraction of NTFPs offers considerable potential in the conservation of tropical forests. Judicious harvesting and processing of NTFPs can enhance rural incomes and can contribute to gross national product without degrading forests. Moreover, local communities can be involved in conservation because of the economic stake they are likely to have in preserving the resource base. At the same time a substantial amount of biodiversity can be conserved in these forests. However, the over-harvesting of NTFPs can have a negative impact on conservation of biodiversity. There are few studies that document the impact of NTFP extraction on forest structure and composition; such studies are required to advance the knowledge of socio-biological mechanisms operating in NTFP extraction systems and to design and develop appropriate extraction systems.

The response of the forest vegetation to anthropogenic pressures may depend upon the intrinsic features of its flora. In particular, the reproductive features and regeneration potential of the constituent species might strongly influence their response to human induced pressures such as harvesting fire and grazing. Forest impacted by human disturbances tends to have a thinner canopy and relatively drier environment. Parasites play an important role in shaping the dynamics of both plant and animal communities.

Phyllanthus indofischeri and *Phyllanthus emblica*, commonly called *Amla or Nelli* is abundant in deciduous forest, and forms one of the major NTFP fruit species. The species can be differentiated based on the leaf size, flowers and on the fruit size. In India, the distribution of *Phyllanthus emblica* ranges from sea level to an altitude of 5,000-ft (1,800-m) while *P. indofischeri* trees are found at lower altitudes. However, is a slight variation in their habitats and other characteristics. The trees are medium sized, and are wide spread in scrub and dry deciduous forests throughout India. *Terminalia chebula* commonly called Gallnut also forms a major NTFP fruit species. The flowering starts during March and continues to the end of April. Fruiting starts immediately after the flowering season. They have a patchy distribution.

The objectives of the present study are to examine the ecological sustainability of the resource that contribute to the livelihood of the people by assessing:

1. The resource status of a few important forest fruit tree species (*Phyllanthus emblica, P.indofischeri* and *Terminalia chebula*) at Malé Mahadeshwara Reserve Forest.
2. The change in resource status of the trees with respect to intrinsic (age) and extrinsic (parasitic infestation, damages caused to the tree on extraction and spatial distribution) factors.
3. The regeneration of the tree species as affected by human disturbance.

Study Area

Malé Mahadeshwara Reserve Forests is located between 11°55 to 12°15 north and 77°45 to 77°25 east from east in Kollegal Taluk of Chamarajangar

district of Karnataka state. The area enjoys a mild, equable climate throughout the year but in recent years the temperature has risen. Deforestation and reduction of the forest, quality wise, may be the reason for the gradual warming. It receives rainfall from northeast monsoon as well as the southwest monsoon. The bulk of the rain is derived from the Northeast monsoon and falls during September and October. The driest months are January–March. The total area of M.M. Hills is 434.80 sq. km. Ponnachi, a settlement (Area: 12.49 sq km) which is located at the periphery of the MM Hills reserve forest has been considered for this study. The vegetation type at Ponnachi is mainly dry deciduous forest, interspersed with bamboo stands (*Bambusa arundinacea* and *Calamus strictus*). Ponnachi also has two small shola patches at an altitude of 1514m.

Methodology

The study was conducted during November 2000 to April 2001.

Distribution: Ten transects of six quadrats each (50 x 20m for trees, 10 x 10 m for shrubs, 1 x 1 m for herbs) were laid in a radiating manner from the settlement. The quadrats were separated by an interval of 200m. The parameters observed were: DBH, height, abundance, altitude, GPS location, distance from the settlement, number of parasites and number of cut branches. In addition to this diversity parameters such as Shannon diversity, species richness and abundance were computed for all species occurring within the transects. These were analysed with relation to the altitude at which they were occurring, and the distance from the settlement. Size class distribution of *P. emblica* and *P. indofischeri* with respect to increasing distance from the settlement was also computed

Productivity: We selected trees of *P. emblica* (N=81)and *P. indofischeri* (N=54)in a randomly stratified manner, in four directions leading away from the settlement. The following parameters were observed: DBH (in cm), height

of the tree, altitude, number of parasite infestations, number of cut branches and number of fruits.

Results

Distribution

Relative Density

Overall, the three NTFP species under consideration were found in greater densities at a distance of 400-1000m away from the settlement. This is probably because of lesser levels of disturbance in terms of cut stems, harvesting, fodder and fuelwood collection etc., as one moves away from the settlement. Among the three species, *P. emblica* was found to be higher in the 500-800m range, *P. indofischeri* in the 400-1000m range and *Terminalia chebula* in the 400-1000m range. However, the densities of all three species were much lower than those in Kombudikki (see Table1). This reflects on the lesser ecological status of the NTFP species in the Ponnachi area

Table 1: Density of NTFP trees around two settlements (number of trees/6 ha)

Species	Kombudikki (no. of trees)	Ponnachi (no. of trees)
Phyllanthus emblica	220	47
Phyllanthus indofischeri	230	5
Terminalia chebula	329	32
Acacia concinna	97	0

Size Class distribution of P. emblica and T. chebula (Fig 2 & 3)

P. emblica and T. chebula were classified into DBH size classes and plotted with respect to increasing distance from the settlement. As the number of *P. indofischeri* was very low (n=5), such a classification was not attempted. In both the species, there was very little representation in the seedling and sapling stage. At mid distances (400-800m), there was a higher representation among the size categories. Maximum number of trees fell into the 15-30 cm size class category. This shows that the population is in the recovery phase, i.e. there are fewer young and old individuals compared to the middle age group. All categories are not represented at any distance level, indicating that the population of these NTFPs is/was highly stressed.

Diversity Parameters with respect to altitude and distance from the settlement (Fig 4&5)

Diversity parameters were estimated for all quadrats. The dominant trend in the data is that with increase in distance and altitude, there is an overall increase in species diversity for trees. However, there is a drop in diversity at mid distance and altitude. For shrubs, there is a steady increase in diversity along the distance-altitude gradient. The same pattern is seen for species richness of both types as well.

Ecological status (trees) Fig. 4

Age: Age, as measured by basal area, was plotted against the altitude distance gradient. A few older trees were found to be in higher altitudes and distances, but the majority was of a similar age and located at mid altitudes, but all along the distance gradient.

Disturbance: Disturbance was measured by the sum of the number of cut stems in a quadrat. This was highest in areas close to the settlement and decreased as one moved away from the settlement. Trees in high altitudes did not have many cut stems.

Productivity

Phyllanthus emblica

Size class distribution (Fig. 6 and 7): As in the distribution data set, trees were maximum (35%) in the size class of 10-15 cm DBH. However, the number of trees in the young stage was fewer, indicating the lack of good regeneration among the population. There was no obvious relation between the size class and the number of fruits produced, but maximum fruits were produced this year by trees with basal area range between 0.02-0.04m, indicating that the intermediate size class is the most active reproductively.

Altitude (Fig 8,9): Most (41%) of the *P. emblica* trees fall within the altitude range of 1200-1300m. This can be explained either as a preference of the species for areas of higher altitudes or by the fact that most higher altitude areas in Ponnachi are at considerable distance from the settlement. Disturbance decreases along this gradient and hence may account for the relatively larger numbers of *P. emblica*. With respect to productivity, trees at mid altitudes produced more fruits than trees at either low or high altitudes.

Effect of parasites (Fig 10): There seems to be decided impact of parasites on the number of fruits produced by a tree. Individuals with high number of parasites (~10 and above) were found to produce no fruits. Conversely, trees with few or no parasites were found to have a higher fruit number. A similar pattern was found in Kombudikki as well.

Effect of disturbance (Fig 11): Disturbance, as measured by the number of cut branches also plays a role in the fruit number, individuals exhibiting a large number of cut branches (>5 weighted average between primary, secondary and tertiary stems) did not produce any fruits this year.

Phyllanthus indofischeri

Size class distribution (Fig 12,13*): P. indofischeri* also showed a similar pattern with respect to *P. emblica*. There were no individuals in the smallest size class, suggesting a lack of regeneration potential, and the maximum trees (40%) were in the 10-15 cm DBH range. Old trees were comparatively fewer as well. With respect to productivity, basal area was plotted with number of fruits produced. Older trees produced more fruits (R^2=0.2516, p<0.00016), suggesting that the input into the next generation is predominantly contributed by this age class.

Altitude (Fig 14, 15): Most (40%) of the trees fall within the 1000-1200 m altitude range, suggesting that either this species prefers mid altitude ranges or it flourishes in areas of intermediate disturbance.

Effect of parasites : *P. indofischeri* is not preferred by *the Loranthus* parasite. Only one individual in the data set was affected by parasites. Therefore, stress due to parasite attack is not of any significance to the productivity of the species.

Effect of disturbance (Fig 16): The number of fruits produced shows a negative trend with respect to (weighted average of) number of cut stems. The stress posed by physical damage seems to affect the productivity of *P. indofischeri*.

Comparison between P. emblica and P. indofischeri

Parasites (Fig 17):There is a distinct difference in the relative number of trees attacked by parasites. There is a distinct preference of *Loranthus* for *P. emblica*. Among the fruiting trees, 42% of *P. emblica* trees were infected as opposed to 3% of *P. indofischeri* trees.

Disturbance (Fig 18): There was no difference between the two species with respect to the number of cut stems. This indicates that there is almost equal weightage given to both species with respect to harvesting of fruits. However, among the non-fruiting trees, *P. emblica* seems to be the more preferred (87%).

Discussion points

In the absence of actual extraction values determined from the harvesters, the impact of collection on NTFPs can only be inferred. Our data shows that:

a. The populations of *P. emblica and P. indofischeri* are not uniformly distributed across all size classes, and furthermore, there is a lack of individuals in the smallest size class and the regeneration is low. Density is also low, in comparison to the data from Kombudikki. Though the species are similarly harvested, there is a preference for *P. emblica* in terms of fuelwood and fodder requirements.
b. Disturbance is known to decrease with distance from the settlement, as is shown by the number of cut stems.
c. There seems to be highest ecological activity in regions of mid distance and mid altitude, indicating that there is definitely a stress on the populations of NTFPs in and around the Ponnachi settlement.

Reproductive strategy studies in *Phyllanthus emblica*

1. Do past reproductive effort influence the extent of current reproductive investments : a case study using *Phyllanthus emblica*

In plants as in animals, the current reproductive investments (such as into flower, fruits) has been reported to be influenced by the past reproductive effort of the plant. Thus if the past reproductive effort has been substantial in terms of reproductive output, the investments into the reproduction the following season is subdued. This is argued to be true for most perennials and in fact has led to the identification of *alternate bearing* behaviour. We investigated the possibility of alternate bearing behaviour in *Phyllanthus emblica*.

Experiment 1: Relation between per cent flowering branches and total flower number per tree (in time t+1) and number of fruits per tree (in time t).

We examined the relation between the past reproductive output (time = 2000) with the current reproductive investments (time = 2001). We hypothesise that if the past reproductive output constitute a resource drain on the plant, the present reproductive investments should be negatively affected. In other words, with increase in past reproductive output (in form of fruit number per tree) there should be a decrease in the per cent flowering branches. We tested this hypothesis by following the fruit number produced per tree during 2000 and the per cent flowering branches during 2001 for a set of trees permanently labelled at Kombudikki at MM Hills.

The data indicated that there is an overall negative relation between the fruit number and per cent flowering branches (Fig 1) , though in most of the cases the R^2 was quite low (Table 1). A similar pattern was evident for the

relation between the total flower number per tree and the fruit number (Fig 2 and Table 2). These results show that though not unequivocally, the past reproductive effort may reduce the current reproductive investment in *Phyllanthus emblica*.

Experiment 2 : Monitoring of the productivity of selected trees of Phyllanthus emblica from 1999-2000.

We monitored the total productivity of N= 69 trees starting 1999 at Kombudikki site at MM Hills. The total fruit number was counted for the marked trees and the productivity at 2000 was regressed on the productivity at 1999. But for a few outliers there seem to be negative relation between the productivity between the two time periods (Fig 3). The average number of fruits per tree decreased from about 60 during 1999 to about 20 during 2000, perhaps indicating the alternate bearing of the trees. We also computed the per cent of fruiting and non-fruiting trees during 1999 and 2000. In 1999 nearly 50 per cent of the trees did not fruit as opposed to about 60 per cent in 2000.

For the season 2000 – 2001, we followed fruiting and non-fruiting trees for their flowering behaviour. Our results showed that among trees that fruited during 2000, a relatively less per cent of them flowered during 2001 compared to trees that did not fruit during 2000 (Fig 4). However a chi-square analysis indicated there was no significant disassociation between the fruiting in one season and non-fruiting in the other. A large fraction of the trees did not fruit in either season (χ^2= 1.38,p<0.2405).

The data presented from the above studies indicate that the reproductive investments in the current season may be defined by the reproductive effort already spent. In a way this conforms the alternate bearing of the trees that have been earlier reported for other perennial tree species. Indeed the data is also supported from the observation of the quantity of fruits extracted over a ten-year period, which indicated a periodicity of about two years (Fig 5).

Table 1 Regression Summary for Dependent Variable: FLOWER Number

R= .37752090 R^2= .14252203 Adjusted R^2= .09691150

F(5,94)=3.1248 p<.01182 Std.Error of estimate: 1215E2

	BETA	St. Err. of BETA	B	St. Err. of B	t(94)	p-level
Intercpt			-27653.3	145519.3	-0.19003	0.849694
TBA	**0.218481**	**0.100187**	**1669459**	**765547.2**	**2.180739**	**0.031699**
ALT	0.037288	0.103275	45.09664	124.9016	0.361057	0.718867
PARASITE	-0.18422	0.100781	-8298.9	4540.013	-1.82795	0.07073
CUT	-0.07208	0.100818	-1225.92	1714.605	-0.71499	0.476389
FRUITS	**0.293096**	**0.098492**	**545.5238**	**183.3178**	**2.975836**	**0.003714**

Table 2 Regression Summary for Dependent Variable: Male Female Ratio

R= .15326469 R^2= .02349006 Adjusted R^2= -----

F(5,94)=.45224 p<.81069 Std.Error of estimate: 44.273

	BETA	St. Err. of BETA	B	St. Err. of B	t(94)	p-level
Intercpt			42.8195	53.00654	0.807815	0.421236
TBA	0.096141	0.106915	250.7576	278.8566	0.899235	0.370825
ALT	-0.05608	0.11021	-0.02315	0.045496	-0.50888	0.612032

PARASITE	-0.07946	0.107548	-1.22186	1.653735	-0.73885	0.46184
CUT	-0.05971	0.107588	-0.34663	0.624558	-0.555	0.580215
FRUITS	0.063722	0.105106	0.040484	0.066775	0.606268	0.545798

2. Floral sex ratio in *Phyllanthus emblica* : Does floral sex ratio respond to changes in the resource status of the plant ?

The evolution of floral sex ratio or the allocation of resources to the sexes has been argued to be guided by the relative fitness the sexes accrue to the plant under a given set of circumstances (Charnov, E. 1982. *The theory of sex allocation. Princeton Univ. Press, Princeton*). According to the theory, plants will be selected to allocate more of their resources to females under resource good conditions (as reflected by the age or size of the plant) and to males under resource poor conditions (as under stressful environments). We examined the lability of the sex ratio of *Phyllanthus emblica* as a function of the altitude the trees were found, the basal area of the trees, the extent of epiphytic (parasite load) and the extent of cut and broken stems on the plant.

We recorded the male to female flower ratio for a set of N= 57 trees in Komudikki during 2001. For the respective trees, we recorded the altitude at which the tree is located, the girth of the trees, number of epiphytes and the number of cut and broken stems.

The sex ratio of the trees during the peak flowering period across the altitude seem to be highest (ie in favour of males) at mid altitudes and more female biased at lower and higher altitudes. At a later time period nearing the end of flowering period, the sex ratio across the altitudes was distinctly less male biased. That is at any given range of altitude, the sex ratio at advanced stage

of flowering was less male biased (Fig 6) . The observed results could emerge due to a) the early onset of males and their subsequent sensence earlier than females, b) late onset of females and their retention for a longer period of time. In any case it appears that functionally at the later stages of the flowering period the sex ratio is distinctly less male biased.

The sex ratio was positively correlated with the basal area of the trees (Fig 7). That is there seems to be an increase in maleness as the basal area of the trees increased. The male to female ratio of the trees was negatively related to the total number of stems cut in the plant (Fig 8). The number of parasites did not alter the sex ratio in any predictable manner (Fig 9). These results seem to contradict the generally predicted behaviour in shift in the sex ratio. Both the increase in basal area and the decrease in the cut and broken stems could be expected to enrich the resource status of the plant and hence lead to more female biased or less male biased sex ratio. However in these results, we obtained a more male biased sex ratio with increase in basal area and decrease in the cut and broken stems. It is likely that disagreement in the former case may be due to autocorrelation that need to be teased out. However conforming to the results obtained with respect to the cut and broken stem, Freeman et al (1980, cf Charnov, 1982) reported that in 8 species there was a shift from male to femaleness upon experiencing a trauma such as removal of leaves, flowers or crown pruning. It is likely that these are adaptive shifts, aimed at converting the available biomass that faces imminent risk of loss in to female flowers and fruits.

We conducted a multiple regression analysis to examine the possible factors that explain the sex ratio of trees of Phyllanthus. The result is summarised below in Table 3. The regression failed to explain sufficiently the observed variation in the sex ratio. However, from the beta-coefficients, it is suggested

that the sex ratio declines with parasite load and the cut stems while increasing with basal area of the trees.

Table 3: Regression Summary for Dependent Variable: MFR

R= .15326469 R^2= .02349006 Adjusted R^2= -----

F(5,94)=.45224 p<.81069 Std.Error of estimate: 44.273

	BETA	St. Err. of BETA	B	St. Err. of B	T (94)	p-level
Intercept			42.8195	53.00654	0.807815	0.421236
Total Basal Area	0.096141	0.106915	250.7576	278.8566	0.899235	0.370825
Altitude	-0.05608	0.11021	-0.02315	0.045496	-0.50888	0.612032
Parasite Load	-0.07946	0.107548	-1.22186	1.653735	-0.73885	0.46184
No. of Cut branches	-0.05971	0.107588	-0.34663	0.624558	-0.555	0.580215

3. Patterns of fruit removal in *Phyllanthus emblica* : implications for seedling fitness

The patterns of fruit removal (or disperal) has important implications for the upward cascade of events that determine the ultimate reproductive success of a tree. Too early an removal for instance could jeopardise the seed germination and fitness for want of favourable conditions for establishment. On the other hand too late a removal may cost the plants in being pre-empted from germination and establishment by conspecific competition. We analysed the fruit removal patterns in *Phyllanthus emblica* and addressed the consequences on the phenology and the reproductive success of the plants.

Experiment 1: Pattern of fruit removal from trees harvested and non-harvested.

We examined the pattern of fruit removal from selected trees of *Phyllanthus emblica* at Kombudikki from November 2000 to April 2001 at frequent intervals. The first observation was taken on 17.11.00 much before the fruits were harvested by the local communities. Thereafter, the data was categorised into trees that were harvested and those that were not harvested. The pattern of fruit removal for the two groups is shown in Fig 10. In the first 40 days of the observation, nearly 80 per cent of the fruits were removed from trees that were harvested (this data reflects the extent of harvesting) compared to about 30 per cent removal in trees that were not harvested (the removal of fruits in these trees could have been affected by a few animal dispersal agents such as primates and also may be due to the maturation of the fruits. In the non-harvested trees there was a nearly monotonic increase in the removal of fruits with all fruits being removed by about 120 days.

The phenology of the trees with respect to fruiting, flowering and formation of incipient fruits was followed from November 2000 to April 2001 (Fig 11). The per cent of the trees with fruits declines gradually from November (75 per cent of the trees are in fruiting) to mid-March (10 per cent of the trees are in fruiting). The flowering episode commences from early February to mid-March with the peak number of trees in flower during mid-February to mid-March 2001. The incipient fruits start developing from mid-March to April 2001. Thus there seems to be very little overlap between the fruiting, flowering and fruit set among the trees. There was no significant change in the phenology of the various features between the trees that were harvested (rapid removal of fruits) compared to those not harvested (gradual removal of fruits).

In an attempt to address the implication of the differences in the temporal patterns of fruit removal on the reproductive success we examined several parameters such as average number of seeds per fruit, average fresh weight

of fruits (g), per cent seed predation and infected by fungus, per cent aborted seeds, average seed weight (mg), and per cent germination of seeds at periodical intervals from fruits obtained from selected trees (n= 15 trees) at Kombudikki.

The average number of seeds per fruit and the average seed weight did not differ with time of fruit collection (Fig 12 and 13). The average fresh weight of fruits decreased significantly with increase in time to which fruits were retained on the tree indicating that there is a considerable amount of drying of fruits on the tree (Fig 14). The per cent seed predation (as evident from emergence hole on seeds) and the infection of seeds by fungus was very high in seeds obtained from fruits that were harvested early on compared to those from fruits collected at a later stage from the trees (Fig 15). The significantly higher predation and infection rate in the early stage could be facilitated by a higher moisture content of fruits (see Fig 14). The per cent seeds aborted (as evident from the malformed and sclerotised seeds) did not vary with time of collection (Fig 16). Finally the per cent germination of seeds was estimated across the time of collection. While the overall per cent germination was considerably low (the maximum obtained was about 5 per cent), there was clear increase in the per cent germination of seeds with time (Fig 17).