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Economic & Environmental Impact Assessment of Biodiversity on and around Farms

B V C Reddy, K N Ganeshaiah, Lalith Achoth and C P Gracy

University of Agricultural Sciences, Bangalore

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RESEARCH PROJECT REPORT

ECONOMIC AND ENVIRONMENTAL IMPACT ASSESSMENT OF BIODIVERSITY ON AND AROUND FARMS

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TECHNICAL ASSISTANCE PROJECT

PRINCIPAL INVESTIGATOR : Dr. B. V. CHINNAPPA REDDY

CO - PRINCIPAL INVESTIGATORS : Dr. K. N. GANESHAIAH
Dr. LALITH ACHOTH
Dr. C. P. GRACY

RESEARCH ASSOCIATE : Dr. M. R. GIRISH

JUNIOR RESEARCH FELLOWS : Miss. G. INDIRANI
Mr. SREENIVAS. B. T.

UNIVERSITY OF AGRICULTURAL SCIENCES
GKVK, BANGALORE – 560 065

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Principal Investigator : **Dr. B. V. CHINNAPPA REDDY**
Associate Professor,
Department of Agricultural Economics,
UAS, GKVK, Bangalore - 560 065

Co- Principal Investigators : **Dr. K. N. GANESHAIAH**
Professor,
Department of Genetics and Plant Breeding,
UAS, GKVK, Bangalore - 560 065

Dr. LALITH ACHOTH
Associate Professor,
Department of Dairy Economics and Business Management,
UAS, GKVK, Bangalore - 560 024

Dr. C. P. GRACY
Associate Professor,
Department of Agricultural Economics,
College of Horticulture, UAS,
Mudigere, Chickmagalore District

Research Team : **Dr. M. R. GIRISH**, *Research Associate*

Miss. G. INDIRANI, *Junior Research Fellow*
Mr. SREENIVAS. B. T., *Junior Research Fellow*

UNIVERSITY OF AGRICULTURAL SCIENCES
GKVK, BANGALORE – 560 065
2001

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B. V. Chinnappa Reddy

K. N. Ganeshaiah

Lalith Achoth

C. P. Gracy

M.R. Girish

G. Indirani

Sreenivas. B.T.

CONTENTS

Sl. No.	Chapter	Page No.
I	Executive Summary	I
1.	Introduction	1
2.	Objectives	7
3.	Methodology	9
4.	Data Analysis	18
5.	Results	42
6.	Discussion	97
7.	Recommendations	139
8.	References	142
9.	Appendices	146

LIST OF TABLES

Sl. No.	TITLE	Page No.
1.	Classification of study area into different zones based on degree of biodiversity on and around farms	11
2.	Details of the sample households	17
3.	An outline of Social Accounting Matrix framework	32
4.	Accounting relationships of SAM	35
5.	Socio-economic characteristics of sample respondents in different zones	43
6.	Livestock details of sample respondents in different zones	44
7.	Land type in different zones	45
8.	Cropping pattern in different zones	45
9.	Average yields of major crops in different zones	46
10.	Indicators of sustainability of farming systems	47
11.	Indicators of resilience of farming systems	49
12.	Collection pattern of selected NTFPs for the period 1995-2000	51
13.	Programmes for promoting sustainable extraction of NTFPs	52
14.	Composition of economic value of benefits from biodiversity around farms	54
15.	Benefits and associated costs from various activities	58
16.	Total Economic Value of benefits from different sources	58
17.	Per cent changes in source-wise share of household income	60
18.	Flow of environmental services	60

19.	Willingness To Pay for chemical-free products	61
20.	Willingness To Pay for chemical-free products according to income groups	62
21.	Common ailments and number of species used as medicines in zones 1 and 2	63
22.	Results of semi-log regression analysis for Travel Cost Method	65
23.	Willingness To Pay (WTP) for maintenance of recreation site	66
24.	Supplementary benefits from BDOAF	67
25.	Social accounting matrix for zone-1	69
26.	Production multiplier matrix for zone-1	70
27.	Household income multiplier matrix for zone-1	71
28.	Social accounting matrix for zone-2	72
29.	Production multiplier matrix for zone-2	74
30.	Household income multiplier matrix for zone-2	74
31.	Social accounting matrix for zone-3	76
32.	Production multiplier matrix for zone-3	78
33.	Household income multiplier matrix for zone-3	78
34.	Social accounting matrix for zone-4	80
35.	Production multiplier matrix for zone-4	82
36.	Household income multiplier matrix for zone-4	82

37.	The economic value of selected direct benefits from BDOAF and related activities	84
38.	Employment pattern of households	85
39.	Source-wise share of food consumption of households	86
40.	Resource use pattern for various crops in different zones	88
41.	Resource productivity in ragi under different zones	88
42.	Allocative efficiency of resources in ragi cultivation	89
43.	Reduction in dependency on external inputs in ragi cultivation	92
44.	Agro-ecosystem health indicators	92
45.	Source-wise consumption pattern of subsistence requirements in different zones	93
46.	Consumption expenditure of the households	95
47.	Total direct use values of selected benefits (functions) from BDOAF	96

EXECUTIVE SUMMARY

Economic and Environmental Impact Assessment of Biodiversity On and Around Farms

Introduction

The need for maintenance of Biodiversity On and Around Farms (BDOAF) is important because biodiversity ecosystem is complex and fragile. They provide multitude of economic and non-economic benefits. In many regions of India, eco-friendly farming systems are practiced traditionally. Due to apparently high profits of mono-species cropping systems (High Yielding Varieties and hybrids), free-rider problem associated with common property resources (CPRs), market failures and the loss of biodiversity due to unabated degradation of ecosystems, society is inadvertently losing many of the direct and indirect environmental and material benefits from these areas.

According to the tenets of ecology, certain minimum level of biodiversity has to be maintained for the sustenance of ecosystem. In this study, the *'Soliga'* community, which is practicing eco-friendly agriculture that is akin to the BDOAF concept, was studied. The BDOAF is viewed as a benefactor of a multitude of direct benefits and environmental services to the system vis-a-vis modern agriculture. Further, there is a need to demonstrate the benefits and services and valuation of these benefits and services. The study draws comparison between farms located in zones having different levels of biodiversity.

Study area

The Biligiri Rangaswamy Temple (BRT) Wildlife Sanctuary (fig.1) along the eastern part of the Western Ghats, (Chamarajanagara district, Karnataka) presents an ideal setting for the study. The BRT sanctuary spread over an area of 540 sq. km. located in the confluence of the eastern and Western Ghats and harbors different types of forests ranging from shrubs, deciduous evergreen sholas to grasslands. An indigenous tribe *'soligas'* inhabits the sanctuary. The tribe is practicing agriculture in the most traditional way at the core of the forest, while; relatively input-intensive farming systems are located in the periphery of the sanctuary. Outside the sanctuary, farming systems are commercial in nature and are adopting input-intensive farming methods. The agriculture at the core of the forest practiced by *soligas,* is characterized by biodiversity rich surroundings and derive a lot of ecosystem benefits whereas the agriculture outside the sanctuary is biodiversity poor and depends on the external sources for inputs.

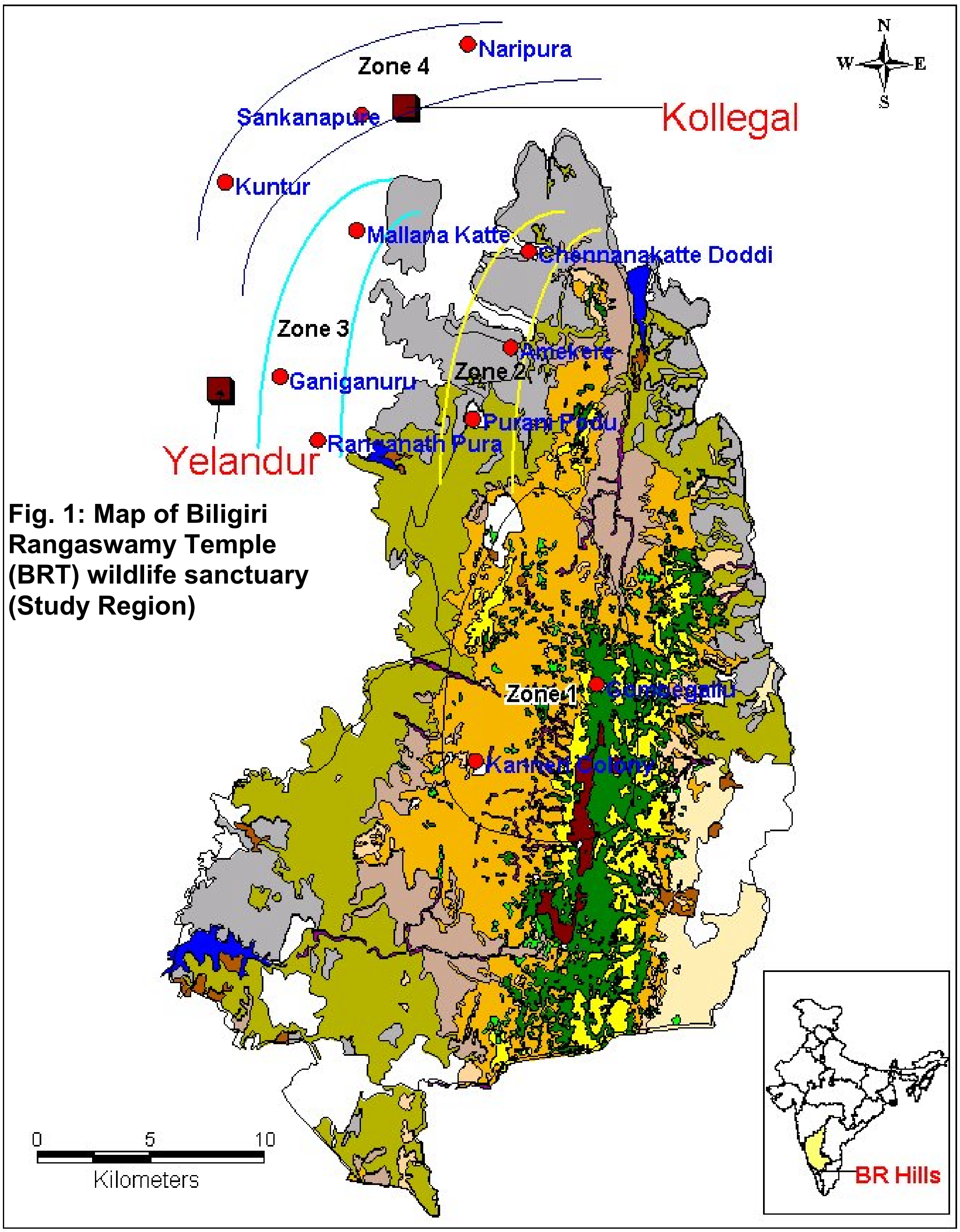

Fig. 1: Map of Biligiri Rangaswamy Temple (BRT) wildlife sanctuary (Study Region)

Sampling design

Farms were selected from four zones namely core (Zone-1), buffer (Zone-2), periphery (Zone-3) and outside the sanctuary (about 4-5 km away from the boundary of BRT) (Zone-4). These four zones represent varying levels of biodiversity and hence, nature of farming practices differ. From these four zones, 30 farmers each (a total sample size of 120 farmers) were selected. From the farms, data pertaining to various facets of farming systems and activities were collected using both structured and unstructured schedules were developed for the purpose.

Objectives

The objectives of the present study are to:

Establish the degree of influence of BDOAF on resilience and sustainability of farming systems.

- Study the institutional and social factors those sustain traditional farming.
- Assess economic, environmental and supplementary benefits and associated direct and indirect costs in traditional farms (BDOAF) vis-a-vis commercial agriculture.
- Study inter-sectoral flow of resources, backward and forward linkages and determine the extent of dependencies of farm families on BDOAF and
- Study the resource use pattern and resource allocation efficiency of farms with varied levels of BDOAF.

Methodology

The sustainability and resilience of the spectrum of agro-economic-systems with varying levels of biodiversity were analyzed using economic, ecological and environmental indicators determined *a priori*. To examine sustainability, the indicators computed are: degree of crop heterogeneity on farms; share of eco-friendly inputs in the total cost of cultivation of the crops; ratio of cost of various inputs to the total cost of cultivation of the crops; and net energy efficiency and income diversity index. For assessing the resilience, the indicators considered are: average cash cost per unit of output; average cash cost per rupee of gross returns; sensitivity analysis; Herfindahl index; Simpson index and threshold yields.

Information on formal, informal and social institutions prevalent in the area and attitudes and perceptions of people in sustaining the traditional farming were elicited.

To assess economic benefits, the total economic value of BDOAF was computed considering the returns or the benefits from and the associated costs of crop and livestock diversity, kitchen garden and trees on farms and Non-Timber Forest Products (NTFPs). To assess environmental benefits, the flow of environmental benefits from the BDOAF were identified and expressed on a four-point scale in order to reflect the magnitude of flow of these services in each zone. The three environmental goods and services namely chemical-free products, medicinal plants and eco-tourism were quantified using Contingent Valuation Method (CVM), replacement cost approach and Travel Cost Method (TCM) respectively. To assess the supplementary benefits, the value of benefits from NTFPs, kitchen garden and trees on farms were considered. These products were valued by considering the value of close substitutes or opportunity cost.

The Social Accounting Matrix (SAM) approach was employed to study the inter-sectoral flow of benefits between forestry (NTFPs), agriculture, livestock and other sectors of rural households and dependency of farms on BDOAF. The production multiplier matrices of different zones helped to prioritize investment decisions, which would enhance the welfare of the economy.

Resource-use pattern was studied to assess the extent of use of various inputs by the farmers. Allocative efficiency of input use in crop production was studied to know the scope for additional input use to maximize profit.

Environment Economics Component

- *Economic value of reduction in dependence* of farms on external inputs due to environmental and economic benefits from eco-friendly farming system of BDOAF was estimated for all the zones by computing shares of farm and non-farm sources of inputs.

- *Ecosystem health indicators* were assessed by considering the extent of use of inputs and agricultural practices, which do not interfere with the ecology of the system. The indicators of general health of the ecosystem, namely, the level of use of mechanical and chemical energy, crop and tree diversity and value of eco-friendly food produced on the farm were considered.

- *Quality of life* of the people in different zones was analyzed in terms of nutritive foods (in value terms) and proportion of this derived from farm sources. It was hypothesized that higher the proportion of nutritive foods derived from the farm sources, greater will be the quality of life as food derived from the farm sources are normally free of chemicals.

Results and Major findings

1. The socio-economic profile of the sample respondents in the four zones revealed that average size of the family of households in all the zones was almost the same at 6 persons per family. The family composition was more or less similar in all the zones except in zone-1, in which the number of males per family was relatively more than that of females. The literacy levels of respondents was higher in zones 3 and 4 than those of zones 1 and 2 mainly because of greater awareness, proximity to schools, proximity to roads, good transportation facilities etc. Lack of schools and poor transportation facilities in zones 1 and 2, resulted in low literacy levels and consequently poor development of these areas.

2. In general, households in zones 3 and 4 had higher levels *of* productive assets in terms of land, livestock (cattle, goat, sheep, poultry), irrigation facilities and other resources than households in zones 1 and 2. Farmers in zones 3 and 4 had

irrigation facility and therefore they could grow commercial crops. Hence, agriculture in these two zones was highly commercialized, whereas, households in zones 1 and 2 practiced only traditional agriculture, consequently expenditure on purchased inputs and yields of crops were relatively lower in these two zones.

3. Farmers in zone-1 produced mainly ragi along with cereals and pulses. In recent years, organic coffee is emerging as a cash crop in this region. However, still it has not attained the scale of commercial nature. Farmers in zone-2, in addition to ragi, cultivated paddy also under assured irrigation. Households in zones 3 and 4 cultivated ragi, paddy and commercial crops notably sugarcane as there was canal irrigation facility.

4. Farms in zones 1 and 2 were more sustainable ecologically than farms in zones 3 and 4 as revealed by the indicators of degree of crop heterogeneity, application of eco-friendly inputs, ratio of purchased inputs to total costs, income diversity index and net energy efficiency. Thus, relatively more traditional nature of agriculture in zone-1 was contributing to ecological sustainability of farms in this zone as compared to other zones.

Table 1: Indicators of sustainability of farming systems

Sl. No.	Indicator	Zone-1	Zone-2	Zone-3	Zone-4
1.	Degree of crop heterogeneity on farms	3.8	3.03	1.53	1.60
2.	Per cent area under input intensive crops	0	20.00	77.00	91.00
3.	Quantity of fertilizer (kgs per acre)	0	34.86	187.38	233.97
4.	Pesticide use (Rs. per acre)	0	13.81	121.15	118.59
5.	Eco-friendly inputs (Rs. per acre)	0	165.74	520.18	497.10
6.	Ratio of cost of purchased inputs to total cost of cultivation	0	0.17	0.86	0.88
7.	Income diversity index	2.45	3.89	2.29	2.15
8.	*Net energy efficiency*	3.90	2.29	1.85	2.44

5. The resilience of farms was relatively greater in zones 1 and 2 as indicated by their ability to produce crops more economically, ability to withstand effects of variations

in input and output price, lower threshold yields and supplementary benefits from BDOAF. The aggregate collection pattern of selected non-timber forest products (NTFPs) from BDOAF in Biligiri Rangaswamy Temple (BRT) area revealed that there was no definite trend in the collection pattern of NTFPs except in the case of gooseberry in which there was discernible sustainable extraction pattern over a five-year period. The institutions operating in BRT area have initiated various educational programs to conserve biodiversity through participatory resource monitoring by involving *soliga* tribe.

Table 2: Indicators of resilience of farming systems

Sl. No.	Indicator	Zone-1	Zone-2	Zone-3	Zone-4
1.	Average cash cost per unit of ragi output	0.13	0.95	6.22	2.67
2.	Average cash cost per rupee of gross returns from ragi crop	0.03	0.19	1.21	0.53
3.	Per cent reduction in net returns from ragi crop (sensitivity analysis), due to				
	- 25 % increase in price of inputs	0.72	5.22	314.01	28.32
	- 25 % decrease in output price	25.72	30.22	339.01	53.22
4.	Herfindahl index	0.63	0.69	0.78	0.76
5.	Threshold yield (kgs / acre)	4.35	57.83	589.03	366.52
6.	Per capita household expenditure (rupees)	9903	11163	23631	21100
7.	Simpson index	0.56	0.41	0.24	0.20
8.	Supplementary income (BDOAF sources) (Rs)	5265.68	3019.01	129.47	88.33

6. Major economic and environmental benefits that households in zones 1 and 2 derived from surrounding BOOAF included numerous NTFPs for market and consumption requirement, supplementary benefits such as fruits, tubers, vegetables, fuel wood and other-related products. The average value of NTFPs derived by

households in zone 1 and 2 were Rs.10,497 and Rs.4,972 per household respectively. Among various NTFPs collected, four products, namely lichens, moss, gooseberry and honey contributed significantly to cash income from NTFPs in zone 1, whereas, in zone-2, gooseberry, lichens, fuel wood and honey contributed bulk of NTFPs cash income. Households in zones 3 and 4 derived comparatively more income from agriculture and livestock activities than households in zones 1 and 2 due to commercial nature of agriculture and livestock activities particularly dairy enterprises in these two zones. However, households in zones 1 and 2 obtained utilities from kitchen garden to the extent of Rs.780 and Rs.221 per household per year, which was lacking in zones 3 and 4. Though households in zone-I had a wide range of livelihood options, the total income of the households from various sources was highest in zone-4 (Rs.65,066). In other zones, it was Rs.56,181, Rs. 21,622 and Rs.18,889 in zone-3, zone-I and zone-2 respectively.

7. The major source of income for *soliga* tribe in zone-I was NTFPs collection, which contributed about 49 per cent to the total household income. For households in zones 2, 3 and 4, agriculture was the major source. Over a period of seven years importance of NTFPs as a source of income for households in zones 1 and 2 is declining revealing a diversification of livelihood sources.

8. Households in biodiversity rich zones were deriving various environmental (direct and indirect use and non-use values) from surrounding BDOAF. We attempted the valuation of three environmental benefits (direct use values) namely, chemical-free products, medicinal flora and recreational benefits. Results of *contingent valuation method* (CVM) revealed that consumers were willing to pay an average price premium ranging from Rs.1.00 to Rs.4.50 for quality products *of makaliberu,* soapnut, turmeric and honey extracted from BRT region. Consumers with higher income were willing to pay higher premium for these products. The replacement cost approach indicated that average annual savings due to use of local medicines prepared from biodiversity sources instead of using allopathic medicines for common ailments worked out to Rs.749 and Rs.360 per household in zones 1 and 2 respectively. The BRT area has a great potential for eco-tourism as revealed by the

results of individual travel cost method (behavioral linkage method). Results of *travel cost method* (TCM) showed that, average non-consumptive use value derived by each tourist from visiting BRT was estimated to be Rs.352. A CVM survey showed that visitors were willing to pay an average amount of Rs.205 for maintenance of recreation site.

9. The average supplementary benefits realized by the households in the form of NTFPs for self-consumption, nutritious food from kitchen garden, small timber and medicinal plants was highest in zone-1 (Rs.6,014) and it was lowest in zone-4 at Rs.88.

10. The production multiplier matrices (SAM analysis) revealed that in all the four zones, dairy sector and ragi crop sub-sector of agriculture had the highest multiplier values implying that any new investment in these areas would generate relatively greater returns when compared to that in other sectors / sub-sectors. Out of the expected increase in income due to new investment in dairy sector and ragi crop sub-sector of agriculture, the marginal households were expected to benefit the most followed by small households.

11. The degree of dependence of households on BDOAF in terms of direct economic value derived, employment generation and consumption pattern, for their livelihoods was the highest (52.71%) in zone-1 while the least was in zone-4, which was 0.38 per cent. Among different components of BDOAF, the dependency on NTFPs was high in zone-1. The BDOAF sources generated employment opportunities to the extent of 38 per cent in the form of NTFPs collection for households in zone-1and 33 per cent in zone 2. The BDOAF related employment generation was almost negligible in the other two zones. The dependency of households on BDOAF was striking in zones 1 and 2 as more than 56 per cent of food requirement was met from BDOAF and farm sources. Households in zones 3 and 4 met major share of their requirement from market. Thus, importance of BDOAF on the livelihoods of people was strongly pronounced in zones 1 and 2.

12. Farms in zone-I used only farm-based inputs mainly seeds, whereas, farms in the other zones applied purchased inputs such as FYM and fertilizers. The usage of fertilizers increased from zone-2 through zone-4. A highest quantity of 520 kg of fertilizers per acre of sugarcane was applied in zone-4. The application of chemicals for plant protection in the three zones exhibited similar trend. The resource productivity which was estimated using appropriate functional forms and allocative efficiency (based on MVP-MFC ratios) for *ragi* crop in all the zones showed that there was scope for increasing area under dry land *ragi* and enhancing FYM use in zones 3 and 4. In zones 1 and 2, farms had only scope for increasing returns by way of using more of seeds.

13. The environmental economics aspects of biodiversity were examined in terms of the following four components; reduction in dependence of farms on external inputs, ecosystem health, quality of life and direct use values. The economic value of reduction in dependence of farms on external sources due to environmental and economic benefits from eco--friendly farming practices was highest at almost 100 per cent in zone-I due to non-application of external inputs. It was lowest in zone-4 at 36.53 per cent. Though zone-1 was on strong ecological foundation, the value of output and consequent income levels were very low as compared to zone-4, which had a poor level of biodiversity. As revealed by the selected indicators, the ecosystem health was (viewed, in terms of eco-friendly inputs and practices), relatively higher in zones 1 and 2 than zones 3 and 4. The degree of eco-friendly input usage was greatest in zone-1; therefore, the farms in this zone were relatively on a stronger ecological foundation. The quality of life as viewed primarily from intake of nutritive foods such as fruits, vegetables, etc., supplied from surrounding BDOAF though appears to be high among households in zones 1 and 2, in value terms, expenditure on milk and non-vegetarian foods and other human development components was lower among households in zones 1 and 2. The average consumption expenditure was the highest among households in zone-4 at Rs.23,025 and it was lowest in zone-1 at Rs.9,904 per household. The direct use values derived from the households from surrounding BDOAF were estimated and expressed as consumptive and non-consumptive use values. The average

consumptive use values derived by the households in zone-1 and zone-2 were the highest for NTFPs at Rs.4,914. The consumptive use values for quality products collected from BRT area ranged from Rs.I.00 to 4.50. From medicinal flora, households in zones 1 and 2 realized an average consumptive use values worth about Rs.554. The magnitude of non-consumptive use values (recreation) derived by individuals visiting BRT area was estimated to be about Rs.352.

14. The results of the study show that BDOAF provided a wide range of livelihood options to *soliga* tribe. But this has not transformed into livelihood certainties as income levels of *soliga* tribe from agriculture and BDOAF related activities were lower. This predicament originates primarily due to lack of property rights on the lands they cultivate and NTFPs collection particularly in the zone-I. Consequently, the general consumption level and expenditure on human development components among *soliga* tribe were lower than those of households in zones 3 and 4 who had a high degree of livelihood certainties. Hence, there is a need for evolving alternative income generating activities, which not only ensure livelihood certainties of these communities but also minimize pressure on BDOAF resources.

Table 3: Environmental Economics Component

Characteristic	Zone 1	Zone 2	Zone 3	Zone 4
Reduction in dependency on external sources for inputs (Rs & %)	2257.59 (100.00)	2442.74 (91.18)	1188.38 (34.94)	855.28 (36.53)
Total purchased inputs on farm (Rs)	0	236.27	2213.17	1486.23
No. farmers using plant protection measures for ragi crop	0	0	1	2
Fertilisers (kgs) - Ragi - All crops	 0 0	 22.09 34.86	 34.33 187.38	 43.24 233.97
Simpson index for tree species diversity on farms	0.56	0.41	0.24	0.20
Per cent acreage under input intensive crops	0	20	77	91
Usage of mechanical power				

Characteristic	Zone 1	Zone 2	Zone 3	Zone 4
(Mega Joules / acre) - Ragi - Paddy	 0 -	 0 0	 14.70 653.60	 179.20 345.20
Chemical-free foods available to households (Rs /household)	1911.35	1190.85	0	0
Number of different crops on farms (crop diversity)	3.8	3.03	1.53	1.60

Table 4: Direct use values of selected benefits (services) from BDOAF

Sl. No.	Type of benefit	Category of use value	Average value
1.	NTFP extraction (Rs. / household / annum)	Consumptive use value	4914.00
2.	Chemical-free products (Rs. / kg)	Consumptive use value	1.00 - 4.50
3.	Medicinal flora (Rs. / household / annum)	Consumptive use value	554.30
4.	Recreation (Rs. / household)	Non-consumptive use value	351.69

Recommendations

The results of the study will be useful in evolving policy recommendations for management of biodiversity resources. These resources have characteristics of a public good. Hence, utilization of these resources needs to be regulated in order to ensure intergenerational equity and sustainability for future.

1. Development and conservation of BDOAF in biodiversity poor regions may help in sustaining ecology of the region besides supplementing dietary compositions of households. Hence, educational and participatory programs may be formulated and implemented to create awareness about importance and need for establishing adequate BDOAF.

2. Dairy sector and *ragi* crop sub-sector of agriculture generate relatively greater returns when compared to that in other sectors. Hence, investments should be

directed towards these sectors. Such investments will not only transform the traditional crop and dairy enterprises into more viable economic activities on the one hand but also reduce the pressure on forests for NTFPs on the other hand. Due to increase in income from new investment in dairy sector and ragi crop sub- sector of agriculture, the marginal households were expected to benefit the most, followed by the small households. This will result in more equitable distribution of income in the economy.

3. The rich biodiversity around farms in zone-1and zone-2 provides usufruct utilities to - tribal households. However, it is not very clear whether all NTFPs are being extracted in a sustainable manner by the *soliga* tribe. Therefore, it is worthwhile to examine whether NTFPs are being extracted in a sustainable manner without affecting ecology of the system by analyzing influence of market and institutional factors on the extraction patterns.

4. A systematic documentation and extraction for medicines can be developed so that valuable medicines can be extracted with major share of proceeds from such mechanisms being directed towards the tribal welfare. Local institutional network may be involved to a larger extent to facilitate documentation although currently this activity is being undertaken by one NGO. The systematic documentation of traditional medicinal practices is essential because only a few people know the knowledge of use and preparation and the same is passed on orally to the next generation.

5. Long term research forays need to be initiated to determine optimal mix and level of BDOAF, which ensures and/ or maximizes social welfare in tune with ecological harmony.

6. Many usufruct benefits from BDOAF, their cash income and quality of life are low. In this regard, cash income generating activities may be initiated to augment their meager income levels. This may also reduce pressure on BDOAF.

7. In general, tourism potential and in particular eco-tourism needs to be exploited. Sites that have such potential including the BRT area can be developed into good eco-tourism centers. This was evident by the willingness to pay by the tourists for the maintenance of the recreation site. This was also reinforced by the use values (consumer surplus) estimated from the study, for the BRT sanctuary area.

8. In order to know the total value of BDOAF, a more detailed multidisciplinary study can be initiated so that total impact in terms of climate, soil, physical and other aspects of BDOAF can be quantified.

CHAPTER I: INTRODUCTION

The recognition of environmental degradation in developing countries is a recent phenomenon, largely spurred by serious concerns raised by the Rio Earth Summit (1992), which emphatically called for evolution of committed corrective measures. The emergence of environmental economics clearly recognized negative externalities created by developmental projects that threatened the very sustainability of development in less developed countries. Recognizing the environmental havoc of development projects, lending and aid agencies reviewed their lending policies to incorporate the environment friendly provisions to minimize the negative externalities of development initiatives (Pearce and Maler, 1991).

Today, India is facing three major categories of environmental threats. They are (a) a high degree of pollution due to industrialization (b) rapid degradation of natural resources and (c) soil-ecological imbalances due to indiscriminate use of inorganic fertilizers and plant protection chemicals. For India, from an agricultural point of view, the last two categories of environmental problems are of serious concern. Environmental degradation is largely attributed to human aspirations for improved livelihoods, which frequently clash with maintenance of biodiversity, especially in the tropics (Randall, 1991).

In developing countries, the degradation process is abetted by the food security initiatives such as high yielding varieties (HYVs) programmes which, though unintended, ruthlessly destroyed biodiversity and genetic stock of field crops by encouraging the cultivation on grasslands (CPRs), biodiverse lands around the farms, forest and ecologically and environmentally fragile lands. Moreover, spread of mono-species culture and mono-genotype cropping systems and application of artificial and environmentally dangerous chemicals such as fertilizers and pesticides further encouraged the destruction of biological diversity.

The present high agricultural production in developing countries like India, is largely area led growth rather than productivity led growth, which clearly signals large scale cultivation of forest converted area and marginal lands which means further erosion of biodiversity and decline in the health of agro-ecosystems. The commercial agriculture began to use less and less of eco-friendly functions (such as natural parasites, predators and pollinators) and inputs (moisture and nutrients) and more of high cost external resources or inputs. This has a cascading effect on reducing the stability and sustainability of farming systems and increasing dependencies on less environment friendly inputs.

Presently, all over the globe, population is inadvertently embarking upon a mass extinction of ecosystem under the guise of development to augment the human livelihoods. It has been reported, that out of 1,260 million ha of tropical forests in the world (9 % of the total land area), annually we are losing about 7 million ha due to human intervention (Barbier et al, 1991).

Today, twenty crop species provide about 90 per cent of the energy needs of humankind. Rice, wheat and maize supply about 60 per cent of the calories and protein that is derived from plants. Pastorlists are squeezed into ever-diminishing space and sometimes overgraze the land and high input modern farming practices pollute the soil and water with chemicals. All these concentrated activities trigger a potentially dangerous process leading to loss in biodiversity. However, some land use systems and agricultural practices enhance biodiversity within managed landscapes. For example, the judicious use of livestock waste as organic manure enhances the species diversity of macrofauna and microflora.

The functional relationship between the biological diversity and the set of services on which humanity depends has to be clearly understood and properly addressed. Biodiversity helps to sustain a flow of ecological services that are pre-requisites for economic activities. These include photosynthesis, provision of food, fodder, fibre and other renewable resources, soil generation and conservation, pollination of crops, recycling of nutrients, controlling pest activity, filtering of pollutants and waste assimilation, flood control, climate moderation, operation of the hydrological cycle and maintenance of the gaseous composition of the atmosphere. These functions sustain and protect human activities and therefore human well-being. In economic terms, biodiversity forms fundamental factors of production. These factors are becoming increasingly scarce in the present agriculture as a result of extensive commercialization and specialization. People can no longer afford to ignore this as a part of development, for, indeed this loss affects the poor farmers and makes farmers and countries like India, more vulnerable to the vagaries of the global economic system.

India is one of the world's largest and oldest agricultural societies, one which has remained predominantly rural despite decades of modernization. Even today, every aspect of the country's economy and polity and the day-to-day living of the majority of its one billion population, is governed by the performance of the agricultural sector. India's population is expected to exceed 1500 million by 2025 AD and requires about 325 million tonnes of food grains. The country has to increase the food production by five million tonnes per year as against the present rate of 3.1 million tonnes per year to meet the growing demand. Hence, with these challenges ahead, the stability and sustainability of Indian agriculture is of paramount importance. In this context, the role of biodiversity assumes special significance because of its increasing importance on sustainability and ecological-environmental aspects. As farmers and environmentalists struggle against these problems, they have also realized that there are many aspects of traditional farming which are still relevant and that modern methods should at best supplement and complement indigenous and local knowledge rather than displacing it. There are important trade-offs, complementarities and inter-relationships among alternative choices that have to be made in a world of resource scarcity in order to achieve a sustainable agro-ecosystem.

The erosion of biodiversity threatens the long-term stability and sustainability of Indian agriculture as it erodes the genetic base on which scientists are depending for continuous improvement of crops and livestock. For the country as a whole, the increasing reliance on a narrow genetic range of crops represents a high-risk proposition. All the above developments have resulted in an increasing dependence of farmers on the markets and the government. Virtually all inputs for farming, except land and family labour are obtained from outside the village. And due to increased specialization in growing a few crops (especially cash crops), there is a heavy dependence on the market for food requirements. These developments have greater effect on self-sufficiency of farmers and sustainability of farming activities.

The need for maintenance of Bio-diversity On and Around Farms (BDOAF) gains credence because biodiversity or ecosystem is complex and fragile. It provides a multitude of economic and non-economic benefits. The tenets of ecology recognize that every species has its place in the broader scheme of things. Species that do not have even directly conceivable value could still be valued for their ecosystem support (Randall, 1991). In many regions of India, ecologically friendly farming systems are in practice. But attempts to understand the nature of eco-friendly practices and their economic and non-economic benefits are rarely initiated. The present study is a modest attempt in this endeavor.

Prior to the introduction of high yielding varieties (HYVs), farming systems in South India were replete with rich biodiversity on and around farms or irrigation tanks systems which were supplying lot of biomass and inputs to agriculture and a balance existed between agriculture and ecology-environment. This functional balance was strongly supported and reinforced by the traditional institutions prevalent in village communities. These institutions were evolved centuries ago and nurtured by the successive generations in order to protect and sustain the functional relationships. However, during the past few decades, agriculture and rural development policies have brought about significant changes in agricultural systems.

Traditional agriculture systems which were finely interwoven with the social and cultural fabric of villages as also with the forests and other ecological features within which the villages existed, could not withstand the far reaching changes brought about by the green revolution and other development policies. Agricultural schemes have resulted in homogenizing growing conditions, for example, by surface irrigation, a complex mosaic of diverse micro-habitats have been replaced by immense stretches of uniform agricultural landscape. Intercropping is replaced by monocropping, wherein a wide diversity of species is replaced by a handful of profitable ones. Added to this, changing attitudes towards coarse and fine grains, supply of HYV seeds and other inputs at subsidized cost by the government, attraction to maximize profits through cash crop monoculture and lack of incentives for marketing of traditional crops have led to erosion of biodiversity on and around farms.

In recent years, realizing negative externalities of technological misdemeanors and human induced ecological distractions in terms of reduced resilience, stability and sustainability, environmentalists, ecologists and the like have been successful in generating a lot of debate to create awareness and evolve ameliorative mechanisms. The concept of BDOAF can be considered as an ameliorative mechanism in this direction. It is broadly similar to the biotic reserves maintained by farmers around farms in the fifties and sixties, which was benefactor of environmental services to the farming systems. Farmers were deriving a multitude of tangible and intangible benefits or values from BDOAF.

Presently, rich biodiversity on and around farms could be seen in Western Ghats regions including Biligiri Rangaswamy Temple (BRT) sanctuary area. These areas have a high degree of biodiversity and are termed as 'hotspots' of biodiversity. In these areas, farms are replete with rich biodiversity on and around farms (BDOAF) from which households derive many benefits and functions. While the functions of and utilities derived from biodiversity have been very well documented, the value of biodiversity in developing countries has not been fully judged, especially agro-biodiversity. The value of biodiversity as opined by Flint (1992) depends on how it is defined. That is whether we are referring to biodiversity or biological resources at different levels or scales. According to Flint, the value of biodiversity is the difference between the current or future value of a range of genes / species / ecosystems and the value of a less diverse range. Although, it is often difficult to estimate the value of biodiversity, economists are able to recognize different types and values of biodiversity. In the present study, an attempt is made to address direct use values derived by household from biodiversity.

Farms in BRT area are practicing traditional farming systems and are deriving direct and indirect use values from surrounding biodiversity. The types of direct use values derived by households in the BRT area comprise consumptive, productive and non-consumptive values. Though traditional farming systems practiced by households in the BRT are eco-friendly, they may not be economically sustainable as the magnitude of inputs used and their productivity are very low. Hence, the dependence on surrounding forests for the extraction of Non-Timber Forest Products (NTFPs) for their livelihoods will be intense. Whether such conspicuous dependency on NTFPs is sustainable in the long run?

Traditional farming systems imply sub-optimal level of modern input use, consequently, the level of income. Therefore, the income levels of soliga tribe (which depends on surrounding forests) have to be augmented by diversifying their livelihood sources in order to minimize dependence of these communities on biodiversity. Hence, it is useful to analyze resource use pattern in their farming endeavors.

The present study attempts to recognize the role of biodiversity in enhancing the livelihood options of marginal communities vis-à-vis communities that enjoy property rights on land and consequently lesser uncertainty of their livelihoods.

CHAPTER II: OBJECTIVES

The overall objective of the study is to compare traditional farming system of soligas with commercial farming systems with respect to various environmental, economic, production and supplementary functions and benefits that emanate from surrounding biodiversity. The study aims at assessing the role of varied levels of BDOAF in maintaining socio-economic, livelihood and environmental quality of the dependents.

The specific objectives of the study are

1. To establish the degree of influence of BDOAF on sustainability and resilience of farming systems.

2. To study the institutional and social factors that sustain traditional farming.

3. To assess economic, environmental and supplementary benefits and associated costs (direct and indirect costs) in traditional farms (BDOAF) vis-à-vis commercial agriculture.

4. To study intersectoral flow of resources, backward and forward linkages and determine the extent of dependencies of farm families on BDOAF and

5. To study the resource use pattern and resource allocation efficiency of farms with varied levels of BDOAF.

Justification and relevance of each objective

Objective 1: As BDOAF performs various environmental, economic and other functions, it is necessary to assess to what extent BDOAF is going to enhance resilience of farms in absorbing shortfall in income and provide stable returns to the households and finally how it contributes to the sustainability of farming systems vis-à-vis commercial agriculture. Identification of certain important indicators of sustainability and resilience would be attempted through this objective.

Objective 2: Examines the factors sustaining traditional farming despite the pressure on agricultural and forestlands for commercialization. The institutional and social factors sustaining BDOAF would be identified for replication of such eco-friendly farming practices elsewhere.

Objective 3: Though we are quite aware of beneficial impacts of BDOAF, we are not very clear regarding the exact nature and pattern of flow of environmental, economic and supplementary benefits that emanate from BDOAF and associated direct and indirect costs. In order to examine economic viability and dependability and sustainability of BDOAF it is essential to document, analyse and value the types of benefits and costs from BDOAF vis-à-vis commercial farming systems.

Objective 4: Rural economy (whether BDOAF or commercial farms) is characterized by existence of various sectors like agriculture, forestry, livestock, trade and others. The inter-linkages among the sectors and inter-sectoral flows of resources between the sectors will enable us to identify the importance of BDOAF in the village economy. Further, the scope for effecting changes in these sectors in terms of enhancing flow of benefits and improving efficiency and thereby welfare of the economy could be examined. Such an exercise calls for identification of backward and forward linkages in terms of rural institutions and infrastructure facilities, which strengthen activities, and adds value to the farm products. The livelihood patterns of families depending on BDOAF can be assessed through social accounting matrix analysis.

Objective 5: There is a general feeling that resource use pattern is over optimal under commercial farms and below optimal under BDOAF farms. Thus, this objective seeks to examine this issue and the scope for identifying optimum level of BDOAF that ensures long-term efficiency and sustainability of farming systems.

CHAPTER III: METHODOLOGY

In this chapter, a general description and typology of methods and procedures adopted in realizing objectives of the present investigation are presented under the following subheads.

3.1. Description of the study area

The study covers a wide area, located in and around Biligiri Rangaswamy Temple (BRT) Wildlife Sanctuary located in Chamarajanagar district, in the state of Karnataka, India ($11^{0}47'$-$12^{0}09'$N and $77^{0}05'$-$77^{0}15'$E). The terrain is highly undulating with altitude ranging from 600 metres to 1,800 metres above mean sea level. The laterite soil cover present on the bedrock is shallow and gravelly with preponderance of quartz pebbles and iron concretions. The soil in the valley is alluvial and loamy to slightly sandy loam, with fairly good water holding capacity. The sample villages located in the plains of Kollegal taluk are bestowed with irrigation facilities arising from waters of Kabini canal and a few tanks present in and around villages.

The climate of the area is tropical monsoon with rainy season extending from March to September. The area enjoys both south-west monsoon from the west coast about 160 kms away and north-east monsoon from the east coast nearly 210 kms away. The rainfall is highly sporadic and varies greatly between locations, presumably because of highly undulating terrain. The rainfall is found to be generally higher at higher altitudes than at lower altitudes. On an average, the area receives an annual rainfall ranging from 1,484 mm to 1,850 mm. The temperature ranges from 18^{0}C to 32^{0}C. Relative humidity varies from 53 per cent in December to 95 per cent in September.

The BRT wildlife sanctuary is endowed with rich biodiversity. The natural vegetation of this sanctuary consists of mainly five types of forests, viz., dry deciduous forests, scrub forests, evergreen forests, savannas and sholas (low forests of evergreen nature in pockets at high altitude). The degree of natural vegetation in the plains is very low and sparse.

The Biligiri Rangaswamy Temple (BRT) Wildlife Sanctuary in south-west India is the home of an aboriginal tribe, *Soliga.* Approximately 4,000 *soligas* live in the 540 sq.kms sanctuary and 11,000 in the periphery or areas surrounding the sanctuary. The *soligas* have lived in the BRT forests for centuries, practicing shifting agriculture, hunting wildlife and gathering a wide variety of products from the wild habitats. Starting from the early part of this century, the shifting agriculture was progressively curtailed and completely banned by 1972, when the area was declared a wildlife sanctuary. The *soligas* are now being given small pieces of land (1 – 2 ha per household) to practice settled agriculture. The usufruct rights allow *soligas* to continue gathering a wide variety of Non-Timber Forest Products (NTFPs) from the state owned forest lands in the sanctuary (Hegde *et al,* 1996)

The study area represents a wide spectrum of farming systems ranging from very low input 'primitive' farming (comprising of traditional multi-cropping system in association with rich biodiversity on and around farms) to 'commercial input intensive' farming systems (mostly monoculture and specialization with little biodiversity on and around farms). The study area represents a varying gradient with respect to degree of biodiversity on and around farms and it also has an interface zone between the primitive farming systems and commercial input intensive farming systems.

In the interiors of the forest and also to some extent in the periphery, the area has quite a number of forest species, which provide many useful products, having both value-in-use and value-in-exchange.

The study area was classified into four distinct zones based on the degree of biodiversity on and around farms (Ganeshaiah and Umashaankar, 1999). The features of the zones are presented in Table 1. In zone-1, which is located in the core of the forest, zero input 'primitive' farming is being practiced. This zone is inhabited by the *"Soliga"* tribe, who practice traditional farming only. *Soligas* live in settlements called *"podus"*, which are located in the core of forest and practice settled agriculture. They collect a wide range of forest products, mainly to meet their subsistence needs and then to earn cash income by selling to Large-scale Adivasi Multi-Purpose Society (LAMPS).

The *soligas* also collect many greens, tubers and roots for their daily household consumption. They have small kitchen gardens next to their huts, where they grow many useful plants and trees, which help to sustain their living. The plants and trees generally grown are alternaria species, pumpkin, tomato, brinjal, beans, tubers, banana, guava, pomegranate, jackfruit, jamunfruit, etc.

Agriculture in this zone is primitive type and only rainfed crops are taken up. Mixed cropping is predominant in this zone. Ragi, the main crop along with maize, field beans, and other pulses are grown commonly. The conventional crop production practices followed in other regions are not prevalent here. Initially, before the sowing season, the stalk and residues of the previous crops are cut and burnt. After this, the field is prepared for sowing maize, by digging the entire field with the help of pickaxe / spade. Alternatively, maize is dibbled in the field. Later, with the onset of monsoon, the entire field is dug with the help of spade, pickaxe etc., and ragi is broadcasted. Again the field is disturbed to ensure the seeds are covered with soil. During the course of crop growth, very little attention is paid to the crop. There is no application of fertilizers and very little quantity of farmyard manure is applied. Weeding is the only intercultural operation followed, that too, when the fields are infested with weeds. Only manual weeding is done. Harvesting is generally a multi-stage operation and is not done at one point of time. This is because many varieties of the same crop i.e., ragi are grown in the same field. During the whole process of crop production only manual labour is used and no bullock labour is used. A few farmers also grow coffee in small plots.

Table 1: Classification of study area into different zones based on degree of biodiversity on and around farms

Sl.No.	Zones	Degree of BDOAF
1.	Zone-1	Very high BDOAF
2.	Zone-2	Relatively less BDOAF
3.	Zone-3	Poor BDOAF
4.	Zone-4	Very poor or almost nil BDOAF

Note: BDOAF - Biodiversity on and around farms

In zone-2, which is located in the buffer and periphery of the forest, ‘low external input’ farming is practiced. This zone is also inhabited by *soligas*, who practice settled agriculture and collect forest products but to a lesser extent when compared to that in zone-1. As such, the farmers in this zone do not enjoy the benefits of forest to a fuller extent as enjoyed by farmers in zone-1. However, the farmers do enjoy to some extent the benefits of development of the outside world.

Agriculture in this zone is of a mixed type. Farmers in addition to ‘primitive’ farming also practice conventional farming with the help of bullock labour and with a little amount of external inputs. The crops grown in this zone are ragi, maize, field beans and paddy. Crop protection measures were also taken up when there is incidence of pests and diseases.

In zone-3, which is located relatively far from the centre of the forest, farmers practice high input farming. Agriculture is of conventional type and large amounts of inputs are used in crop production. The crops grown are paddy, sugarcane and ragi. The system of monoculture is very common. Normally, one or two crops are grown every year. All the normal activities and operations necessary for crop production are performed. The farmers in this zone do not collect any forest products, as they do not have access to it. The biodiversity in this zone is poor.

In zone-4, which is located quite far away from the core of the forest, farmers practice input intensive agriculture and farming is highly commercial in nature. The farmers mainly grow paddy, sugarcane and commercial crops. Monoculture is popular in this zone. The land is never left fallow throughout the year unless the irrigation facility fails. The biodiversity in this zone is very poor or almost nil.

With respect to irrigation facility, farmers in zone-3 and zone-4 get water from kabini canal and also from a few tanks located near the villages. In zone-2, irrigation facility is available only in village Murattipalya, where a few farmers grow paddy. Zone-1 has absolutely no irrigation facility.

3.2 Conceptual framework

In India, a significant number of marginal and tribal households who do not have access to productive assets depend on forestry and related activities for their livelihoods. The dependence of these households is stronger in such areas where bio-diversity is rich. The overall objective of the study is to examine the flow of economic and environmental benefits from surrounding biodiversity and their influence on the livelihoods of the households, especially marginal and tribal households.

Though there are quite a few studies exemplifying strong linkage between livelihoods of marginal/tribal households and non-timber forest products, there are few systematic attempts to establish relationship between degree of bio-diversity and livelihoods of surrounding households. Further, most of the studies confined to a few direct use values notably direct consumption values derived from bio-diversity often not fosussing on environmental aspects. The present study also attempts to quantify non-consumptive direct use values such as recreation through behavioural linkage approach. Further, the ecosystem health under different types of livelihood pursuits was also assessed. These imperatives necessitate a domain in which varying levels of biodiversity and livelihood patterns are present.

The study region was classified into four zones based on the degree of biodiversity (Ganeshaiah and Umashaankar*,*1999*)*. This classification sheds light on how the degree of biodiversity influences livelihoods options and concomitant sustainability of livelihoods. The magnitude of biodiversity was measured using Simpson and Herfindahl indices. While the Simpson index indicates species richness and evenness, Herfindahl index estimates crop diversity in the region. It is hypothesized that, higher the degree of biodiversity, the wider will be the range of livelihood options although a greater degree of biodiversity per se may not contribute to economic sustainability directly. This classification was purposively adopted for the study, because of non-existence of this type of biodiversity gradient elsewhere that facilitates a comparison within a given compact area. Although regions with varying levels of biodiversity are available in

Karnataka, they do not provide an ideal setting wherein an identical agro ecological system properties are present in a single compact area. Since the emphasis in the present study is on the influence of degree of biodiversity on various facets of human society, it is essential that the study site facilitates a comparison of regions with varying levels of biodiversity. Hence, we have purposely chosen BRT region, which approximates an ideal setting for the study.

Ever increasing human consumption is placing a tremendous pressure on natural resources and biodiversity. This is clearly evident in developing societies through their livelihood patterns. Conventional agro-ecosystems are generally more productive but far less diverse than natural systems. Unlike natural systems, conventional agro-ecosystems are far from self-sustaining. Their productivity can be maintained only with large additional inputs of energy and materials from external human sources; otherwise they quickly degrade to a much less productive level. The study addresses whether present agricultural practices and livelihoods have any influence on the sustainability of the four types of agro-ecosystems through a set of indicators.

The term sustainability has no universal definition and it has been interpreted in a contextual paradigm. So also, there are no thumb rules available on the sufficiency of the number of indicators to be used for measuring sustainability. In the present study we have used this term to mean the degree of self-reliance of production system and households for their existence. A system which has a greater dependence on external source of inputs and markets and lower level of eco-friendly inputs into agriculture is considered to be more vulnerable and hence less sustainable in the long run and vice-versa. The sustainability of the system is studied primarily from the view point that biodiversity is a public good and resource poor societies place a greater pressure on public good for their livelihoods, which may threaten the very existence of public good.

In the present study, spatial sustainability is defined in terms of predetermined indicators that reflect the protection of natural ecosystem and resources. The term sustainability has been operationalized taking into consideration a set of specific predetermined indicators (Heinen quoted in Bell and Morse, 2000). Estimation of various use values (direct, indirect, consumptive and non-consumptive use values) will shed light on the magnitude of benefits derived by proximate households. Such use values will help in monitoring, regulating and maintaining biodiversity resources for future sustainable uses. Hence, an attempt was made to quantify selected use values using Environmental Impact Assessment (EIA) techniques.

The households derive a diverse set of utilities from biodiversity through various sectors like forestry, agriculture, livestock and others. These sectors are inter-related with one another through backward and forward linkages or relationships. In order to know the linkages between the BDOAF dependent sectors and other sectors of the economy, Social Accounting Matrix (SAM) analysis was performed. From SAM, production and household income multipliers can be obtained which throw light on sectors that are profitable for investment and also indicate which category of institution benefits the most from such investments. Backward and forward linkages for various sectors can be worked out which in turn will indicate at what rate the economy should grow and to what extent the economy will be stimulated to grow respectively. Thus, from SAM analysis, sectors / sub-sectors that have the highest potential for growth due to new investments can be identified. This kind of exercise has strong policy relevance because there is a need for identifying sectors and sub-sectors that have a strong growth potential to augment and ensure livelihood certainties of marginal communities such as tribal people.

3.3 Sampling design

In this study, a multi-stage sampling procedure was employed to select the sample farmers. In the first stage, Biligiri Rangaswamy Temple (BRT) Wildlife Sanctuary was purposively selected since it represented a wide spectrum of farming systems ranging from zero input ‘primitive’ farming to input intensive ‘commercial’ farming. In the second stage, the study area was divided into four zones based on the degree of biodiversity on and around farms (Ganeshaiah and Umashaankar, 1999), namely zone-1, zone-2, zone-3 and zone-4.

In the third stage, 30 farmers from each zone were randomly selected. Farmers within each zone belonged to different *'podus'* or 'villages' within the zone. The total sample thus comprised of 120 farmers. The zone-wise distribution of sample is shown in Table 2.

3.4 Collection of data

The primary data were collected from the head of each selected household by personally interviewing them with the help of a pre-tested schedule designed for the study. The respondents were fully explained about the purpose of the research study and the practical utility of the findings. Each one of them was interviewed personally and informally. The necessary information was collected for the agricultural year 1999-2000. For this purpose, three schedules were developed and pre-tested in the study region.

The first schedule covered the following information. General information regarding the educational level of the respondents, size of the family, size of holding, sources of irrigation, annual cropping pattern, area of operation, crops grown during 1999-2000, resource use on the farms and their availability on the farm, dependency on markets for inputs, production practices of main crops, number and type of animals maintained, feed and fodder requirements, output obtained, pest and disease occurrence, bio-diversity on and around farms, about kitchen garden, collection of Non-Timber Forest Products (NTFPs), direct and indirect benefits from BDOAF, sources of income, credit utilisation, consumption pattern of the household, fuelwood requirements and other necessary details required for the study were collected. The second schedule was related to Contingent Valuation Method (CVM) for eliciting consumer's Willingness To Pay (WTP) for chemical free products obtained from BRT. The third schedule was used for collecting data from tourists visiting BRT for estimating use values (consumer surplus).

The secondary data were also collected from the taluk offices and veterinary hospitals of Chamarajanagar, Yelandur and Kollegal taluks of Chamarajanagar districts.

Table 2: Details of the selection of sample households

Sl.No	Zones	Name of the settlement / village	No. of households selected
1.	Zone-1	Gombegalu	4
		Keredimbu	4
		Kanneri Colony	8
		Muthugadagadde	8
		Yarakinagadde	6
2.	Zone-2	Puranipodu	12
		Kythadevarahalli	4
		Murattipalya	8
		Karalakattedoddi	6
3.	Zone-3	Gumbally	10
		Surapura	10
		iii Ganiganuru	10
4.	Zone-4	Sankanapura	10
		Palya	10
		Kunturu	10
	Total		120

Data collected pertained to aggregate figures of area under different crops, human population and livestock population. In addition, primary data were also collected from farmers regarding crops like cotton, groundnut, etc and data pertaining to livelihood patterns of landless labourers were also collected for constructing social accounting matrix.

CHAPTER IV: DATA ANALYSIS

This chapter gives a detailed account of various analytical tools used for the analysis of primary data collected from respondents.

4.1 Sustainability and resilience of farms

The process of identifying the elements of sustainability begins with two kinds of existing systems; natural ecosystems and traditional ecosystems. Both have stood the test of time in terms of maintaining productivity over long periods. Natural ecosystems provide an important reference point for understanding the ecological basis of sustainability. The ecological conditions of sustainability include species diversity, organic matter content of the soil, top soil depth, etc.

The classification of the study area into four zones was based on the degree of biodiversity. The biodiversity on and around farms performs various ecological functions which are likely to have an impact on sustainability and resilience of farms under different agro-ecological settings.

Farshad and Zinck (1993) suggested the use of a six-pillar model that takes into consideration environmental soundness, economic viability, social acceptability, individual manageability, agro-technical adaptability and political acceptability. However, the sustainability and resilience of farms under different zones were assessed based on indicators identified *a priori.* A brief description of computation of these indicators is given below.

4.1.1 Sustainability

In the present study, the notion of sustainability is viewed from an agro-ecological perspective. Biodiversity has a strong bearing on the sustainability, more so on ecological sustainability. In the long run, economic sustainability of farms largely depends on ecological sustainability. Therefore, the study focused ecological sustainability rather than economic sustainability.

The concept of sustainability is very broad and has been defined in several ways keeping in view the context under which it is addressed. Ecological sustainability is viewed in terms of kind of input use, farming practices followed, type of cultivation, etc. Based on these criteria, ecological sustainability of farms in different zones was inferred. Ecological sustainability was attempted on a spatial scale rather than on time scale due to lack of time series data on various physical, economic and ecological variables pertaining to the region. The application of spatial scale of sustainability for agro-ecosystems has been suggested in the literature for farm, villages etc. if comparable situations are available. Niu *et al* (1993) have developed a framework for sustainable development that builds on the basic definition of sustainable development given in the World Commission on Environment and Development report (1987). They suggested employing a spatial systems approach with each spatial system comprising five sub-systems. The sustainability indicators are then selected to gauge each of these sub-systems. In the present study, the study region represents an ideal setting in terms of a comparable biodiversity gradient for inferring sustainability of farms on a spatial scale. However, as suggested by these authors, spatial scale in sustainability suffers from various limitations. (Bell and Morse, 1999; Boggia and Abbozzo, 1998; Farshad and Zinck, 1993 and Niu *et al,* 1993). A brief description of indicators representing spatial scale of sustainability developed for the study is presented below.

Degree of crop heterogeneity on farms: The number of field crops grown per farm was considered to indicate crop heterogeneity. It was hypothesised that more the number of crops grown per farm, higher will be the sustainability of agriculture. Since higher crop heterogeneity introduces an element of informal insurance against risk in the farm business. Moreover, from ecological point of view, crop heterogeneity is preferred over monocropping.

Application of eco-friendly inputs: Eco-friendly inputs like farmyard manure, green manure and organic inputs help to sustain agricultural production in the long run, by maintaining the production environment relatively healthy. Therefore, if the quantity of these inputs is more, then such a farming system can be considered relatively more sustainable, even though such systems in general, may give lower yields. However, such reduced yields are offset by the advantage gained by the reduced dependence on external inputs and an accompanying reduction in adverse environmental inputs.

Ratio of cost of purchased inputs to the total cost of cultivation of the crop: If the ratio of cost of purchased inputs (including seeds, farm yard manure, fertilizers, plant protection chemicals, irrigation, hired labour, etc.,) to the total cost of cultivation of the crop is lower, such a farming system is said to be relatively more sustainable because it implies use of farm based organic inputs in larger quantities instead of inorganic forms of inputs. The scarcity of such inputs along with fluctuations in the input prices will influence their usage levels in crop production and consequently the crop performance.

Degree of pesticide use: Pesticides are generally used when there is pest or / and disease incidence. The indiscriminate use of pesticides results not only in the pest and disease organisms developing resistance over a period of time but also in the elimination of beneficial organisms like predators, pollinators, etc. This leads to high incidence of pests and diseases. Hence, if the degree of commercial pesticides used on the farms is greater, then, that farming system can be considered to be relatively less sustainable.

Fertilizer application per unit of cropped area: High levels of fertilizer application slowly affect the soil health, by altering the physical, chemical and biological properties of the soil and thereby the soil microbial activity gets impaired. In the long run, the soil is likely to become unsuitable for crop production. Hence, if the fertilizer application per unit of cropped area is more when compared with another unit of area for the same crop, then the former is said to be unsustainable over a period of time.

Per cent area under input intensive crops: The acreage under input intensive crops like paddy, sugarcane etc., per acre of cultivated land was calculated. In times of adversity, it will be difficult to maintain the level of production in the case of input intensive crops. It was hypothesized that a farming system with lower proportion of area under input intensive crops was more sustainable.

Income diversity index: The index was computed by considering the income obtained from different crop and livestock activities, NTFPs, kitchen garden and trees on farms. The index was obtained by using the formula

$$D_I = 1 / \sum_{i=1}^{n} (y_i / Y)^2$$

where, D_I = Income diversity index

y_i = Income from the i^{th} activity

Y = Total income from all activities

It is hypothesized that, higher the value of the index, greater will be the sustainability of farms because it implies relatively a lesser pressure on farms which is from ecological view more sustainable. A value of one reflects complete specialization.

8. *Net energy efficiency*: Agro-ecosystems depend on both ecological and agricultural forms of energy. When a natural system capable of producing a certain amount of energy containing biomass is converted into an agro-ecological system, the natural capability limit is often exceeded by adding energy inputs. The greater the input of external energy, the more the natural capability of the system can be exceeded and the less sustainable the system becomes. Because of this relationship, an analysis of an agro-ecosystem's output / input energy balance ratio can be a comprehensive indicator of its sustainability. The ratio reveals the energy balance of the entire farm by converting all physical units into their energy equivalents. The energy balance was computed for ragi crop as it was common for all four zones. A farm with a higher value can be considered as more sustainable than a farm with a lower value, because farm is able to produce more by making use of less energy units.

4.1.2 Resilience

Resilience can be considered as a measure of system stability because it indicates a system's (farm's) ability to absorb disturbances before it "flips" from one state to another (Holling quoted in Kooten and Bulte, 2000). In the present study, we have made an attempt to understand how a farming system can cope with shocks and stresses from external sources. Keeping this objective in view, the following indicators were developed.

1. *Average cash cost per unit of output*: The cash expenditure incurred for fertilizers, pesticides, hired labour, etc., to produce an unit of output was computed. Generally, the level of cash expenditure per unit of output could be related to risk, for example, in times of adversity, an individual farmer cannot afford to incur huge costs on farming alone as one has to meet the basic requirements first. Assuming this to be true, it can be hypothesised that higher the average cash cost per unit of output, lesser will be the resilience of the farming system in that particular zone.

2. *Average cash cost per rupee of gross returns from ragi crop*: The concept of the previous indicator holds well in this case also. The approach is slightly different, wherein the returns realised for the farm produce was accounted. Therefore, the hypothesis of the previous indicator holds well in this case also.

3. *Sensitivity analysis*: The sensitivity analysis approach was used to study the extent of reduction in net returns for changes in price of inputs and outputs. For this, a simulation exercise was performed. The prices of inputs and outputs were increased and decreased by 25 per cent each respectively. It was hypothesised that lower the reduction in average net returns upon increase or decrease in input and output prices, higher will be the resilience of that farming situation.

4. *Herfindahl index*: Herfindahl index was computed by taking sum of acreage proportion of each crop in the total cropped area.

$$\text{Herfindahl Index} = \sum_{i=1}^{n} P_i^{\,2}$$

where, N is total number of crops and P_i represents acreage proportion of the i^{th} crop in total cropped area. With the increase in diversification, the herfindahl index would decrease. This index takes a value one when there is complete specialisation and approaches zero as N gets large, that is, if diversification is ‘perfect’. Thus, the herfindahl index is bounded by zero and one. It is hypothesized that lower the value of herfindahl index, higher will be the resilience of the farm.

5. *Threshold yield*: It is the minimum yield to be realized to cover the total costs incurred in the production of a particular crop. In case of any external shocks or disturbances, crops with higher threshold yields will be unable to cover the total costs when compared to those with lower threshold yields. Therefore, lower the threshold yield, higher will be the resilience of the farming system.

6. *Per capita household expediture*: The ratio directly indicates financial resilience of households. A household (farm) with a lower amount of per capita expenditure is said to possess a greater resilience, because during the times of adversity, the household will be capable of reducing costs.

7. *Simpson index*: This was calculated to know the species richness on the farm. The diversity index is given by,

$$p_i = n_i / N, \qquad i = 1,2,3\ldots\ldots S$$

where n_i is the number of individuals of the i^{th} species and N is the known total number of individuals for all S species in the population. Simpson’s index varies from 0 and 1 gives the probability that two individuals drawn at random from a population belong to the same species. Simply stated if the probability is high that both individuals belong to the same species then the diversity of the community sample is low. This index was calculated for the tree species on the farm and diversity among the species within the kitchen garden maintained by the households.

8. *Supplemenatary income*: A higher level of supplementary income either from farm or non-farm sources will add to the financial resilience of the household (farm) as the household is not entirely dependent on farm income and thereby reducing the pressure on it.

4.2 Institutional and social factors influencing sustainable extraction of NTFPs and eco-friendly farming practices

To study the institutional and social factors influencing eco- friendly farming practices, rapid rural appraisal exercise was conducted and group discussion meetings were held with tribal farmers in BRT sanctuary area. In the meetings, the role of formal institutions such as Non-Governmental Organizations (NGO) operating in the area in educating the households about sustainable extraction of NTFPs, eco-friendly farming practices, environmental education was elicited. Further, informal institutions, social customs and norms prevalent among *soliga* tribe having a bearing on sustainability of traditional farming practices and collection of NTFPs was also studied. Only qualitative information on sustainability could be gathered as the time series data on these variables were not available since organizations operating in the region have not maintained this type of data. This was one of the important constraints faced in the research study.

4.3 Assessment of economic, environmental and supplementary benefits and associated (direct and indirect) costs from BDOAF

4.3.1 Economic benefits

Households in the study region derive a plethora of benefits from BDOAF, which includes economic as well as non-economic values. Economic values include consumptive and productive and non-economic values are mostly recreational values. Economists classify these uses / values as direct and indirect values (Freeman, 1993 and Flint, 1992). The study focused only on two types of direct use values namely consumptive and non-consumptive use values from BDOAF and ignored production values as they mostly pertain to use of genes and strains of crops for breeding purposes. The indirect values were also not considered due to paucity of required data and difficulty in administering questions for estimating those values.

The direct consumptive benefits (value) derived from BDOAF were computed considering the market value or opportunity cost of benefits and the associated costs in deriving such benefits. For valuation purpose, crop and livestock diversity, kitchen garden, trees on farms and Non-Timber Forest Products (NTFPs) were considered.

The gross returns from cultivation of various crops on farms were computed by multiplying the actual yield with market prices. The costs in the form of labour and other inputs were valued at market prices. The tribals in zone-1 and zone-2 harvested / gathered NTFPs from the forest located around the farms. The value of different products collected by the households was estimated taking into consideration the price paid by LAMPS to collectors. The opportunity cost of labour and incidental costs were considered for computation of costs. The returns from livestock in the form of milk, farmyard manure, sale of goat, sheep and poultry birds and bullock labour was considered at their market value / opportunity cost. Similarly, the associated costs of managing livestock in the form of labour and inputs were also taken into account. The fuelwood and fruits from the trees on farms were valued at market prices. Similarly, the benefits from kitchen garden in the form of vegetables, fruits and fuelwood were valued at market prices. Though the tribal people collected a number of NTFPs, only a few selected NTFPs were considered for the analysis, which were common to almost all households. Except green fodder, all other NTFPs were collected / gathered by the tribal households from the forest. In the case of green fodder, cattle were left for grazing in the forest. Hence, the quantity of grass consumed by the animal was valued using a standard procedure reported by Singh (1989).

[Fodder requirement of an animal per year] = [body weight of the animal] * 0.02 * 365 –[fodder obtained from agricultural products]

4.3.2. Environmental benefits

Biodiversity assumes characteristics of a public good because consumption and access to benefits from biodiversity are non-rival and non-excludable. (Hanley *et al*, 1997). BDOAF performs various environmental functions and thereby surrounding households are benefitted in several ways.

The flow of environmental benefits from the BDOAF in the study region was identified and expressed on a four point scale in order to reflect the importance and magnitude of flow of these services in each zone. In the present study, only three environmental services/goods namely, chemical free products, use of flora for medicinal preparations and eco-tourism were considered for estimation of their values, as estimation of value of other benefits required various scientific data on time series basis, which was not maintained.

4.3.2.1 Chemical free products

From the BDOAF in BRT, about 18 NTFPs are collected by the *soliga* tribe for both consumptive and economic purposes. Some of them are procured / extracted and processed organically without adulteration by an NGO at BRT. The products so obtained are almost akin to chemical free products. Therefore, the quality of these products is superior to those available in the market. In the present study, an attempt was made to quantify the price premium consumers were willing to pay for the quality using Contingent Valuation Method (CVM). Only four commonly used products namely honey, soapnut powder, turmeric and *magaliberu* were considered for the study. Using CVM, the premium that consumer was willing to pay for the quality of these products was estimated. For this purpose, a separate schedule was prepared and administered to 120 respondents drawn randomly from three diverse locations in Bangalore. Consumers from three localities in Bangalore city were explained the quality attributes of the four products before eliciting their WTP. The average, minimum and maximum amount, the consumer was willing to pay for these products over the current market price were estimated. Simple averages and percentages were used to analyse the data.

4.3.2.2 Medicines from flora

Although allopathic medical facilities are available in the BRT area, the tribal people use plant extracts to cure different types of ailments. Therefore, they are able to save a considerable amount on medicines, travel and incidental expenditures. Using 'replacement cost' approach, the savings made by tribal people on medicines and travel was estimated under certain assumptions. The replacement cost approach assesses the value of a resource / activity / illness to restore the original status. In this, we are trying to estimate cost involved in regaining health and by using natural medicines, how the tribal people can save in terms of modern medicine. The health damage suffered by a person is measured as the cost of restoration or replacement or acquisition of the equivalent of the services (medicinal plants) provided (Garrod and Willis,1999). However, the duration of illness, opportunity cost of illness, side effects of allopathic medicines and consequent costs were not considered because the respondents were not able to approximate the exact information of the same.

4.3.2.3 Eco-tourism

BRT has a game sanctuary and an ancient temple. The topography of BRT presents an aesthetic panoramic view at certain vantage points. These features of BRT attract quite a large number of tourists from different parts of the state. Thus, it as an important recreational site in the state. In order to estimate the recreational use value realized by tourists, a survey was carried out in BRT using a Travel Cost Method (TCM). A random sample of 100 respondents coming from various places such as Bangalore (190 kms from BRT), Mysore (110 kms), Mandya (90 kms) and others were selected. The schedule was administered to the sample visitors and data were collected during the months of May and June 2000, during which visitation by tourists to the BRT will be usually higher.

Use value (consumer surplus) derived by tourists from visiting BRT sanctuary can be determined based on revealed preferences of tourists (also referred to as behavior linkage method). Thus, when preferences are expressed for the eco-tourism service, it is easier to estimate the demand function and consumer surplus. Since, such sites fail to reflect true worth or market value of the use of the site, the TCM was used to estimate the value of the recreation site. In this method, travel cost and other incidentals incurred by the individual to reach the site were used as a surrogate for estimating the value of the site. As travel costs vary across individuals living at different distances from the site, the data on travel cost can be used to derive a demand curve for the site services. Then, the visitation rate per annum for each visitor was computed and was used in the functional analysis. Statistical demand functions were estimated by regressing the annual visitation rates upon the education, age, distance travelled and incidental expenses at the site.

The two variants of TCM are Zonal Travel Cost Model (ZTCM) and the Individual Travel Cost Model (ITCM). The ZTCM divides the entire area from which visitors arrive into a set of zones and then defines the dependent variable as the visitation rate. On the contrary, the ITCM defines the dependent variable as the number of site visits made by each visitor over a specified period. In the present study, ITCM was used as lack of access to zonal population data constrained the use of ZTCM (Harou *et al,* 1998).

The demand curve in ITCM model relates annual visits to the cost of trip and other variables which is represented as

$V = f(E, A, D)$

where,

V = Number of visits made by the individual in a year (visitation rate)

E = Annual income of individual

A = Age of the individual

D = Distance traveled

We used distance traveled as a proxy for the variable – cost of trip because in the earlier regression function estimation, the variable – cost of trip was not statistically significant. Hence, the reciprocal of the regression co-efficient of the variable – distance traveled was multiplied by 0.76 (cost of trip in rupees per kilometer) to obtain consumer surplus estimates. The cost of trip comprises incidental cost at site, actual travel costs and related expenditure.

A semi-log function was fitted to the data and Consumer Surplus (CS) was estimated as

$CS = 1/b_i * 0.76$

Where, b_i is the regression coefficient associated with the variable – distance traveled

0.76 = Average cost of trip per kilometer for sample respondents in rupees.

Semi-log function was purposively used to estimate the consumer surplus owing to its advantages over other functional forms. As described by Garrod and Willis (1999), semi-log function overcomes the problems of finite visits at zero cost and negative visits above critical costs in linear functional forms. This may cause certain problems in the statistical interpretation of the demand curve. Similarly, double log functional form implies infinite visits per head at zero cost and generates infinite consumer surplus whenever the demand for recreation is inelastic. The greatest appeal for semi-log function is, it implies a finite number of visits at zero cost. It never predicts negative visits even at very high costs. Computationally, it is easier to estimate consumer surplus. The regression function was estimated using the 'e-views', an econometric package.

Visitors' Willingness To Pay (WTP) for protection, maintenance and conservation of BRT was elicited from the same respondents who were interviewed for travel cost model to estimate use values (consumer surplus). A separate schedule was used for collecting data for TCM and WTP surveys.

4.3.3 Supplementary benefits from BDOAF

The BDOAF generates a plethora of products that do not have ready markets in the locality. Most of them were used for home consumption. In BRT, greens, tubers, fodder, mushroom, fuelwood, kitchen garden, fruit trees, etc. on farm were some of the supplementary benefits derived by *soliga* tribe from BDOAF. These products were valued by considering the value of close substitutes or opportunity cost.

4.4 Social Accounting Matrix Analysis

SAM reflects every aspect of the functioning of a village economy such as production and consumption, savings and investment, income generation and its distribution, transfers and external trade and income flows. Data are presented in the form of a square matrix. The row represents the demand for a product and the corresponding column represents the supply for producing the same. In other words, each row corresponds receipts to the account and the corresponding column shows how the total receipts are distributed to other accounts.

The village economy is characterised by a set of simple production accounts and relatively complex labour allocation patterns. Family labour may be allocated to agriculture production, livestock maintenance, collection of NTFPs, wage work or any other kind of work either inside the village or outside the village. For each production activity, the rows contain payments received by the activity for the commodities that it produces (and sells to the commodity accounts). The corresponding column account breaks up value of total output into value of intermediaries, payments to factors, profits accruing to the owners of the activity (in this case, households), etc. The commodity row accounts give the components of total demand, intermediate use, consumption demand by household group and exports. The commodity column accounts show what part of each commodity's total supply comes from each production activity and imports. The factor accounts are of great importance because they show how factor incomes are generated and distributed to households and other institutions. The household and other institutional accounts show the sources of each institution's income (along the row) and the objects of expenditure (down the column) such as consumption, savings, etc. The capital row account shows each household group's savings and the column account breaks up total investment (which equals total savings). Finally, the rest of the world row account shows payments made by the village to the rest of the world. The column account shows payments received by the village from outside the village (Subramanian and Sadoulet, 1990).

A theoretical village SAM model is presented in Table 3. The Input-Output (I/O) for village economy (entry 1,1) consists of mainly four sectors such as NTFPs, agriculture, livestock and trade. The NTFPs sector is divided into fodder, food and non-food sub-sectors. Trade sector refers to the retailing (sales and purchases) of goods produced within the village. The village economy is likely to have a large import component (5,1) since the economy is subsistence in nature. As the transition from a subsistence to a market economy unfolds, an increasing share of village production will tend to be exported (1,5). The village production activities result in income payments to capital (2b, 1) and labour (2a, 1). Payments to capital include imputed returns to capital. Separate entries are made for hired and own labour services in order to provide a sharper

Table 3: An outline of Social Accounting Matrix framework

Sl. No.	Expenditures / Receipts	1 Activities	2 Factors	3 Institutions	4 Capital	5 Rest of the World	6 Total
1.	Activities a. NTFPs i. Fodder ii. Food iii. Non-food b. Agriculture c. Livestock d. Trade	Village input-output table		Consumption	Investment	Exports	Total sales
2.	Factors a. Labour i. Family labour ii.Hired labour b. Capital	Value added in village production					Total labour and capital value added
3.	Institutions a. Landless b. Marginal c. Small d. Large		Payments to households for labour and capital services used in production	Payments to house-holds for labour services outside the village		Wages earned from outside the village	Total household income
4.	Capital			Household savings			Total savings
5.	Rest of the world	Imports					Total imports from the Rest of the world
6.	Total	Total sales	Total payments to labour and capital	Total institutional expenditures	Total capital investment	Total exports to the Rest of the world	Total Receipts/ Expenditures

focus on inter-household farm-labour linkages in village production activities. Together, accounts I and 2 represent the flow of commodities across product markets and of inputs across factor markets within the village economy (Adelman *et al* 1988).

The value additions at village level and wage income are channeled into four village household institutions. The household institutions are defined by size of holdings using Small Farmers Development Agency (SFDA) classification. The institution accounts (3a-d) provide a detailed breakdown of payments for labour services supplied by village households to employers both inside and outside the village. Total payments to the households for labour services in village production are represented by entries (3a-d, 2).

The household accounts in turn, channel household income into final village consumption demand for village products (1a-d, 3) and savings. The household savings are represented by the entry (4, 3). Total imports into the village from Rest of the World are shown by the entry (5, 1). The capital investment entry (1,4) may or may not play a significant role depending on the nature of the village economy.

Transforming the social accounting matrix into a predictive model requires several procedural steps such as delineation of accounts into exogenous and endogenous, transformation of SAM into technical co-efficient matrix and finding out multiplier through matrix inversion.

Multipliers generated from the SAM are supply driven, especially in zone-1 and zone-2 because the village production sectors such as agriculture, NTFPs and livestock are little affected by demand. The rise in demand for above products is met by import. There is very little scope to bring more area under cultivation and increasing productivity through intensive cultivation is remote due to the low economic status of tribal households in rainfed area. The cash income from NTFPs depends on the productivity and health of the forest. Weather conditions also play a crucial role.

Multipliers generated from the SAM could be demand driven, especially in zone-3 and zone-4, because the agricultural production activity is designed to meet the demand of the outside market, after meeting the internal demands. The basic foods required may be produced at village level or purchased in the market. The farmers in these zones are highly profit-oriented, commercial in nature and the irrigation facility also helps them to engage in commercialized farming activity.

The technical coefficients of production through household accounts of the SAM are calculated in a form where a_{ij} is a technical co-efficient calculated as Z_{ij}/X_j and denotes the flow Z, from SAM sector i to SAM sector j and X is the total gross output of SAM sector j. Table 4 gives the accounting relationships of SAM.

The endogenous accounts include production sectors, factors of production and institutions / households. Accounts such as rest of the world are treated as exogenous accounts. The endogenous accounts are balanced by construction, having equal row and column sum vectors. When there is only one exogenous account, the total of the leakages or outflows out of the village (the row sum of L) is equal to the sum of the initial injection in the economy (the column sum of X). However, when there are several exogenous accounts, this does not hold for each account individually, but only in the aggregate.

Equation (1) states that transactions between endogenous accounts denoted by matrix N, can be expressed as the product of a square matrix, A_n, of average propensities to consume and a vector of endogenous incomes, y_n. Similarly, equation (2) equates leakages, L, with the product of a non-square matrix, A_l, of average propensities to leak and the endogenous income, y_n. It is important to note that the matrices A_n and A_l can be obtained directly. Equation (3) and (4) express the accounting relationships by which endogenous incomes are determined. Equations (5) and (6) have the same role with respect to incomes of the exogenous accounts, y_x.

Table 4: Accounting relationships of SAM

Expenditures / Receipts	Endogenous accounts	Exogenous accounts	Totals
Endogenous accounts	$N = A_n y_n$ ………………(1)	X	$y_n = n + x$…………(3) $= A_n y_n + x$……..(4)
Exogenous accounts	$L = A_l y_n$…………………..(2)	R	$y_x = l + Ri$…………(5) $= A_l y_n + Ri$……(6)
Totals	$y'_n = (i' A_n + i' A_l) y_n$…….(7) .. $i' = i' A_n + l' A_l$ …………(8)	$y'_x = i' X + i' R$………..(9) .. $A_l y_n - X'_i = (R-R')i$…(10)	$\lambda'_a y_n = x' i$………..(11)

Source: Pyatt and Roe (1979)

Note:

$A_n = Ny_n^{-1}$ = matrix of average endogenous expenditure propensities

$A_l = Ly_n^{-1}$ = matrix of average propensities to leak

$Ni = n$ = vector of row sums of $N = A_n y_n$

$Xi = x$ = vector of row sums of X

$Li = 1$ = vector of row sums of $L = A_l y_n$

$\lambda'_a = i' A_l$ = vector of column sums of A i.e., the vector of aggregate average propensities to leak

N = matrix of SAM transactions between endogenous accounts

X = matrix of injections from exogenous into endogenous accounts

L = matrix of leakages from endogenous into exogenous accounts

R = matrix of SAM transactions between exogenous accounts

Equation (7) sums expenditures (columns) of the endogenous accounts. It implies that, for these accounts, row and column sums will be equal provided equation (8) holds, that is, provided column sums of A_n plus those of A_l add to unity in all cases. Equation (9) expresses column sums for exogenous accounts. The requirement that these be equal to row sums [equation (6)] yields equation (10). Finally, an implication of (10) is obtained in (11), which states that, in aggregate, injections into the system must equal the leakages.

From equation (4) and definition of l, it follows that $Y_n = (I-A_n)^{-1}x = M_a x$ and $l = A_l(I-A_n)^{-1}x = A_l M_a x$ provided that $(I-A_n)^{-1}$ exists. This inverse is the accounting multiplier matrix M_a which relates endogenous incomes y_n to injections x (Pyatt and Roe, 1979).

Social accounting matrices were computed for all the zones, separately. The data collected from the sample households were averaged out and then blown up for the population in each institution by multiplying the corresponding average by the total number of households in that category for all the zones separately.

SAM analysis was performed for all the zones separately. The production multiplier matrix and household income multiplier matrix were derived from the Leontief inverse matrix.

4.5 Dependency of the households on BDOAF

The *soliga* tribe living around the forests in BRT depends on BDOAF for a plethora of benefits. The dependency of the households on BDOAF was assessed in terms of total economic value of the benefits, employment pattern and consumption pattern.

4.5.1 Total economic value

The total economic value of benefits derived by the households from BDOAF was computed by taking into consideration agriculture, livestock, NTFPs collection, utilities from trees on farm, kitchen garden, wage income and others. The dependency of the households was estimated by computing the proportion of the benefits exclusively derived from BDOAF in the household income.

4.5.2 Employment pattern

The extent of dependency of the households for their employment on different sources namely agriculture, wage employment, livestock, collection of NTFPs and other sources was computed in terms of labour days for men and women.

4.5.3 Consumption pattern

The share of food items derived from BDOAF out of the total food consumption by the households was assessed for indicating household's dependency on BDOAF for food items. The dependency on market and on farm was estimated for the households in each zone.

4.6 Allocative efficiency of resources

The primary objective of any rational farmer is profit maximization from farm activities. It is imperative that one allocates resources keeping in view the respective contributions in monetary terms. Thus, the degree to which this is accomplished is determined by measuring the allocative efficiency of resources. Under these conditions, if the marginal contribution of one unit of input is greater than its price, the resource allocation is said to be efficient and there is scope for application of more input. If the marginal contribution of one unit of input is less than the price of the input in question, then the farmer is said to be inefficient in input use.

Allocative efficiency is determined by calculating the ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC). The Marginal Physical Product (MPP) of each input times unit price of output (price/unit quantity) gives the MVP i.e.,

$MVP_i = MPP_i * P_y$

where, MPP_i = Marginal physical product of i^{th} input

P_y = Unit price of output

The marginal physical product was estimated at geometric mean level of i^{th} input. The marginal product of i^{th} input was derived from the respective production function, which best explains the relationship.

The use of production function varied with type of crops across zones. The variables used in general were as follows.

$Y = f(x_1, x_2, x_3, x_4, x_5)$

Y= Total returns from specific crop (Rs.)

X_1= Area under the crop (acres)

X_2= Value of farm yard manure used (Rs.)

X_3= Value of fertilizers used (Rs.)

X_4= Value of labour used in cultivation (Rs.)

X_5= Value of seeds (Rs.)

Semi-log production function was fitted for ragi in zone-4 and zone-3 by incorporating above variables in the function. However, Cobb-Douglas production function was fitted for ragi in zone-2 and zone-1 with seeds as the explanatory variable.

4.7 Environment Economics Component

4.7.1 Economic value of reduction in dependence of farms on external inputs due to environmental and economic benefits from eco-friendly farming systems of BDOAF

As farms generate lot of benefits from BDOAF, it could be expected that farms with rich BDOAF would depend less on external sources for various inputs. Thus, there will be considerable savings in monetary terms as well. The economic value of such expenditure was worked out for ragi crop for all the zones. The economic value of reduction in dependency was estimated by computing shares of farm and non-farm sources of inputs.

4.7.2 Ecosystem health indicators

The indicators of general health of the ecosystem namely level of use of mechanical and chemical energy, crop and floral diversity, eco-friendly food produced on the farm and number of medicinal preparations from plants used for human ailments were computed. These variables were identified to amply reflect the condition of bio-ecosystem health. In the development of indicators, emphasis was placed on the ecological aspects of farming systems by focussing the effect of modern input use in agriculture on the ecology.

4.7.3 Quality of life

The quality of life as indicated by consumption pattern was studied in two ways. Firstly, the share of nutritive food in total consumption basket and the proportion of this derived from farm and BDOAF sources, secondly, expenditure on human development components namely, education, clothing and high value foods.

4.7.4 Direct use values of selected benefits from BDOAF

The value of biodiversity is often difficult to define and estimate. This indicates that although biodiversity rarely has a money price in local or international markets, its economic value is wide ranging and significant (Flint, 1992). Economists recognize two main types of values viz. use values and non-use values. Use values refer to the current or future utilitarian value of biodiversity to humankind and can be subdivided into consumptive, non-consumptive and productive. The consumptive and non-consumptive values were computed for zones 1 and 2. Three types of benefits (functions) of BDOAF reflecting consumptive use value namely, NTFPs extraction, chemical-free products and medicinal flora and one type of function reflecting non-consumptive use value namely, recreation was estimated using approximate environmental impact assessment methods.

CHAPTER V: RESULTS

In this chapter, results of the analysis obtained with the help of the analytical tools discussed in the previous chapter have been presented. The results are presented under the following heads.

5.1 Socio-economic characteristics of the sample households

5.1.1 Land holdings, family size and literacy

The socio-economic characteristics of the sample households are presented in Table 5. The average land holding size was 1.52, 2.03, 2.76 and 3.40 acres per household in zone-1, zone-2, zone-3 and zone-4 respectively. In all the four zones, the average size of the family was almost the same. The average size of the family was 5.73, 6.00, 6.00 and 6.03 in the four zones respectively. As far as the family composition was concerned, all the families in all the zones had almost the same number of male members. The number of male members per family was 3.03, 3.10, 3.20 and 3.30 in the four zones respectively. Similarly, the number of female members per family was almost the same in all the zones. The number of female members per family was 2.07, 2.90, 2.80 and 2.73 in zone-1, zone-2, zone-3 and zone-4 respectively.

It was found that literacy rate was relatively higher in zone-3 and zone-4 compared to that in zone-1 and zone-2. The literacy rate was 20.35, 22.22, 36.11 and 34.80 per cent in zone-1, zone-2, zone-3 and zone-4 respectively.

5.1.2 Livestock possession of the sample households

In the study area, livestock comprised cattle, buffalo, goats, sheep and poultry. The details of livestock particulars are depicted in Table 6. With regard to cattle, the number of animals maintained per household in zone-1 was 0.43. The cattle number was the highest in zone-2 (2.97) as compared to other zones. The number of cattle was 2.03 and 1.93 in zone-3 and zone-4 respectively.

It was found that, respondents did not own buffaloes in zone-1 and zone-2 whereas; their number was 0.26 and 0.47 in zone-3 and zone-4 respectively. With respect to goats, the number of animals per household in zone-2 was higher than that of other zones. The number of goats per household was 1.47, 2.57, 1.37 and 0.43 in zone-1, zone-2, zone-3 and zone-4 respectively. On the contrary, the number of sheep per household was more or less the same in all the zones. The number of sheep per household was 0.53, 0.87, 0.90 and 0.53 in the four zones respectively. The average number of poultry birds per household was found to be highest in zone-1 at 4.86 per household. The number of poultry birds per household was 3.43, 1.50 and 1.77 in zone-2, zone-3 and zone-4 respectively.

Table 5: Socio-economic characteristics of sample respondents in different zones (per household)

Sl. No.	**Socio-economic indicators**	**Zone-1**	**Zone-2**	**Zone-3**	**Zone-4**
1.	Land (acres)	1.52	2.03	2.76	3.40
2.	Family size (numbers)	5.73	6.00	6.00	6.03
	a. Male members (nos.)	3.03	3.10	3.20	3.30
	b. Female members (nos.)	2.07	2.90	2.80	2.73
3.	Literacy (%)	20.35	22.22	36.11	34.80

Table 6: Livestock details of sample respondents in different zones (Number per household)

Sl. No.	Livestock	Zone-1	Zone-2	Zone-3	Zone-4
1.	Cattle	0.43 (10.00)	2.97 (56.66)	2.03 (66.66)	1.93 (53.33)
2.	Buffalo	0.00	0.00	0.26 (10.00)	0.47 (26.67)
3.	Goats	1.47 (40.00)	2.57 (46.67)	1.37 (23.33)	0.43 (13.33)
4.	Sheep	0.53 (20.00)	0.87 (23.33)	0.90 (16.66)	0.53 (16.66)
5.	Poultry	4.86 (66.66)	3.43 (43.33)	1.50 (16.66)	1.77 (20.00)

Note: Figures in parentheses indicate percentage of sample households possessing livestock

5.1.3 Type of land holdings in different zones

The type of land holdings consisted of dry, irrigated and fallow lands and the particulars of which are furnished in Table 7. The land type in zone-1 was predominantly rainfed and the per farm rainfed land was 1.49 acres. The land type in zone-2 was a mixed one with rainfed and irrigated land covering 70.44 per cent and 18.72 per cent of the farm size respectively. In zone-3, the irrigated land formed 73.91 per cent of the total farm land size (2.76 acres) and rainfed land accounted for 25.36 per cent of the total farm land. In zone-4, the irrigated land formed 89.09 per cent out of the total farm size of 3.39 acres and only 7.08 per cent was rainfed.

5.1.4 Cropping pattern

The details of cropping pattern and area under major crops are presented in Table 8. The major crops grown in the study region were ragi, paddy, sugarcane and coffee. In zone-1, the cropped area was distributed almost evenly between ragi (54.05 %) and coffee (45.95 %). The total area covered under these crops in sample respondent farms was 44.60 acres. On the contrary, in zone-2, the area under major crops (ragi and paddy) was 54.50 acres. Out of this, ragi covered 79 per cent and the rest was paddy area.

Table 7: Land type in different zones **(in acres)**

Sl. No.	Land type	Zone-1		**Zone-2**		**Zone-3**		**Zone-4**	
		Total	**Per farm**	**Total**	**Per farm**	**Total**	**Per farm**	**Total**	**Per farm**
1.	Dryland / Rainfed	44.60	1.49 (98.03)	43.00	1.43 (70.44)	21.00	0.70 (25.36)	7.25	0.24 (7.08)
2.	Irrigated land	0	0	11.50	0.38 (18.72)	61.32	2.04 (73.91)	90.65	3.02 (89.09)
3.	Fallow land	1.00	0.03 (1.97)	6.50	0.22 (10.84)	0.50	0.02 (0.07)	4.00	0.13 (3.83)
4.	**Total**	45.60	1.52	61.00	2.03	82.82	2.76	101.90	3.39

Note: Figures in parentheses indicate percentage to the total per farmland size

Table 8: Cropping pattern in different zones (in acres)

Sl. No.	Crops	Zone-1		Zone-2		Zone-3		Zone-4	
		Total	Per farm	Total	Per farm	Total	Per farm	Total	Per farm
1.	Ragi	24.25	0.80 (54.05)	43.00	1.43 (79.00)	16.75	0.55 (21.15)	9.25	0.31 (10.58)
2.	Paddy	0.00	0.00	11.50	0.38 (21.00)	39.83	1.33 (51.15)	57.15	1.90 (64.84)
3.	Sugarcane	0.00	0.00	0.00	0.00	21.50	0.72 (27.70)	21.75	0.72 (24.58)
4.	Coffee	20.35	0.68 (45.95)	0.00	0.00	0.00	0.00	0.00	0.00
5.	Total	44.60	1.48	54.50	1.81	78.08	2.60	88.15	2.93

Note: Figures in parentheses indicate percentage to the total per farm cropped area

In zone-3, the major crops were ragi, paddy and sugarcane. The area under major crops was about 78 acres. Out of this, the share of ragi, paddy and sugarcane was 21.15, 51.15 and 27.70 per cent respectively. Paddy accounted for a major chunk of area in zone-3. In zone-4, the area under the major crops (ragi, paddy and sugarcane) was 88.15 acres, out of which, the share of ragi, paddy and sugarcane was 10.58, 64.84 and 24.58 per cent respectively. Paddy accounted for the largest area in zone-4 also.

5.1.5 Yields of major crops in the four zones

The average yields of major crops obtained by farmers in different zones are presented in Table 9. In the case of ragi, farmers in zone-4 realised the highest yield of 709 kilograms (kgs) per acre while in zones 1, 2 and 3, ragi yields were 158, 355 and 657 kgs per acre respectively. For paddy and sugarcane, yields were highest in zone-3. Farmers in zone-1 did not raise paddy and sugarcane due to lack of assured irrigation.

Table 9: Average yields of major crops in different zones (in kgs per acre)

Sl. No.	Crops	Zone-1	Zone-2	Zone-3	Zone-4
1.	Ragi	158	355	657	709
2.	Paddy	-	846	1891	1764
3.	Sugarcane	-	-	45310	44580

5.2 Sustainability and resilience of farms

5.2.1 Sustainability

The sustainability of farming systems was studied through different indicators developed for the study. The values of various sustainability indicators for the four zones are furnished in Table 10. The indicators reflect physical, economic and environmental aspects of sustainability of farming systems. It could be observed from the table that the degree of crop heterogeneity of farms was the highest at 3.8 in the biodiversity rich zone (zone-1), whereas, it was lowest in the biodiversity poor zone (zone-4) at 1.60. While the per cent area under input intensive crops raised by the farmers in biodiversity rich zone (zone-1) was nil, it was highest (91%) in zone-4. It was estimated that, the fertilizer application per acre of cropped area was the highest in the biodiversity poor zone (zone-4) at 233.97 kgs, whereas, it was nil in biodiversity rich zone. Even in zone-3, the application of fertilizers to crops was more than that of zone-2.

Pesticide use for plant protection against pests and diseases was relatively higher in zone-4 than in the other zones. It was observed that on an average, each farm household spent about Rs. 118.59 on plant protection chemicals in the biodiversity poor zone (zone-4). The pesticide usage declined as we move from zone-3 to zone-1.

Table 10: Indicators of sustainability of farming systems

Sl. No.	Indicator	Zone-1	Zone-2	Zone-3	Zone-4
1.	Degree of crop heterogeneity on farms	3.8	3.03	1.53	1.60
2.	Per cent area under input intensive crops	0	20.00	77.00	91.00
3.	Quantity of fertilizer (kgs per acre)	0	34.86	187.38	233.97
4.	Pesticide use (Rs. per acre)	0	13.81	121.15	118.59
5.	Eco-friendly inputs (Rs. per acre)	0	165.74	520.18	497.10
6.	Ratio of cost of purchased inputs to total cost of cultivation	0	0.17	0.86	0.88
7.	*Income diversity index*	2.45	3.89	2.29	2.15
8.	Net energy efficiency	3.90	2.29	1.85	2.44

The indicator of eco-friendly input (FYM) use showed that the application of FYM was highest (Rs. 520.18) in zone-3 followed by zone-4 (Rs. 497.10) and zone-2 (Rs. 165.74). However, in zone-1, farmers did not apply FYM for any crop at all.

The indicator of ratio of cost of purchased inputs to the total cost of cultivation revealed that farmers in zone-4 (biodiversity poor zone) depended on external inputs to the extent of 88 per cent (0.88) of their input requirements as compared to absolute non-dependence of farmers in zone-1. In zone-2, it was about 17 per cent and in zone-3 it was almost equivalent to that of zone-4. The income diversity index for zone-2 was the highest at 3.89 followed by zone-1 (2.45), zone-3 (2.29) and zone-4 (2.15).

A detailed analysis of energy use pattern will throw light on the requirement and sustainability of crop production activity. The energy use is represented in the form of energy balance by converting all physical units (both inputs and outputs) into their energy equivalents and is expressed in MJ per acre. The energy balance was computed for ragi crop, as it was common for all the four zones. The output / input energy balance ratio was highest in zone-1 at 3.90 followed by zone-4 (2.44). The ratio was the lowest for zone-3 (1.85).

5.2.2 Resilience

The resilience of farms in the four zones was examined in terms of various indicators that reflected physical and economic dimensions of farms and the results are furnished in Table 11.

It is evident from the table that, the average cash cost per unit of output for ragi was the lowest at Rs. 0.13 in the biodiversity rich zone, whereas, it was highest in zone-3 with a value of Rs. 6.22. However, in zone-4, which is very poor in terms of biodiversity, average cash cost per unit of output of ragi was 2.67. In the present study, only ragi crop was considered for comparison purpose because ragi was the only crop, commonly grown in all the four zones. The indicator of average cash cost per rupee of gross returns reveals the ability of the farm business to recover quickly from financial shocks. Thus, lower the value, the greater will be the resilience of farms. Farmers in zone-1 incurred only Rs. 0.03 as cash cost to realize one rupee of gross income. On the contrary, in zone-3, the cash cost exceeded the returns, while in zone-4, it was substantially higher at Rs. 0.53.

The effect of changes in market prices (sensitivity analysis) on the profitability of ragi crop was examined. A 25 per cent rise in input prices would result in the greatest reduction of net returns to the extent of 314.01 per cent in zone-3 followed by 28.32 per cent in zone-4 and 5.22 per cent in zone-2. The reduction in net returns was lowest in zone-1 at 0.72 per cent. Similarly, the effect of changes in market price of output revealed that, a 25 per cent fall in output price would reduce net returns from ragi crop to the extent of 339.01 per cent in zone-3. While in zone-1 (biodiversity rich zone), the effect of price decline was the lowest (25.72 %).

Table 11: Indicators of resilience of farming systems

Sl. No.	Indicator	Zone-1	Zone-2	Zone-3	Zone-4
1.	Average cash cost per unit of ragi output	0.13	0.95	6.22	2.67
2.	Average cash cost per rupee of gross returns from ragi crop	0.03	0.19	1.21	0.53
3.	Per cent reduction in net returns from ragi crop (sensitivity analysis), due to				
	- 25 % increase in price of inputs	0.72	5.22	314.01	28.32
	- 25 % decrease in output price	25.72	30.22	339.01	53.22
4.	Herfindahl index	0.63	0.69	0.78	0.76
5.	Threshold yield (kgs / acre)	4.35	57.83	589.03	366.52
6.	Per capita household expenditure (rupees)	9903	11163	23631	21100
7.	Simpson index	0.56	0.41	0.24	0.20
8.	Supplementary income (BDOAF sources)	5265.68	3019.01	129.47	88.33

The Herfindahl index shows the degree of crop diversification on the farms. The lower the value of index, the greater will be the crop diversification on the farms. The analysis indicated that the index for zone-1 was found to be lowest (0.63) and it was highest for zone-3 (0.78). The Simpson's index was computed to know the tree species diversity on farms. The results of analysis revealed that tree species diversity was the greatest in zone-1 as the value was highest at 0.56. It progressively declined with the level of biodiversity, the least being 0.20 in zone-4.

Threshold yields were computed to know the minimal level of yield to be realized to cover the total costs per unit area, which explains the degree of resilience of farms. The threshold yield for ragi in zone-1 was very low at 4.35 kgs, whereas, it was highest in zone-3 with a value of 589.03 kgs per acre. While, households in zone-4 required 366.52 kgs to cover the costs. It was only 57.83 kgs in zone-2.

5.3 Institutional and social factors influencing the sustainable extraction of NTFPs and traditional farming practices

In order to examine whether NTFPs were being collected / extracted from BRT area in a sustainable manner, the time series data (1995-96 to 1999-2000) on quantity collected for six important NTFPs was considered for the entire *soliga* tribe in BRT sanctuary. The data presented in Table 12 exhibited divergent trends in the collection for the period under consideration for five products. In the case of gooseberry, the cyclical pattern of productivity which spans a 3-4 years cycle revealed a sustainable extraction pattern. However, we could not arrive at any conclusion on sustainable extraction of the other NTFPs. However, we attempted to study the role of institutions (both formal and informal) in educating and promoting sustainable extraction / harvesting methods and practices.

Group meetings and Rapid Rural Appraisal (RRA) exercises conducted at BRT showed that formal institutions (NGOs) were imparting training and education on various environmental issues including sustainable extraction of NTFPs to *soliga* community. Table 13 shows various educational activities undertaken on environment by the institutions operating in BRT area. The Integrated Tribal Development programme of Vivekananda Girijana Kalyana Kendra (NGO) encompasses formal education on environment, biodiversity documentation and job - oriented courses to train *soliga* youth.

Another NGO, Ashoka Trust for Research in Ecology and the Environment (ATREE), primarily a research organisation on ecology and environment involves local tribal community in Participatory Resource Monitoring (PRM). In this programme, the local community is involved in the estimation as well as mapping of the productivity of the NTFPs yielding species. This kind of exercise will help in determining the sustainable extraction levels of NTFPs at different sites. The Forest Department through its personnel educates the community about the proper method of extraction of NTFPs. In addition to the above, informal institutions,social norms

Table 12: Collection pattern of selected NTFPs for the period 1995-2000

(quantity in kg)

Sl. No.	Name of the NTFP	1995-96	1996-97	1997-98	1998-99	1999-2000
1.	*Alale*	54	139	262	74	89
2.	*Antavala*	239	189	1374	915	429
3.	Gooseberry	73754	35799	25537	13656	74945
4.	Honey	927	5253	8000	6710	530*
5.	Lichens	7029	14046	3133	7288	5128
6.	Soapnut	118	1233	549	1621	48

Source: Records maintained by LAMPS, B.R. Hills
* Some discrepancy was noticed in the figure as expressed by sources of data customs, psychological beliefs play an important role in the conservation of biodiversity.

Table 13: Programmes for promoting sustainable extraction of NTFPs

Institutions	Programme / Training	Related to Pro-BDOAF
VGKK	School education	Course exclusively on Environment.
VGKK	Vocational training	Job oriented course to train soliga youth on sustainable management of forests.
VGKK	Integrated Tribal Development Programme	Documentation of the floral and faunal diversity.
ATREE	Participatory Resource Monitoring	Community is involved in estimation, mapping of resources and determination of optimum extraction levels of NTFPs.
Forest Department	Awareness activities	Knowledge about sustainable extraction of NTFPs.
Grama Soliga Abhivruddi Sanghas	Campaigns	Environmental education to create awareness on sustainable extraction and fight against threats to biodiversity (eg: quarrying, resorts, etc.).

Informal Institutions	Traditions, customs, religious practices and social norms	1. Community decisions on sustainable extraction of NTFPs. 2. Worship sacred trees and animals. 3. Offering prayers and performing rituals before collection of NTFPs. 4. Traditional knowledge on the importance of biodiversity is imparted to younger generation.

Note: VGKK – Vivekananda Girijana Kalyana Kendra

ATREE – Ashoka Trust for Research in Ecology and the Environment

5.4 Economic, environmental and supplementary benefits from BDOAF vis-à-vis commercial farming

5.4.1 The economic value of selected direct benefits of biodiversity on and around farms

The economic benefits derived from BDOAF by the soliga tribe are presented under the following sub-heads.

5.4.1.1 Non Timber Forest Products (NTFPs)

Only the households in zone-1 and zone-2 derived economic benefits from NTFPs collection. The tribals collected around 18 different NTFPs to meet their consumption and cash requirements. It could be observed from Table 14 that, the total income from NTFPs collection was higher in zone-1 (Rs.10,496.70) compared to zone-2 (Rs. 4,972.25). Further, the type of NTFP availability varied in different locations, which was reflected in terms of efforts (costs) needed for the collection. The B:C ratio of a majority of the commodities except alale and antavala was lower in zone-2 when compared to that of zone-1.

5.4.1.2 Benefits and costs from agriculture

Ragi was the staple food crop and hence it was grown in all the four zones. A comparison of the benefit-cost ratio for ragi across the zones revealed that the net returns was highest in zone-4 (Rs. 1,074.70) followed by zone-3 (Rs. 607.30), zone–2 (Rs. 556.49) and in zone-1 (Rs.333.16). Paddy was cultivated in all the zones except zone-1, whereas sugarcane was found in zone-3 and zone-4 only (Table 15). Paddy production was not profitable in zone-2 as the B:C ratio was less than one. From this, it could be inferred that, in zone-3 and zone-4, agriculture was commercialized compared to zone-1 and zone-2. In the zones 1 and 2, the entire farm output was consumed by the households while in the case of zone-3 and zone-4, only a part of the yield was retained for home consumption and the rest was marketed.

Table 14: Composition of economic value of benefits from biodiversity around farms

(rupees / year / household)

Sl. No.	Name of the NTFP	Zone-1					Zone-2				
		NCI	CI	Total income	Total cost	B:C Ratio	NCI	CI	Total income	Total cost	B:C Ratio
1.	Alale	-	101.33 (1.65)	101.33 (0.96)	44.11 (1.49)	2.3	-	48.66 (2.18)	48.66 (0.97)	7.81 (0.29)	6.23
2.	Antavala	52.60 (1.20)	163.40 (2.66)	216.00 (2.05)	118.35 (4.01)	1.83	-	66.33 (2.97)	66.33 (1.34)	3.75 (0.14)	17.68
3.	Beewax	-	117.83 (1.92)	117.83 (1.12)	7.50 (0.25)	15.71	-	22.86 (1.02)	22.86 (0.46)	-	-
4.	Broom	-	-	-	-	0	-	8.33 (0.37)	8.33 (0.16)	9.37 (0.35)	0.89
5.	Dhoopa	2.40 (0.05)	4.20 (0.06)	6.6 (0.06)	13.50 (0.46)	0.49	-	-	-	-	0
6.	Fuelwood	2951.3 0 (67.63)	-	2951.30 (28.12)	972.95 (32.99)	3.03	1483.17 (54.15)	328.49 (14.71)	1811.66 (36.43)	994.68 (36.95)	1.82
7.	Gooseberry	-	1062.80 (17.33)	1062.80 (10.13)	230.67 (7.82)	4.6	-	737.33 (33.02)	737.33 (14.82)	342.17 (12.7)	2.15
8.	Green fodder	161.53 (3.70)	-	161.53 (1.54)	41.51 (1.41)	3.90	285.83 (10.43)	-	285.83 (5.75)	217.25 (8.07)	2.00
9.	Greens	142.33 (3.26)	-	142.33 (1.36)	-	-	79.33 (2.90)	-	79.33 (1.60)	-	-
10.	Honey	232.00 (5.32)	863.00 (14.07)	1095.00 (10.43)	458.06 (15.53)	2.4	92.30 (3.36)	327.28 (14.66)	419.58 (8.44)	209.31 (7.78)	2.00
11.	Horns	-	399.05 (6.51)	399.05 (3.80)	30.13 (1.02)	13.24	-	126.43 (5.66)	126.43 (2.54)	53.25 (1.98)	2.37

Sl. No.	Name of the NTFP	Zone-1					Zone-2				
		NCI	CI	Total income	Total cost	B:C Ratio	NCI	CI	Total income	Total cost	B:C Ratio
12.	Lichens	-	1795.83 (29.27)	1795.83 (17.10)	544.35 (18.46)	3.3	-	468.10 (20.96)	468.10 (9.41)	208.96 (7.76)	2.24
13.	Makaliberu	-	12.33 (0.20)	12.33 (0.12)	7.5 (0.25)	1.64	-	112.85 (5.05)	112.85 (2.27)	188.02 (6.98)	0.60
14.	Moss	-	1502.11 (24.49)	1502.11 (14.31)	258.17 (8.75)	5.82	-	-	-	-	0
15.	Mushroom	306.00 (7.01)	-	306.00 (2.92)	-	-	246.97 (9.02)	-	246.9 (4.96)	147.11 (5.47)	1.68
16.	Roots and tubers	451.66 (10.35)	-	451.66 (4.30)	182.96 (6.20)	2.47	551.66 (20.14)	-	551.66 (11.09)	277.40 (10.30)	1.98
17.	Shilinabitha	-	-	-	-	0	-	20.00 (0.89)	20.00 (0.45)	12.5 (0.46)	1.6
18.	Soapnut	63.50 (1.45)	111.50 (1.82)	175.00 (1.67)	39.07 (1.33)	4.48	-	66.33 (2.97)	66.33 (1.33)	20.25 (0.75)	0.79
19.	Total income	4363.32 (100)	6133.38 (100)	10496.70 (100)	2948.83 (100)	3.55	2739.26 (100)	2232.99 (100)	4972.25 (100)	2691.83 (100)	1.85

Note: NCI - non-cash income, CI- cash income

Figures in parentheses indicate percentage to the respective column totals

5.4.1.3 Benefits and associated costs from livestock rearing

The income from livestock maintenance was maximum in zone-3 at Rs. 5,346.67 per household per annum as compared to Rs. 4,824.07 in zone-4, while in zone-1 and zone-2, households realized gross incomes of Rs. 298.84 and Rs. 2,028.68 respectively. The average cost of maintaining livestock was Rs. 114.36, Rs. 615.82, 3,381.50 and Rs.2,565.00 in the four zones respectively. The B:C ratio for livestock indicated that it was profitable to maintain livestock in all zones. (Table 15)

5.4.1.4 Benefits from kitchen gardens to the households

Households in BRT area have maintained kitchen gardens in the backyard of their houses in which they grew vegetables, greens and other household requirements. The households in zone-1 realised Rs.779.36 worth of fruits and vegetables and fuelwood from their kitchen gardens, whereas, households in zone-2 realized benefits worth Rs. 220.58 (Table 15). However, households in zone-3 and zone-4 did not realise any kitchen garden benefits as they had not maintained such gardens.

5.4.1.5 Economic benefits from maintaining trees on farms

The households in all zones realized benefits from trees on farms in the form of fuelwood and fruits. However, the value of timber was not considered for the purpose of analysis. In zone-1, the households realized benefits worth Rs. 123.01 while in zone-2, it was Rs. 59.17. In zone-3 and zone-4, the value of benefits was Rs. 260.08 and Rs. 247.08 respectively (Table 15).

5.4.1.6 The value of benefits from various sources in the four zones

The total economic value of benefits was highest in zone-4 (Rs.65,066.39) followed by zone-3 (Rs.56,181.10), zone-1 (Rs.21,622.37) and zone-2 (Rs.18,889.54). The households in zone-1 realised 48.55 per cent of the total economic value of benefits from NTFPs collection, followed by wage income (25.16 %) and agriculture (20.74 %). On the contrary, in zone-2, agriculture contributed 33.58 per cent to the total economic value of benefits, followed by NTFPs (26.32 %) and wage income (17.28 %) (Table 16). In zone-3 and zone-4, agriculture was the major occupation contributing 86.15 per cent and 85.10 per cent respectively to the total economic value of benefits. The next important source of income was livestock whose contribution was 9.52 and 7.41 per cent respectively.

Table 15: Benefits and associated costs from various activities

Sl. No.	Activities	Zone-1	Zone-2	Zone-3	Zone-4
I	Agriculture (Rs. per acre)				
1.	Ragi + Inter-crops				
	Benefits	2590.75	3235.50	4008.85	3416.20
	Costs	2257.59	2679.01	3401.55	2341.51
	Net returns	333.16	556.49	607.30	1074.70
	B: C ratio	1.15	1.21	1.18	1.46
2.	Paddy				
	Benefits		4387.95	10968.00	11917.15
	Costs	-	4726.17	6181.22	5855.30
	Net returns		-338.22	4786.78	6061.85
	B: C ratio		0.93	1.77	2.04
3.	Sugarcane				
	Benefits			35579.30	37336.00
	Costs	-	-	14302.32	17308.97
	Net returns			21276.98	20027.03
	B: C ratio			2.48	2.15
4.	Coffee				
	Benefits	3573.20			
	Costs	1949.90	-	-	-
	Net returns	1623.30			
	B: C ratio	1.83			
II	Collection of NTFPs (Rs. per household)				
	Benefits	10496.80	4972.25		
	Costs	2948.83	2691.83	-	-
	Net returns	7333.63	2235.05		
	B: C ratio	3.55	1.85		
III	Livestock (Rs. per household)				
	Benefits	298.84	2028.68	5346.67	4824.07
	Costs	114.36	615.82	3381.50	2565.00
	Net returns	184.48	1412.86	1965.17	2259.07
	B: C ratio	2.61	3.29	1.58	1.88
IV	Kitchen garden				
	Benefits (Rs. per household)	779.36	220.58	-	-
V	Trees on farms				
	Benefits (Rs. per household)	123.01	59.17	260.08	247.08

Table 16: Total Economic Value of benefits from different sources (Rs. per household)

Sl. No.	Sources	Zone-1		Zone-2		Zone-3		Zone-4	
		Value	Per cent	Value	Per cent	Value	Per cent	Value	Per cent
1.	Agriculture	4484.67	20.74	6344.23	33.58	48397.68	86.15	55368.57	85.10
2.	Animal husbandry	298.84	1.38	2028.68	10.74	5346.67	9.52	4824.07	7.41
3.	NTFPs	10496.82	48.55	4972.25	26.32	-	-	-	-
4.	Kitchen garden	779.35	3.60	220.58	1.18	-	-	-	-
5.	Trees on farms	123.02	0.56	59.17	0.31	260.08	0.46	247.08	0.38
6.	Wage income	5439.67	25.16	3264.63	17.28	676.67	1.20	100	0.15
7.	Other sources	0	0	2000	10.50	15000	2.67	4526.67	6.96
8.	Total	21622.37	100	18889.54	100	56181.10	100	65066.39	100

The changing importance of BDOAF sources on livelihoods of the *soliga* tribe was analyzed by comparing the results of the present study with those of a study by Hegde *et al* (1996) pertaining to the year 1992-93. Results presented in Table 17 show that contribution of NTFPs to households income had declined by about 20 and 38 per cent and that of agriculture rose by about 3 and 141 per cent respectively in zone-1 and zone-2 over a period of seven years. The changing proportions over the years revealed that importance of NTFPs in livelihoods was declining over the years, thereby pressure on BDOAF resources was lessened.

5.4.2 Environmental benefits

5.4.2.1 Nature and pattern of flow of services

The existence and maintenance of biodiversity on and around farms manifests in the provision of various environmental services to the proximate households. In Table 18, the flow of environmental services from BDOAF is summarised. Based on the field observations and interactions with respondents, the environmental services were identified and expressed on a four-point scale as indicated in the table. It was found that zone-1 had a good repository of environmental services. On the contrary, the level of environmental services was relatively poor in zone-3 and zone-4.

5.4.2. 2 Valuation of environmental benefits and services

Among the various environmental services emanating from BDOAF, three environmental goods and services, namely chemical free products, medicinal flora and eco-tourism were quantified using environmental impact assessment techniques of Contingent Valuation Method (CVM), Replacement Cost and Travel Cost Method (TCM) respectively.

Table 17: Per cent changes in source-wise share of household income

Sl. No.	Sources	Zone-1			Zone-2		
		1992-93*	1999-2000	Per cent change	1992-93*	1999-2000	Per cent change
1.	Agriculture	20.18	20.74	2.77	15.57	37.56	141.23
2.	Subsidiary income	3.26	1.38	-57.67	4.80	12.01	150.20
3.	NTFPs	60.44	48.55	-19.67	47.63	29.43	-38.21
4.	Labor	14.66	25.16	71.62	23.76	19.33	-18.64
5.	Others	1.44	4.16	188.88	8.24	1.65	-79.97
6.	Gross income	13141.40	21622.37	64.53	13157.87	16889.54	28.36

* Adopted from Hegde et al (1996)

Table 18: Flow of environmental services

Sl. No.	Description	Zone-1	Zone-2	Zone-3	Zone-4
I	Direct use values				
1.	Chemical free products	1	1	2	3
2.	Medicinal flora	1	1	2	3
3.	Eco-tourism	1	1	4	4
II	Indirect use values				
4.	Climatic effect and conditions	1	1	4	4
5.	Soil fertility	1	2	4	4
6.	Pollution free environment	1	2	4	4
7.	Erosion control	1	2	4	4
8.	No incidence of crop diseases	1	2	4	3
9.	Water bodies and ground water level	1	1	2	3

Note: 1-good 2- fair 3- poor 4- very poor

5.4.2.2.1 Valuation of chemical-free products

In the BRT forest area, a large number of NTFPs were being collected by the tribal people. Some of the NTFPs are being processed at BRT without any adulteration and use of chemicals. Hence, they can be considered as pure and of organic origin. A consumer survey was carried out in different localities of Bangalore city to estimate the Willingness To Pay (WTP) for chemical free products of BRT origin. Four commonly used products namely honey, turmeric, soapnut, and *makaliberu* are organically produced and made available by outlets of NGO and LAMPS at BRT. Therefore, these products were considered for estimating the consumer's willingness to pay a premium for chemical free products. The results of WTP are presented in Table 19.

The highest Average Willingness To Pay (AWTP) per kg of honey was Rs.4.50 followed by turmeric (Rs. 2.95) and soapnut (Rs.2.66). The WTP per kg of honey ranged between zero and 30, while for soapnut and turmeric, the range was from zero to 20.

Among the three income categories, the consumers in above Rs.15,000 monthly income category had the highest WTP per kg of honey (Rs.6.56) followed by those in Rs.7,501-15,000 group (Rs.5.24 per kg) and those in upto Rs.7,500 group (Rs.2.97 per kg). Similarly, the consumers in above Rs.15000 category were willing to pay Rs.3.78 extra per kg of pure turmeric compared to Rs.2.45 in the first category (Table 20). Similarly, in the case of turmeric and soapnut, the consumers in the above Rs.15,000 category were WTP highest values of being Rs.3.78 and Rs.3.50 respectively. The consumers were willing to pay the least premium for *makaliberu*.

Table 19: Willingness To Pay for chemical-free products

Sl. No.	**Particulars**	**Honey WTP (Rs.)**	**Soapnut WTP (Rs.)**	**Turmeric WTP (Rs.)**	***Makaliberu* WTP (Rs.)**
1.	Market price (per kg)	140.62	89.15	91.61	92.03
2.	AWTP	4.50	2.66	2.95	1.00
3.	Min WTP	0	0	0	0
4.	Max WTP	30	20	20	15

Note: WTP – Willingness To Pay

AWTP – Average Willingness To Pay

5.4.2.2.2 Medicinal plants

One of the environmental benefits realised by inhabitants in zone-1 and zone-2 was the existence of a large variety of medicinal plants, which helped tribal people to cure many ailments. Table 21 reveals that medicines were extracted from as many as 34 plant species for common ailments. Six species were used to treat gynaecology related problems while 20 species were used to treat major health problems. The common ailments observed in *soliga* community were anaemia, malnutrition, headache, stomach disorders, scabies, throat infection etc. For majority of these ailments, herbal medicines were prepared and administered by knowledgeable / senior members of the village community *(podu)*. Normally, the tribal people go to hospital in the event of serious injuries by wild animals or any other accidents or any other major diseases.

The replacement cost approach indicated that average annual savings due to use of local medicines and avoidance of going to allopathic hospitals worked out to be Rs. 748.60 and Rs. 360 per household in zone-1and zone-2 respectively. Though in zones 3 and 4, households use plant extracted medicines, the magnitude of such usage was negligible. Moreover, in these zones, health facilities like hospitals and clinics are well established which were being utilized by the people.

Table 20: Willingness To Pay for chemical-free products according to income groups

Sl. No.	Monthly income	No. of respondents	Honey Price/kg (Rs.)	Honey WTP (Rs.)	Soapnut Price/kg (Rs.)	Soapnut WTP (Rs.)	Turmeric Price/kg (Rs.)	Turmeric WTP (Rs.)	Makaliberu Price/kg (Rs.)	Makaliberu WTP (Rs.)
1.	Upto 7500	54	122.25	2.97	91.34	2.38	87.41	2.45	90.26	0.89
2.	7501-15000	41	158.19	5.24	87.30	2.51	98.68	3.05	99.26	1.15
3.	Above 15000	25	135.48	6.56	87.65	3.50	88.96	3.78	87.56	1.02

Table 21: Common ailments and number of species used as medicines in zone-1 and zone-2.

Sl. No.	Particulars of diseases	No of plant species used
I	Primary health care	
1.	Common cold	
2.	Cough	
3.	Burns	
4.	Soar eye	
5.	Headache	
6.	Soar throat	34
7.	Skin diseases	
8.	Stomach disorders	
9.	Minor injuries	
10.	Snake bites/scorpion bites	
II	Gynaecology	
1.	Birth control	
2.	Fertility	6
3.	Regulating menstruation	
4.	Increasing milk production	
III	Major problems	
1.	Epilepsy	
2.	Tuberculosis	
3.	Diabetes	
4.	Gangrene	20
5.	Sickle celled anaemia	

5.4.2.2.3 Eco-tourism

The BRT forest area (zone-1 and zone-2) is characterized by hilly terrain and has a game sanctuary. Hence, it attracts a considerable number of tourists for recreation purposes. Thus, tourists derive use values by visiting BRT sanctuary area. In the present study, an attempt was made to estimate use values as derived by tourists visiting BRT area. A survey was conducted at BRT area involving 100 randomly chosen respondents through a schedule developed for the purpose.

Individual Travel Cost Method (ITCM) was used to estimate the use value derived by tourists. For this purpose, a demand function was fitted with visitation rate (number of visits by an individual in a year) as dependent variable. This was regressed on independent variables, namely, education level of visitor, age of the visitor and distance travelled.

Among various functional forms, semi-log model was found to be the most appropriate due too its advantages over other functional forms. The results of the regression analysis are presented in Table 22.

The demand function fitted to the data showed that variable - distance travelled was statistically significant. Consumer surplus was estimated from the semi-log demand function by multiplying the reciprocal of regression co-efficient of variable – distance traveled with 0.76 (as the cost per kilometer in rupees, which includes actual travel cost, incidental cost and other costs at site). The average consumer surplus per visitor worked out to Rs.351.69, which is a proxy for recreation use value derived by tourists using BRT. The area above the average travel cost in the demand curve represents the consumers surplus enjoyed by the tourists. This is a measure of WTP for the services provided. The product of consumer surplus and number of visits by tourists to BRT will provide total use values that BRT provides to recreationists.

The visitors were asked to indicate how much they were willing to pay for maintenance of the game sanctuary. The results of the analysis according to income groups are presented in Table 23. Majority of the respondents (78.75%) had annual income of less than Rs. 36,000.00. The AWTP for this group worked out to be Rs. 200.32. However, visitors with higher incomes were willing to pay higher for the maintenance of the sanctuary. The range of WTP for entire sample was Rs. 0 - Rs.5,000. The average WTP was Rs. 204.75.

5.4.3 Supplementary benefits

Households in BRT area were deriving a great deal of supplementary benefits from BDOAF apart from economic and other benefits, in the form of NTFPs for self-consumption, nutritious food from kitchen garden, small timber and medicinal plants. It could be observed from Table 24 that, households in zone-1 derived the highest value of supplementary benefits to the extent of Rs.6,014.20 followed by households in zone-2 (Rs.3,379.00). In zones 3 and 4, the value of supplementary benefits was very low at Rs.129.47 and Rs.88.33 respectively. The value of benefits from NTFPs, kitchen garden and medicinal plants in zone-1 was Rs.4,363.32, Rs.779.36 and Rs.748.60 respectively, while the corresponding benefits for households in zone-2 were Rs.2,739.26, Rs.220.58 and Rs.360.00. The households in zones 3 and 4 did not realise any of these benefits except small quantities of timber and fuelwood due to scarcity of such species in these zones.

Table 22: Results of semi-log regression analysis for Travel Cost Method

Sl. No.	**Variables**	**Co-efficient**	Std. Error	**Z-Statistic**	**Probability**
1.	Constant	0.863151	0.324402	2.660744	0.0078
2.	Distance	-0.002161*	0.000811	-2.665063	0.0077
3.	Education	-0.007324	0.012902	-0.567674	0.5703
4.	Age	0.005780	0.006912	0.836144	0.4031

Average consumer surplus = Rs.351.69 per visitor

R^2 = 0.115*

* Significant at one per cent level

Table 23: Willingness To Pay (WTP) for maintenance of recreation site

Sl. No.	Annual Income	Visitors (Nos.)	Minimum WTP (Rs.)	Maximum WTP (Rs.)	Average WTP (Rs.)
1.	Upto Rs.12,000	22	0	250.00	55.14
2.	Rs. 12,001 to 24,000	15	0	250.00	45.07
3.	Rs. 24,001 to 36,000	26	10	5000.00	412.73
4.	Rs. 36,001 to 48,000	4	25	500.00	168.75
5.	Rs. 54,001 to 72,000	10	10	1000.00	198.50
6.	Rs. 72,001 to 84,000	1	100	100.00	100.00
7.	Rs. 84,001 to 96,000	1	500	500.00	500.00
8.	Rs. 1,68,001 to 1,80,000	1	500	500.00	500.00
9.	All income groups	80	0	5000.00	204.75

5.5 Intersectoral flow of resources and backward and forward linkages in village economy

Social Accounting Matrix (SAM) was constructed for all the four zones separately to study the intersectoral flow of resources and backward and forward linkages in the village economy. The data collected from the sample households were averaged out and then blown up for the population in each institution by multiplying the corresponding average by the total number of households in that category for the four zones separately.

In zone-1, three major sectors namely forestry or NTFPs, agriculture and dairy sectors were identified. Within each of these sectors, sub-sectors were identified. The NTFPs sector composed of three sub-sectors namely, fodder, food and non-food sub-sectors. Agriculture sector consisted of ragi, maize, groundnut and cotton sub-sectors.

Table 24: Supplementary benefits from BDOAF

Sl. No.	Particulars	Zone-1	Zone-2	Zone-3	Zone-4
1.	NTFPs	4363.32	2739.26	-	-
2.	Kitchen garden	779.36	220.58	-	-
3.	Trees on farms	123.01	59.17	129.47	88.33
4.	Medicinal plants	748.60	360.00	N	N
5.	Total	6014.20	3379.00	129.47	88.33

Note: N - only small quantity of benefits were realised which could not be quantified in economic terms.

The SAM for zone-1 is presented in Table 25. From the table, it can be seen that the fodder sub-sector of NTFPs supplied fodder worth Rs. 15,24,514 to the dairy sector. The maize sub-sector of agriculture supplied fodder worth Rs. 2,94,606 to dairy sector. The dairy sector supplied FYM worth Rs. 2,94,686, Rs. 2,84,525, Rs. 3,65,818 and Rs. 71,131 to ragi, maize, groundnut and cotton sub-sectors respectively. Among the different institutions, the landless category showed dissavings while the other three categories viz., marginal, small and large households showed savings. Out of the total exports from the region, agriculture contributed about 65 per cent, followed by NTFPs with 25 per cent and dairy sector with 10 per cent.

The production multiplier matrices for the zones were generated from the multiplier matrices of the respective zones (Appendices 1-4). The production multiplier matrix for zone-1 is presented in Table 26, from which it is clear that, the dairy sector had the highest production multiplier of 2.76 followed by ragi sub-sector of the agriculture sector (2.69). The trade sector had the lowest multiplier of 1.51.

Table 27 presents the household income multiplier matrix for zone-1. From the table, it can be seen that, the fodder and non-food sub-sectors of NTFPs had the highest income multiplier of 1.75 each. In case of agriculture, ragi sub-sector had the highest income multiplier of 1.62. The dairy sector had a multiplier value of 161 while the trade sector had the lowest multiplier of 0.31.

Table 25: Social accounting matrix for zone-1

	Fodder	Food	Non-Food	Ragi	Maize	Groundnut	Cotton	Fertilizers	PPC	Dairy	C / F
Fodder	0	0	0	0	0	0	0	0	0	1524514	0
Food	0	0	0	0	0	0	0	0	0	0	0
Non-Food	0	0	0	0	0	0	0	0	0	0	0
Ragi	0	0	0	47360	0	0	0	0	0	192000	0
Maize	0	0	0	0	26439	0	0	0	0	294606	0
Groundnut	0	0	0	0	0	291480	0	0	0	21565	0
Cotton	0	0	0	0	0	0	7980	0	0	0	0
Fertilizers	0	0	0	128000	355038	346653	63000	0	0	0	0
PPC	0	0	0	0	0	0	79800	0	0	0	0
Dairy	0	0	0	294686	284525	365818	71131	0	0	0	0
C / F	0	0	0	0	0	0	0	0	0	523200	0
F. Labour	0	1878366	1089958	1920000	1750639	2986369	341302	0	0	6289650	0
H. Labour	0	0	0	640000	583547	995456	113768	0	0	698850	0
Profit	1524514	3017511	2012182	-255006	2358116	4446879	249749	0	0	-1932065	0
Landless	0	0	0	0	0	0	0	0	0	0	0
Marginal	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0
Large	0	0	0	0	0	0	0	0	0	0	0
Savings	0	0	0	0	0	0	0	0	0	0	0
Trade	0	0	0	6080	20459	218610	3990	223172	19950	0	130800
ROTW	0	0	0	18240	61376	655380	3990	669519	59850	0	392400
Total	1524514	4895877	3102140	2799360	5440139	10306645	934710	892691	79800	7612320	523200

Table 25: contd….

	F. Labour	H. Labour	Profit	Landless	Marginal	Small	Large	Savings	Trade	ROTW	Total
Fodder	0	0	0	0	0	0	0	0	0	0	1524514
Food	0	0	0	158360	363800	320600	0	0	40530	4012587	4895877
Non-Food	0	0	0	559070	1284350	551661	0	0	7071	699988	3102140
Ragi	0	0	0	0	483840	691200	1128960	0	230400	25600	2799360
Maize	0	0	0	0	230359	358336	691078	0	383932	3455389	5440139
Groundnut	0	0	0	0	179885	279821	539654	0	899424	8094816	10306645
Cotton	0	0	0	0	0	0	0	0	9267	917463	934710
Fertilizers	0	0	0	0	0	0	0	0	0	0	892691
PPC	0	0	0	0	0	0	0	0	0	0	79800
Dairy	0	0	0	39577	1662232	1266463	989424	0	659616	1978848	7612320
C / F	0	0	0	0	0	0	0	0	0	0	523200
F. Labour	0	0	0	0	0	0	0	0	0	0	16256284
H. Labour	0	0	0	0	0	0	0	0	0	0	3031621
Profit	0	0	0	0	0	0	0	0	0	0	11421880
Landless	812814	1818973	571094	0	0	0	0	0	0	0	3202881
Marginal	8940956	1061067	1713282	0	0	0	0	0	0	0	11715305
Small	4876885	151581	3426564	0	0	0	0	0	0	0	8455030
Large	1625629	0	5710940	0	0	0	0	0	0	0	7336569
Savings	0	0	0	-201332	495789	756957	834389	0	0	0	1885803
Trade	0	0	0	2647206	5261287	2114996	788266	0	0	0	11434816
ROTW	0	0	0	0	1753763	2114996	2364798	1885803	9204576	0	19184691
Total	16256284	3031621	11421880	3202881	11715305	8455030	7336569	1885803	11434816	19184691	

Note: NTFPs sector consists of fodder, food and non-food sub-sectors, agriculture sector consists of ragi, maize, groundnut and cotton sub-sectors,
C / F- Concentrates and feeds, ROTW-Rest of the world

Table 26: Production multiplier matrix for zone-1

Sl. No.	Sectors	NTFPs			Agriculture				Dairy	Trade
		Fodder	Food	Non-Food	Ragi	Maize	Groundnut	Cotton		
1.	NTFPs									
	Fodder	1.06	0.06	0.06	0.07	0.06	0.06	0.06	0.25	0.02
	Food	0.04	1.05	0.05	0.06	0.05	0.04	0.04	0.05	0.01
	Non-Food	0.11	0.13	1.12	0.16	0.13	0.12	0.12	0.15	0.03
2.	Agriculture									
	Ragi	0.18	0.16	0.16	1.13	0.14	0.14	0.12	0.15	0.05
	Maize	0.12	0.11	0.11	0.09	1.10	0.10	0.09	0.13	0.05
	Groundnut	0.12	0.11	0.11	0.10	0.10	1.13	0.09	0.10	0.10
	Cotton	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00
3.	Dairy	0.29	0.29	0.29	0.37	0.31	0.29	0.32	1.27	0.12
4.	Trade	0.54	0.58	0.58	0.71	0.60	0.58	0.60	0.66	1.12
5.	Total	2.46	2.49	2.48	2.69	2.49	2.46	2.46	2.76	1.51

Table 27: Household income multiplier matrix for zone-1

Sl. No.	Sectors / Institutions	NTFPs			Agriculture				Dairy	Trade
		Fodder	Food	Non-Food	Ragi	Maize	Groundnut	Cotton		
1.	Landless	0.14	0.13	0.14	0.25	0.18	0.17	0.18	0.18	0.04
2.	Marginal	0.48	0.63	0.61	0.79	0.60	0.56	0.59	0.79	0.13
3.	Small	0.50	0.50	0.50	0.41	0.43	0.42	0.39	0.44	0.08
4.	Large	0.63	0.48	0.50	0.17	0.38	0.38	0.30	0.2	0.06
5.	Total	1.75	1.74	1.75	1.62	1.59	1.53	1.46	1.61	0.31

Table 28 gives the SAM for zone-2. It can be seen from the table that, the fodder sub-sector of NTFPs supplied fodder worth Rs. 3,11,710 to the dairy sector. The paddy sub-sector supplied dry fodder worth Rs. 1,68,323 to the dairy sector. The dairy sector supplied FYM worth Rs. 1,24,611, Rs. 62,305 and Rs. 20,769 to paddy, ragi and groundnut sub-sectors respectively. All the institutions showed savings. Agriculture contributed about 82 per cent of the total exports of the zone followed by NTFPs with 14 per cent. The remaining export earnings was contributed by the dairy sector.

The production multiplier matrix for zone-2 is presented in Table 29. It is clear from the table that, the dairy sector had the highest production multiplier of 4.39 followed by food sub-sector of NTFPs with 3.51 and non-food sub-sector of NTFPs with 3.46. The trade sector had the lowest multiplier of 2.28.

Table 30 presents the household income multiplier matrix for zone-2. From the table, it can be seen that, the dairy sector had the highest income multiplier of 2.37 followed by food sub-sector of NTFPs (2.34) and non-food sub-sector of NTFPs (2.24). The trade sector had the lowest multiplier of 0.82.

Table 28: Social accounting matrix for zone-2

	Fodder	Food	Non-Food	Paddy	Ragi	Groundnut	Fertilizers	PPC	Dairy	C / F
Fodder	0	0	0	0	0	0	0	0	311710	0
Food	0	0	0	0	0	0	0	0	0	0
Non-Food	0	0	0	0	0	0	0	0	0	0
Paddy	0	0	0	88080	0	0	0	0	168323	0
Ragi	0	0	0	0	17880	0	0	0	137152	0
Groundnut	0	0	0	0	0	112400	0	0	6235	0
Fertilizers	0	0	0	546096	98340	133590	0	0	0	0
PPC	0	0	0	71565	0	0	0	0	0	0
Dairy	0	0	0	124611	62305	20769	0	0	0	0
C / F	0	0	0	0	0	0	0	0	26400	0
F. Labour	28054	1881960	1564930	1125662	1338988	1151666	0	0	2676150	0
H. Labour	3117	0	0	750442	446330	383889	0	0	140850	0
Profit	280539	-829245	-608480	4153745	-22599	1833461	0	0	-2386975	0
Landless	0	0	0	0	0	0	0	0	0	0
Marginal	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0
Large	0	0	0	0	0	0	0	0	0	0
Savings	0	0	0	0	0	0	0	0	0	0
Trade	0	0	0	140928	5006	134904	311210	28626	0	10560
ROTW	0	0	0	211392	7510	202356	466816	42939	0	15840
Total	311710	1052715	956450	7212521	1953760	3973035	778026	71565	1079845	26400

Contd…

Table 28: contd….

	F. Labour	H. Labour	Profit	Landless	Marginal	Small	Large	Savings	Trade	ROTW	Total
Fodder	0	0	0	0	0	0	0	0	0	0	311710
Food	0	0	0	55981	129574	68090	0	0	39953	759117	1052715
Non-Food	0	0	0	144892	335368	250470	0	0	11286	214434	956450
Paddy	0	0	0	0	1446872	779085	556490	0	1043418	3130253	7212521
Ragi	0	0	0	0	841805	453279	323771	0	134905	44968	1953760
Groundnut	0	0	0	0	200429	107923	77088	0	867240	2601720	3973035
Fertilizers	0	0	0	0	0	0	0	0	0	0	778026
PPC	0	0	0	0	0	0	0	0	0	0	71565
Dairy	0	0	0	5233	219784	167455	130824	0	87216	261648	1079845
C / F	0	0	0	0	0	0	0	0	0	0	26400
F. Labour	0	0	0	0	0	0	0	0	0	0	9767410
H. Labour	0	0	0	0	0	0	0	0	0	0	1724628
Profit	0	0	0	0	0	0	0	0	0	0	2420446
Landless	488370	1034777	24204	0	0	0	0	0	0	0	1547351
Marginal	5372075	603620	338863	0	0	0	0	0	0	0	6314558
Small	2930223	86231	605111	0	0	0	0	0	0	0	3621565
Large	976742	0	1452268	0	0	0	0	0	0	0	2429010
Savings	0	0	0	79066	220424	137239	125645	0	0	0	562374
Trade	0	0	0	1199070	2190226	829012	303798	0	0	0	5153340
ROTW	0	0	0	63109	730076	829012	911394	562374	2969322	0	7012140
Total	9767410	1724628	2420446	1547351	6314558	3621565	2429010	562374	5153340	7012140	

Note: NTFPs sector consists of fodder, food and non-food sub-sectors, agriculture consists of paddy, ragi and groundnut sub-sectors, C / F- Concentrates and feeds, ROTW-Rest of the world

Table 29:Production multiplier matrix for zone-2

Sl. No.	Sectors	NTFPs			Agriculture			Dairy	Trade
		Fodder	Food	Non-Food	Paddy	Ragi	Groundnut		
1.	NTFPs								
	Fodder	1.03	0.03	0.03	0.03	0.04	0.03	0.32	0.02
	Food	0.04	1.06	0.06	0.04	0.05	0.04	0.08	0.02
	Non-Food	0.09	0.15	1.15	0.09	0.12	0.10	0.19	0.04
2.	Agriculture								
	Paddy	0.59	0.68	0.68	1.55	0.60	0.55	0.86	0.44
	Ragi	0.29	0.32	0.31	0.26	1.28	0.26	0.43	0.14
	Groundnut	0.17	0.23	0.22	0.17	0.20	1.21	0.27	0.25
3.	Dairy	0.12	0.12	0.12	0.12	0.14	0.11	1.11	0.07
4.	Trade	0.63	0.92	0.89	0.68	0.83	0.69	1.13	1.30
5.	Total	2.96	3.51	3.46	2.94	3.26	2.99	4.39	2.28

Table 30: Household income multiplier matrix for zone-2

Sl. No.	**Sectors / Institutions**	**NTFPs**			**Agriculture**			**Dairy**	**Trade**
		Fodder	**Food**	**Non-Food**	**Paddy**	**Ragi**	**Groundnut**		
1.	Landless	0.16	0.24	0.24	0.21	0.32	0.21	0.39	0.09
2.	Marginal	0.72	1.53	1.46	0.72	1.06	0.78	1.94	0.35
3.	Small	0.54	0.69	0.68	0.47	0.53	0.49	0.71	0.21
4.	Large	0.69	-0.12	-0.04	0.49	0.19	0.45	-0.67	0.17
5.	Total	2.11	2.34	2.24	1.89	2.10	1.93	2.37	0.82

The SAM for zone-3 is presented in Table 31. From the table, it can be seen that, the groundnut sub-sector of agriculture supplied fodder worth Rs.5,28,931 to the dairy sector, followed by paddy sub-sector (Rs.3,71,000) and ragi sub-sector (Rs.2,24,280). The dairy sector supplied FYM worth Rs.3,28,317, Rs.1,40,707, Rs.3,28,317, Rs.93,805 and Rs.46,904 to groundnut, ragi, paddy, mulberry and sugarcane sub-sectors respectively. All the institutions showed savings. Out of the total exports from the zone, about 83.50 per cent was contributed by agriculture, followed by dairy sector with 16.50 per cent.

The production multiplier matrix for zone-3 is presented in Table 32, from which it is clear that, the ragi sub-sector had the highest production multiplier of 2.13 followed by dairy sector (2.10). The trade sector had the lowest multiplier of 1.40. Table 33 presents the household income multiplier matrix. From the table, it can be seen that, the ragi sub-sector had the highest income multiplier of 1.16, followed by sugarcane sub-sector with income multiplier of 1.15. The dairy sector had income multiplier of 1.11. The trade sector had the lowest income multiplier of 0.22.

The SAM for zone-4 is presented in Table 34. From the table, it can be seen that, the paddy sub-sector supplied fodder worth Rs.8,79,723 to dairy sector, followed by ragi sub-sector (Rs.4,39,861) and groundnut sub-sector (Rs.73,310). The dairy sector supplied FYM worth Rs.4,94,721, Rs.1,64,907, Rs.2,74,845 and Rs.1,64,907 to paddy, ragi, groundnut and sugarcane sub-sectors respectively. All the institutions, viz., landless, marginal, small and large households showed savings. Agriculture contributed about 91 per cent of the total exports from the zone followed by dairy sector with nine per cent.

The production multiplier matrix for zone-4 is presented in Table 35. It is clear from the table that, the dairy sector had the highest production multiplier of 2.38 followed by ragi sub-sector of agriculture with 2.16. The trade sector had the lowest multiplier of 1.54. Table 36 presents the household income multiplier matrix for zone-4. The ragi sub-sector had the highest income multiplier of 1.27, followed by dairy sector with multiplier of 1.22. The trade sector had the lowest multiplier of 0.29.

Table 31: Social accounting matrix for zone-3

	Groundnut	Ragi	Paddy	Mulberry	Sugarcane	Fertilizers	PPC	Dairy	C / F
Groundnut	305305	0	0	0	0	0	0	528931	0
Ragi	0	2848	0	0	0	0	0	224280	0
Paddy	0	0	84800	0	0	0	0	371000	0
Mulberry	0	0	0	21450	0	0	0	0	0
Sugarcane		0	0	0	12540	0	0	0	0
Fertilizers	582062	111784	460570	477906	162960	0	0	0	0
PPC	0	9968	119780	0	0	0	0	0	0
Dairy	328317	140707	328317	93805	46904	0	0	0	0
C / F	0	0	0	0	0	0	0	845100	0
F. Labour	1112182	479710	225621	466752	53274	0	0	4750650	0
H. Labour	3336548	1439130	2030589	466752	479466	0	0	527850	0
Profit	5419347	93541	2863874	4191333	1447336	0	0	3635	0
Landless	0	0	0	0	0	0	0	0	0
Marginal	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0
Large	0	0	0	0	0	0	0	0	0
Savings	0	0	0	0	0	0	0	0	0
Trade	228979	6408	49687	19276	12555	448819	32437	31661	211275
ROTW	686936	19224	149062	173488	37665	1346463	97311	94983	633825
Total	11999676	2303320	6312300	5910762	2252700	1795282	129748	7378090	845100

contd….

Table 31: contd….

	F. Labour	H. Labour	Profit	Landless	Marginal	Small	Large	Savings	Trade	ROTW	Total
Groundnut	0	0	0	0	223309	195395	139568	0	1060717	9546451	11999676
Ragi	0	0	0	0	519048	311429	207619	0	259524	778572	2303320
Paddy	0	0	0	0	585650	351390	234260	0	1171300	3513900	6312300
Mulberry	0	0	0	0	0	0	0	0	0	5889312	5910762
Sugarcane	0	0	0	0	0	0	0	0	0	2240160	2252700
Fertilizers	0	0	0	0	0	0	0	0	0	0	1795282
PPC	0	0	0	0	0	0	0	0	0	0	129748
Dairy	0	0	0	0	805005	483003	322002	0	483003	4347027	7378090
C / F	0	0	0	0	0	0	0	0	0	0	845100
F. Labour	0	0	0	0	0	0	0	0	0	0	7088189
H. Labour	0	0	0	0	0	0	0	0	0	0	8280335
Profit	0	0	0	0	0	0	0	0	0	0	14019066
Landless	0	4968201	0	0	0	0	0	0	0	0	4968201
Marginal	4252913	2898117	4065529	0	0	0	0	0	0	0	11216559
Small	2126457	414017	4205720	0	0	0	0	0	0	0	6746194
Large	708819	0	5747817	0	0	0	0	0	0	0	6456636
Savings	0	0	0	233984	610924	380268	953439	0	0	0	2178615
Trade	0	0	0	4260795	6354467	2512354	1149937	0	0	0	15318650
ROTW	0	0	0	473422	2118156	2512355	3449811	2178615	12344106	0	26315422
Total	7088189	8280335	14019066	4968201	11216559	6746194	6456636	2178615	15318650	26315422	

Note: Agriculture sector consists of groundnut, ragi, paddy, mulberry and sugarcane sub-sectors,

C / F – Concentrates and feeds, ROTW-Rest of the world

Table 32: Production multiplier matrix for zone-3

Sl. No.	Sectors	Agriculture					Dairy	Trade
		Groundnut	Ragi	Paddy	Mulberry	Sugarcane		
1.	Agriculture							
	Groundnut	1.10	0.08	0.07	0.07	0.07	0.15	0.09
	Ragi	0.05	1.05	0.05	0.05	0.05	0.09	0.03
	Paddy	0.09	0.10	1.11	0.09	0.10	0.15	0.10
	Mulberry	0.00	0.00	0.00	1.00	0.00	0.00	0.00
	Sugarcane	0.00	0.00	0.00	0.00	1.01	0.00	0.00
2.	Dairy	0.11	0.15	0.14	0.11	0.11	1.1	0.06
3.	Trade	0.59	0.75	0.60	0.51	0.56	0.61	1.12
4.	Total	1.94	2.13	1.97	1.83	1.90	2.10	1.40

Table 33: Household income multiplier matrix for zone-3

Sl. No.	Sectors / Institutions	Agriculture					Dairy	Trade
		Groundnut	Ragi	Paddy	Mulberry	Sugarcane		
1.	Landless	0.23	0.43	0.25	0.10	0.18	0.13	0.05
2.	Marginal	0.40	0.48	0.39	0.39	0.39	0.57	0.08
3.	Small	0.24	0.17	0.23	0.30	0.27	0.28	0.05
4.	Large	0.24	0.08	0.24	0.34	0.31	0.13	0.04
5.	Total	1.11	1.16	1.11	1.13	1.15	1.11	0.22

5.5.1 Backward and forward linkages

Appendix-1 gives the backward and forward linkages for various sectors of the economy in zone-1. With regard to backward linkages among activities, dairy sector had the highest linkage value of 6.17. In case of NTFPs, food and non-food sub-sectors had a value of 6.14 each, while, in the case of agriculture, ragi sub-sector had the highest linkage value of 6.09. With respect to forward linkages among activities, dairy had the highest value of 5.51 followed by 3.26 and 3.13 in the case of ragi sub-sector of agriculture and non-food sub-sector of NTFPs.

In zone-2 also, dairy had the highest backward linkage of 9.33 among activities (Appendix-2). In the case of NTFPs, food sub-sector had the highest backward linkage of 8.38, while, in case of agriculture, ragi sub-sector had the highest linkage value of 7.69. With regard to forward linkages among activities, paddy sub-sector had the highest linkage value of 10.56. In the case of NTFPs, non-food sub-sector had the highest linkage value of 2.82 while dairy sector had a linkage value of 2.75.

Among the activities in zone-3, ragi sub-sector had the highest backward linkage value of 4.64 followed by dairy sector with 4.55. In the case of forward linkages among activities, paddy sub-sector had the highest value of 2.54 followed by dairy sector with a value of 2.49. (Appendix-3)

In zone-4, dairy sector had the highest backward linkage of 5.01 among activities followed by ragi sub-sector with 4.83. In case of forward linkages among activities, paddy sub-sector had the highest linkage value of 3.97 while dairy sector had 2.21 as its linkage value. (Appendix -4)

Table 34: Social accounting matrix for zone-4

	Paddy	Ragi	Groundnut	Sugarcane	Fertilizers	PPC	Dairy	C / F
Paddy	109074	0	0	0	0	0	879723	0
Ragi	0	63035	0	0	0	0	439861	0
Groundnut	0	0	181258	0	0	0	73310	0
Sugarcane	0	0	0	99012	0	0	0	0
Fertilizers	1769880	405225	863918	1588206	0	0	0	0
PPC	356034	30617	0	0	0	0	0	0
Dairy	494721	164907	274845	164907	0	0	0	0
C / F	0	0	0	0	0	0	972000	0
F. Labour	1168738	936880	660297	474321	0	0	5305275	0
H. Labour	6622850	2186054	5942673	4268889	0	0	936225	0
Profit	11043384	3145748	7272415	8975417	0	0	-34905	0
Landless	0	0	0	0	0	0	0	0
Marginal	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0
Large	0	0	0	0	0	0	0	0
Savings	0	0	0	0	0	0	0	0
Trade	736249	12157	1223491	297370	3470421	289988	65980	729000
ROTW	245417	4052	407831	99124	1156808	96663	7331	243000
Total	22546347	6948675	16826728	15967246	4627229	386651	8644800	972000

contd.

Table 34: contd….

	F. Labour	H. Labour	Profit	Landless	Marginal	Small	Large	Savings	Trade	ROTW	Total
Paddy	0	0	0	0	1940179	1293453	1077878	0	4311510	12934530	22546347
Ragi	0	0	0	0	1015210	676807	564006	0	1256927	2932829	6948675
Groundnut	0	0	0	0	497165	662886	497165	0	1491494	13423450	16826728
Sugarcane	0	0	0	0	0	0	0	0	158682	15709552	15967246
Fertilizers	0	0	0	0	0	0	0	0	0	0	4627229
PPC	0	0	0	0	0	0	0	0	0	0	386651
Dairy	0	0	0	0	848860	565906	471589	0	1414766	4244299	8644800
C / F	0	0	0	0	0	0	0	0	0	0	972000
F. Labour	0	0	0	0	0	0	0	0	0	0	8545511
H. Labour	0	0	0	0	0	0	0	0	0	0	19956691
Profit	0	0	0	0	0	0	0	0	0	0	30402059
Landless	0	10976180	0	0	0	0	0	0	0	0	10976180
Marginal	4700031	7982676	6080412	0	0	0	0	0	0	0	18763119
Small	2990929	997835	9120618	0	0	0	0	0	0	0	13109382
Large	854551	0	15201029	0	0	0	0	0	0	0	16055580
Savings	0	0	0	130416	237312	196275	300585	0	0	0	864588
Trade	0	0	0	9761188	10668295	4857027	3286089	0	0	0	35397255
ROTW	0	0	0	1084576	3556098	4857028	9858268	864588	26763876	0	49244660
Total	8545511	19956691	30402059	10976180	18763119	13109382	16055580	864588	35397255	49244660	

Note: Agriculture sector consists of paddy, ragi, groundnut and sugarcane sub-sectors,

C / F - Concentrates and feeds, ROTW- Rest of the world

Table 35: Production multiplier matrix for zone-4

Sl. No.	Sectors	Agriculture				Dairy	Trade
		Paddy	Ragi	Groundnut	Sugarcane		
1.	Agriculture						
	Paddy	1.19	0.19	0.18	0.18	0.31	0.17
	Ragi	0.08	1.09	0.07	0.08	0.14	0.06
	Groundnut	0.06	0.07	1.07	0.07	0.08	0.06
	Sugarcane	0.00	0.00	0.00	1.01	0.00	0.01
2.	Dairy	0.10	0.10	0.09	0.08	1.09	0.06
3.	Trade	0.72	0.71	0.74	0.69	0.76	1.18
4.	Total	2.15	2.16	2.15	2.11	2.38	1.54

Table 36: Household income multiplier matrix for zone-4

Sl. No.	**Sectors / Institutions**	**Agriculture**				**Dairy**	**Trade**
		Paddy	**Ragi**	**Groundnut**	**Sugarcane**		
1.	Landless	0.22	0.24	0.26	0.21	0.15	0.05
2.	Marginal	0.37	0.42	0.37	0.35	0.55	0.1
3.	Small	0.26	0.28	0.24	0.27	0.33	0.07
4.	Large	0.34	0.33	0.31	0.37	0.19	0.07
5.	Total	1.19	1.27	1.18	1.20	1.22	0.29

5.6 Magnitude of dependencies of farm families on BDOAF

The dependency of farm families on BDOAF was analysed in terms of a) direct economic value derived by households, b) employment generation and c) consumption pattern. The results of analysis are presented in Tables 37, 38 and 39.

5.6.1 Direct economic value

Direct economic value of benefits realized per household was Rs. 21,622.37, Rs. 16,889.54, Rs. 54,681.10 and Rs. 60,539.72 in zone-1, zone-2, zone-3 and zone-4 respectively. The dependency of households on BDOAF (NTFPs, kitchen garden, trees on farms) for their livelihoods was highest (52.71 %) in zone-1 followed by zone-2

(27.80 %) and the dependency was least in zone-4 (0.38 %). Among different components of BDOAF, the dependency on NTFPs was observed only in zone-1 and zone-2 (Table 37).

5.6.2 Employment pattern

The total employment generation for family members from the five different economic activities of the households is presented in Table 38. The employment generation was highest in zone-1 (681.50 mandays) followed by zone-2 (578.00 mandays). Relatively, fewer members of the families were employed in farm activities in zone-3 and zone-4. Among the different income earning activities on and around farms, the households in zone-1 derived 37.56 per cent of total employment from NTFPs collection followed by wage income (32.65 %). In zone-2, both NTFPs collection and wage employment accounted for 32.52 per cent each, whereas in the case of zone-3 and zone-4, the generation of employment from BDOAF related activities was nil.

5.6.3 Consumption pattern

In the present context, the consumption among the households refers to intake of food and related items. The consumption pattern was examined in terms of sources of consumption items i.e. from farm and non-farm sources. It is observed that in zone-1, about 58.68 per cent of consumption requirement was met from farm and BDOAF sources, whereas, in zone-2, zone-3 and zone-4, it was 56.46 per cent, 34.92 per cent and 43.62 per cent respectively (Table 39).

Table 37: The economic value of selected direct benefits from BDOAF and related activities (Rs. per household)

Sl. No.	Source	Zone-1		Zone-2		Zone-3		Zone-4	
		Value (Rs.)	Per cent	Value (Rs.)	Per cent	Value (Rs.)	Per cent	Value (Rs.)	Per cent
1.	Agriculture	4484.67	20.74	6344.23	37.56	48397.68	88.50	55368.57	91.45
2.	Livestock	298.84	1.38	2028.68	12.01	5346.67	9.78	4824.07	7.97
3.	NTFPs	10496.82	48.55	4972.25	29.43	-	-	-	
4.	Kitchen garden	779.35	3.60	220.58	1.30	-	-	-	
5.	Trees on farms	123.02	0.56	59.17	0.35	260.08	0.48	247.08	0.41
6.	Wage income	5439.67	25.16	3264.63	19.33	676.67	1.24	100	0.17
7.	Total	21622.37	100	16889.54	100	54681.1	100	60539.72	100
8.	Dependency on BDOAF (%)		52.71		27.80		1.72		0.38

Table 38: Employment pattern of the households

(mandays per annum per household)

Sl. No.	Activity	Zone-1			Zone-2			Zone-3			Zone-4		
		Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
1.	Collection of NTFPs	141	115	256 (37.56)	110	78	188 (32.52)	0	0	0 (0.00)	0	0	0 (0.00)
2.	Agriculture	96	93	189 (27.73)	40	34	74 (12.80)	98	0	98 (30.82)	143	0	143 (45.98)
3.	Livestock maintenance	9	5	14 (2.05)	41	20	61 (10.55)	45	66	111 (34.90)	34	57	91 (29.26)
4.	Wage employment	137.50	85	222.50 (32.65)	114	74	188 (32.52)	60	25	85 (26.72)	36	0	36 (11.58)
5.	Other sources	0	0	0 (0.00)	67	0	67 (11.59)	24	0	24 (7.55)	41	0	41 (13.18)
6.	Total	383.50	298	681.50 (100.00)	372	206	578 (100.00)	227	91	318 (100.00)	254	57	311 (100.00)

Note: Figures in parantheses indicate percentage to the column totals

Table 39: Source-wise share of food consumption of households

(Rs. per household per annum)

Sl. No.	Zones	Farm	Market	Total
1.	Zone-1	6792 (58.68)	4783 (41.32)	11575 (100.00)
2.	Zone-2	6889 (56.46)	5311 (43.54)	12200 (100.00)
3.	Zone-3	5000 (34.92)	9317 (64.08)	14317 (100.00)
4.	Zone-4	5935 (43.62)	7671 (56.38)	13606 (100.00)

5.7 Resource-use and allocation efficiency of farms

The resource use pattern for various crops under different zones will indicate whether resources are being used optimally or not in agriculture. The resource use pattern for different crops in the four zones was examined and results are summarised in Table 40. The results furnished in the table show that, cropping pattern as well as consequent resource use pattern varied across the zones. In zone-3 and zone-4, in addition to the food crops of ragi and paddy, sugarcane and other commercial crops were grown.

It is evident from the table that, in the case of ragi, fertilizer and plant protection chemicals were not applied in zone-1. In zone-2, zone-3 and zone-4, the average fertilizer application per acre of ragi crop was 22.09, 34.33 and 43.24 kgs respectively. For paddy crop, fertilizer use was more than that of ragi in all zones except in zone-1 where paddy was not cultivated at all. Fertilizer use in zone-3 and zone-4 was highest for sugarcane, which was 413.65 and 519.54 kgs per acre respectively.

The farmyard manure (FYM) was also applied in large quantities in all zones except in zone-1. On an average, for ragi crop, 1,000, 2,384 and 1,946 kgs of FYM was applied in zone-2, zone-3 and zone-4 respectively.However, farmers in zone-3 and zone-4 applied the highest amount of FYM to sugarcane at an average rate of 4,270 and 5,977 kgs per acre respectively.The labour used for ragi crop was highest in zone-1 at 171 person days per acre whereas in zone-2, zone-3 and zone-4, the usage was lower than that of zone-1 at 48, 45 and 34 person days respectively. However, use of labour for crop production was highest for sugarcane crop in zone-3 and zone-4 as compared to other crops.

Resource productivity was studied as a prelude to resource allocation efficiency for ragi in all the four zones. In the present study, only ragi was considered for allocative efficiency, as it was the common crop in all the zones. This facilitates comparison of farms across the zones. The results of regression analysis for ragi are presented in Table 41.

The semi-log production function was used to analyse the productivity of resources for ragi in zone-4. The co-efficient of determination was 0.90 and was statistically significant as presented in Table 41. Area under ragi had a statistically significant and positive influence on returns. Fertilizers applied had negative influence on total returns whereas FYM had positive influence.

Semi-log production function was used to analyse the productivity of resources in zone-3. The co-efficient of multiple determination was 0.84 and was statistically significant. Area under crop had a negative and statistically significant influence on total returns. Fertilizers use had a negative and statistically significant influence on total returns. FYM and labour use had a positive influence on yield but was statistically insignificant.

Table 40: Resource-use pattern for various crops in different zones (per acre)

Sl. No.	Inputs	Zone-1	Zone-2		Zone-3			Zone-4		
		Ragi	Ragi	Paddy	Ragi	Paddy	Sugarcane	Ragi	Paddy	Sugarcane
1.	Seeds (kgs)	18.11	10.75	39.13	6.57	39.20	4503.86	6.59	33.12	8413.74
2.	FYM (kgs)	0	1000.00	3217.39	2383.56	4095.18	4269.80	1945.95	4523.18	5977.01
3.	Fertilizers (kgs)	0	22.09	82.60	34.33	129.44	413.65	43.24	143.04	519.54
4.	PPC (kgs)	0	0	0.022	0.014	0.200	0	0	0.500	0
5.	Labour									
	Men (days)	80.00	25.00	35.00	22.00	33.00	89.16	16.00	33.00	53.00
	Women (days)	91.00	23.00	36.00	23.00	32.00	137.07	18.00	42.00	74.40
6.	Bullock (days)	0.50	8.00	12.00	13.00	10.00	9.20	8.00	12.00	10.62
7.	Tractor (hrs)	0	0	0	0.50	2.00	0	0.50	1.00	0
8.	Yield (kgs)	158	355	846	657	1891	45310	709	1764	44580

Table 41: Resource productivity in ragi under different zones

Sl. No.	Zones	Intercept	Land	FYM	Fertilizers	Labour	Seeds	R^2
1.	Zone-4	7.60*** (0.225)	0.64** (0.166)	0.40E-03 (0.01)	-0.87E-03 (0.001)	NI	NI	0.90**
2.	Zone-3	7.69*** (0.243)	-1.15*** (-0.0925)	0.97E-03 (0.001)	-0.30E-02*** (-0.001)	0.66E-03 (0.0001)	NI	0.84***
3.	Zone-2	5.36*** (0.538)	NI	NI	NI	NI	0.60*** (0.139)	0.43***
4.	Zone-1	3.45*** (1.049)	NI	NI	NI	NI	0.71*** (0.260)	0.27***

Note : Figures in the parentheses indicate standard error
*** indicates significance at 1 per cent level
** indicates significance at 5 per cent level
* indicates significance at 10 per cent level
NI- variable not included in the model

Cobb-Douglas production function was a good fit to the data of zone-2 for ragi crop. Hence, it was used for analysis. The co-efficient of multiple determination was 0.43 and was statistically significant. It was found that the value of seeds used had a statistically significant and positive influence on total returns.

Cobb-Douglas production function was used for zone-1 also. The co-efficient of determination was 0.27 and was statistically significant. It was found that quantity of seeds used had a positive and statistically significant influence on total returns.

5.7.1 Allocative efficiency of resources for ragi

Allocation efficiency exists when the resources are allotted to crops according to marginal cost (MC) pricing, i.e., $MC=P_y$. Allocative efficiency in ragi cultivation was calculated for all the zones. The results of marginal analysis for ragi are indicated in Table 42.

The results indicated that, in zone-4, the MVP:MFC ratio for land and FYM was positive. The ratio was negative with respect to fertilizers.

In zone-3, the MVP: MFC ratio for land, FYM and labour were more than unity implying sub-optimal allocation of resources. The ratios were 23.00, 2.94 and 2.00 respectively. The MVP:MFC ratio was negative with respect to fertilizers (-9.22). In zone-2, the MVP:MFC ratio for seeds used was positive and the value was 28.44. In zone-1, the MVP: MFC ratio for seeds used was positive and the value was 6.83.

Table 42: Allocative efficiency of resources in ragi cultivation

ZONE-4

Sl. No.	Variables	Regression coefficient	Geometric mean	MVP	MFC	MVP:MFC
1.	Output (Rs.)		4103.60			
2.	Land (acres)	0.64	1.17	2655.02	205.18	12.94
3.	FYM (Rs.)	0.40E-03	0.57	1.64	1	1.64
4.	Fertilizers (Rs.)	-0.87E-03	38.67	3.59	1	-3.59

ZONE-3

Sl. No.	Variables	Regression coefficient	Geometric mean	MVP	MFC	MVP:MFC
1.	Output (Rs.)		3014.28			
2.	Land (acres)	-1.15	1.00	3466.42	150.71	23.00
3.	FYM (Rs.)	0.97E-03	374.29	2.94	1	2.94
4.	Fertilizers (Rs.)	-0.30E-02	6.27	9.22	1	-9.22
5.	Labour (Rs.)	0.66E-03	2802.38	2.00	1	2.00

ZONE-2

Sl. No.	**Variables**	**Regression coefficient**	**Geometric mean**	**MVP**	**MFC**	**MVP:MFC**
1.	Output (Rs.)		2118.94			
2.	Seeds (Rs.)	0.60	45.00	28.44	1	28.44

ZONE-1

Sl. No.	**Variables**	**Regression coefficient**	**Geometric mean**	**MVP**	**MFC**	**MVP:MFC**
1.	Output (Rs.)		552.44			
2.	Seeds (kgs)	0.71	9.68	41.03	6.00	6.83

Note: MVP- Marginal value of product, MFC-Marginal factor cost

5.8. Environmental Economics Component

5.8.1 Economic value of reduction in dependence of farms on external inputs due to environmental and economic benefits from eco-friendly farming system of BDOAF.

The reduction in dependency on external sources for ragi is presented in Table 43. The table shows the pattern of cash costs incurred for ragi cultivation in different zones. It can be observed that, cash costs incurred on external inputs like fertilizers, plant protection chemicals and hired labour was relatively higher in biodiversity poor zones. The total cost per acre of ragi ranges from 2,257.59 (zone-1) to 3,401.55 (zone-3). It was observed that, there was 100 per cent reduction in dependency on external inputs in zone-1, whereas it was about 35 and 37 per cent reduction in dependency in zone-3 and zone-4 respectively.

5.8.2 Ecosystem health

The ecosystem health in the four zones was analysed in terms of indicators furnished in the Table 44. An examination of table shows that in zone-1, none of the farmer was following plant protection measures for ragi crop whereas in zone-4, two farmers undertook plant protection measures. For paddy crop, a number of farmers in zone-3 and zone-4 applied pesticides while in zone-2, only three farmers used chemicals for control of pests. Thus, on an average, farmers in zone-3 and zone-4 applied higher quantity of chemicals worth Rs. 121.15 and Rs.118.59 per acre respectively than farmers in zone-2 who applied Rs.13.81 worth of chemicals. However, in zone-1, farmers did not take up any plant protection measures. Even with respect to fertiliser usage for crops, it was observed that, farmers in zone-4 and zone-3 applied larger quantities of fertilisers than farmers in zone-2.

The Simpson index, which reflects the degree of tree species diversity in the region was highest at 0.56 in zone-1 and was least in zone-4. The area under input intensive crops (an indirect indicator of ecosystem health) was 91 per cent in zone-4. It was nil in zone-1 and was least in zone-2 at 20 per cent. As a consequence of higher percentage of area under input intensive crops, mechanical power was used in substantial amount for the production of ragi and paddy in zone-3 and zone-4.

The consumption of chemical-free foods by inhabitants was observed only in zone-1 and zone-2. On an average, each household consumed about Rs. 1,911.35 and Rs.1,190.85 worth of chemical-free foods in zone-1 and zone-2 respectively. The crop diversity is also an indicator of ecosystem health. The crop diversity was the highest in zone-1 at 3.8 whereas it was lowest in zone-3 with only 1.53 crops.

5.8.3 Quality of life

The influence of BDOAF on quality of life was viewed in terms of provision of fruits, vegetables and other nutritive foods derived from farm and related sources for four zones and it is depicted in Table 45. It is clear from the table that, the level of consumption expenditure of households on these items was

Table 43: Reduction in dependency on external inputs in ragi cultivation (Rs.per acre)

Sl. No.	Particulars	Zone-1	Zone-2	Zone-3	Zone-4
1.	Fertilizers (a)	0	102.32	157.31	221.08
2.	Pesticides (b)	0	0	14.93	47.57
3.	Hired labour (c)	0	133.95	2040.93	1217.58
4.	Total purchased inputs (a+b+c)	0	236.27	2213.17	1486.23
5.	Total cost	2257.59	2679.01	3401.55	2341.51
6.	Reduction in dependency	2257.59 (100.00 %)	2442.74 (91.18 %)	1188.38 (34.94 %)	855.28 (36.53 %)

Table 44: Agro-ecosystem health indicators

Sl. No.	Particulars	Zone-1	Zone-2	Zone-3	Zone-4
1.	*Farmers practicing plant protection measures for*				
	-Ragi	*0*	*0*	*1*	*2*
	- Paddy	*-*	*3*	*19*	*21*
2.	*Plant protection chemicals (Rs.)*	*0*	*13.81*	*121.15*	*118.59*
3.	*Fertilisers (kgs)*				
	- Ragi	*0*	*22.09*	*34.33*	*43.24*
	- All crops	*0*	*34.86*	*187.38*	*233.97*
4.	*Simpson index for tree species diversity on farms*	*0.56*	*0.41*	*0.24*	*0.20*
5.	*Per cent acreage under input intensive crops*	*0*	*20*	*77*	*91*
6.	*Usage of mechanical power (MJ / acre)*				
	-Ragi	*0*	*0*	*14.70*	*179.20*
	- Paddy	*-*	*0*	*653.60*	*345.20*
7.	*Chemical-free foods*	*1911.35*	*1190.85*	*0*	*0*
8.	*Number of different crops on farms*	*3.8*	*3.03*	*1.53*	*1.60*

Table 45: Source-wise consumption pattern of subsistence requirements in different zones (Rs. per household)

Sl. No.	Source	Zone-1		Zone-2		Zone-3		Zone-4	
		BDOAF	Market	BDOAF	Market	BDOAF	Market	BDOAF	Market
1.	Cereals	637.50	3430.26	2873.47	2931.53	4081.66	3208.60	4886.12	1737.07
2.	Pulses	1482.00	889.33	1106.03	1099.33	0	2320.70	0	1923.67
3.	Vegetables	992.28	313.67	702.91	436.33	0	862.00	0	925.00
4.	Milk	43.83	66.67	321.75	600.00	577.33	870.72	873.45	1517.80
5.	Fruits	687.08	85.33	130.67	249.66	0	732.00	0	657.33
6.	Fuelwood	2951.31	0	1757.66	0	342.95	1325.00	176.25	912.17
7.	Per cent share of the total	58.67	41.33	56.45	43.55	34.92	65.08	43.61	56.39
8.	Total	6793.72	4780.26	6892.49	5316.85	5001.94	9319.02	5935.82	7673.04
9.	Grand total	11573.98		12209.34		14320.96		13608.86	

highest in zone-3 (Rs. 14,320.96) followed by households in zone-4 (Rs.13,608.86), zone-2 (Rs.12,209.34) and zone-1 (Rs.11,573.98). The households in zone-1 met 58.67 per cent of their consumption requirement from farm sources only, whereas, in the case of zone-3 and zone-4, it was 34.92 per cent and 43.61 per cent respectively. Households in zone-3 and zone-4 could meet only part of the requirements of cereals, milk and fuelwood from the farm. For other requirements, they solely depended on market / external resources. Households in zone-1 and zone-2 met not only the requirements of cereals and pulses, but also those of nutritive foods considerably from BDOAF sources.

Table 46 shows the complete consumption pattern of households in different zones including expenditure on education, health, clothing, etc. The results presented in the table reveal that the magnitude of consumption expenditure was highest among households in zone-3 at Rs.23,631.16 and was lowest among households in zone-1 (Rs.9,903.58). Further, the expenditure on nutritive foods like milk, fruits and vegetables and non-vegetarian foods was higher among households in zones 3 and 4 than that of households in zones 1 and 2.

5.8.4 Total value of direct use value of selected benefits from BDOAF

Environmental economists have classified use value from biodiversity as direct and non-direct use values. In the present study, an attempt has been made to quantify direct use values from BDOAF. Due to inadequate data and lack of access on certain scientific data pertaining to BDOAF and related information, we could not attempt the valuation of indirect use values. Results presented in Table 47 show only direct use values.

Tribal households realized a consumptive use value (net) of Rs.4,914 per household per annum from BDOAF. This forms little less than 50 per cent of the total household income. Though, values are based on actual payments received by collector, they need not reflect true market price, because, there appears to be some degree of market imperfection in transmitting market price signals. In such cases, these values appear to be underestimates.

The price differential by way of premium for per kg of chemical-free product ranged between Rs.1 to Rs.4.50 depending on type of product. The benefits for the use of medicinal plants was Rs.554.30 per household per annum. The non-consumptive use value (recreation) of Rs.351.69 indicates the recreational benefits derived from visiting the BRT area. This value indirectly reveals tourists WTP for preserving the biodiversity.

Table 46: Consumption expenditure of the households3 (Rs. per household per annum)

Sl. No.	Items	Zone-1	Zone-2	Zone-3	**Zone-4**
1.	Basic food items	4648.26 (46.94)	4397.02 (39.39)	6474.17 (27.40)	4421.74 (19.21)
2.	Vegetables and fruits	399.00 (4.03)	685.99 (6.15)	1594.00 (6.75))	1582.33 (6.87)
3.	Non- vegetarian food	320.83 (3.24)	625.00 (5.60)	931.16 (3.94)	526.60 (2.29)
4.	Other essentials	1008.33 (10.18)	1289.60 (11.55)	1536.60 (6.50)	1253.10 (5.44)
5.	Milk	66.67 (0.67)	600.00 (5.37)	870.72 (3.68)	1517.8 (6.60)
6.	Clothing	1235.00 (12.47)	1296.67 (11.62)	2326.67 (9.85)	2616.67 (11.36)
7.	Kerosene	207.17 (2.09)	269.40 (2.41)	927.20 (3.92)	630.33 (2.74)
8.	Fuel wood	0 (0)	0 (0)	1325.00 (5.61)	699.67 (3.04)
9.	Medicines	68.33 (0.69)	110.00 (0.99)	757.67 (3.21)	350.83 (1.52)
10.	Education	28.33 (0.29)	26.67 (0.24)	386.67 (1.64)	536.66 (2.33)
11.	Others	1921.66 (19.42)	1863.26 (16.68)	6501.30 (27.49)	8888.36(38.61)
12.	Total expenditure	9903.58 (100)	11163.61 (100)	23631.16 (100)	23024.09 (100)
13.	Total cash income	10169.43	12385.61	52640.79	56642.98
14.	Consumption expenditure as % of cash income	97.38	90.13	44.90	40.65

Note: Values in parentheses indicate the percentage to the column totals

Other essentials refers to salt, sugar, jaggery and spices

Miscellaneous items refer to consumer durables etc.

Non-vegetation food refers to fish and meat

Table 47: Direct use values of selected benefits (functions) from BDOAF

Sl. No.	Type of function / benefit	Category of use value	Average value
1.	NTFP extraction (Rs. / household / annum)	Consumptive use value	4914.00
2.	Chemical-free products (Rs. / kg)	Consumptive use value	1.00 - 4.50
3.	Medicinal flora (Rs. / household / annum)	Consumptive use value	554.30
4.	Recreation (Rs. / household)	Non-consumptive use value	351.69

CHAPTER VI: DISCUSSION

Keeping in view the objectives, the results of the study are discussed in this chapter under the following headings.

6.1 Socio-economic characteristics of the sample households

6.2 Sustainability and resilience of farms

6.3 Institutional and social factors influencing sustainable extraction of NTFPs and traditional farming practices

6.4 Economic, environmental and supplementary benefits from BDOAF vis-à-vis commercial farming

6.5 Intersectoral flow of resources and backward and forward linkages in village economy

6.6 Magnitude of dependencies of farm families on BDOAF

6.7 Resource use and allocative efficiency of farms

6.8 Environment Economics component

6.1 Socio-economic characteristics of the sample households

The details of socio-economic characteristics of sample respondents are discussed below under specific headings.

6.1.1. Family size

The average size of the family of households in zone-1 was 5.73 and it was almost six each in zone-2, zone-3 and zone-4 (Table 5). Among the sample respondents, it was found that a majority of households in zone-1 and zone-2 was nucleus families. This is because of the strong traditional customs and norms followed in the *'Soliga'* tribal community, which has led to a small size of family. In zone-3 and zone-4 also, most of the families were nucleus in nature and only a few joint families were observed. The family composition was more or less similar in all the zones except in zone-1 in which the number of males per family was relatively more than that of females.

6.1.2 Literacy

The literacy rate in zone-3 (36.11 %) and zone-4 (34.80 %) was relatively higher than that of zones 1 and 2 mainly because of greater awareness, proximity to schools, proximity to roads, good transportation facilities etc., in these zones (Table 5). It was also found that schools were located in many of the sample villages in zone-3 and zone-4. Hence, households in zone-3 and zone-4 were in a better position to make use of such facilities. However, lack of schools and poor transportation facilities in zones 1 and 2, resulted in low literacy levels and consequently poor development of these areas. But in recent years, NGOs operating in BRT area have opened schools and educational programmes have been launched exclusively for tribal people.

6.1.3 Livestock

It was observed that farmers in general possessed different types of livestock. (Table 6). With respect to cattle, it was found that in zone-1, households had a fewer number of animals (0.43 per household) than the families in other zones. Only 10 per cent of the households possessed cattle in zone-1. One of the reasons for this low per cent of cattle possession could be restrictions imposed by the State Forest Department due to risk involved in grazing the cattle in the forest. The number of cattle was highest in zone-2 (2.97 per household) as compared to the other zones. This may be because cattle formed a subsidiary occupation and it is an important source of draught power for agricultural activities. About 60 per cent of farmers possessed cattle in zone-2. The number of cattle was around two per household in zone-3 and zone-4. The existence of a fairly higher number of cattle in all the zones could be attributed to use of cattle for agriculture and related operations, particularly for transportation. About 67 per cent and 53 per cent of the sample farmers in zone-3 and zone-4 possessed cattle.

About 10 per cent and 27 per cent of the sample farmers possessed buffaloes in zone-3 and zone-4 respectively. The number of buffaloes was 0.26 and 0.47 in zone-3 and zone-4 respectively. Buffaloes were maintained mainly for milk and thereby to earn cash income.

In all the zones, households maintained goats. Goats were reared mainly to earn cash income in periods of needs and to serve meat dishes in festivals celebrated in the villages / settlements. The average number of goats per household was found to be highest in zone-2 compared to other zones, which might be due to the fact that livestock formed a major subsidiary occupation among farmers in zone-2. Only 23 per cent of the sample households in zone-3 possessed goats. The number of goats per household in zone-4 was lowest (0.43) and only about 13 per cent of the sample households possessed goats. One of the reasons for the low number could be the lack of grazing lands in this zone.

In respect of sheep, 20 per cent and 23 per cent of the sample households possessed sheep in zone-1 and zone-2, which mainly served as an alternative source of cash income. Only 17 per cent of the sample households in zone-3 and zone-4 possessed sheep. A low number of sheep and goat possession in these zones could be attributed to the lack of grazing lands or common pasture and menace of wild predators in these zones.

The number of poultry birds reared per household was quite high in zone-1 (4.86 per household). Rearing of poultry birds was a common feature among the *Soliga* households. Almost all the households had poultry birds. The maintenance of poultry birds was easy in this zone, as they could rear the birds in the kitchen garden maintained in the backyard. The poultry birds not only provide meat but also a good source of cash income. However, poultry was not so popular in zone-3 and zone-4.

6.1.4 Land holdings

The size of land holding per household was lowest in zone-1 (1.52 acres) and it was highest in zone-4 (3.39 acres). The households in zone-1 were more dependent on forests and wage income for their livelihoods due to lesser contribution of food or income from land compared to zone-3 and zone-4. The households in zone-3 and zone-4 had 2.76 and 3.39 acres of land and were highly dependent on agriculture and livestock for their livelihoods. The households in zone-2 who had 2.03 acres of land were dependent not only on agriculture but also on forest and wage income for their livelihoods.

A perusal of Table 7 shows that farmers in all the zones owned different types of lands. Farmers in zone-1 were cultivating only drylands. Among all the zones, average size of holding was lowest in this zone. A major reason for this could be rules and regulations of forest department to expand farm size and consequently lower dependence of s*oliga* community on agriculture for their livelihoods. Moreover, *soliga* community in zone-1 do not possess ownership rights on the lands they cultivate as forest department regulations do not permit cultivation in zones 1 and 2 as they lie within the jurisdiction of the BRT wildlife sanctuary. About 98 per cent of the total holdings was rainfed, as there was no irrigation facility in the hilly forest and also ground water irrigation was not used because of the traditional farming system.

The average size of holding in zone-2 (2.03 acres) was slightly more than that of zone-1. On an average, 70.44 per cent of the total land was rainfed. In this zone, the farmers (largely *soliga* community) enjoyed irrigation facility from the canals dug in nearby villages. About 10.84 per cent of the land in this zone was left fallow, as the land was less suited for agriculture and was very hard for tilling / cultivation purposes.

The average size of holding was 2.76 acres in zone-3 and out of this, 73.91 per cent formed irrigated land owing to creation of irrigation facility in the villages in the form of canals, tanks and groundwater irrigation.

The average size of holding was highest in zone-4 (3.39 acres), as compared to other zones. Out of this, 89.09 per cent was irrigated, mainly through canals, village tanks, own wells etc., existing in the villages. Only 7.08 per cent of land per farm was rainfed.

6.1.5 Cropping pattern

In zone-1, out of the total cultivated area under major crops, 54.05 per cent of the area was covered by ragi mixtures and 45.95 per cent of the area was under coffee (Table 8). Ragi along with other crops like maize, field bean and redgram almost fulfilled the basic consumption requirements of the families in this zone. Coffee occupied a major portion of the cultivated area in this zone. The area under this crop has increased only in the recent years, mainly because of the influence of a coffee estate located at the boundary of this zone. The coffee plantation is not a full-fledged one in this zone and only seedlings have been planted recently and a very few farmers took up cultural operation in this crop. Agricultural practices are highly primitive in this zone.

In zone-2, of the total cultivated area under major crops, 79 per cent was covered by ragi and 21 per cent by paddy. In this zone too, ragi (a mixed crop with field bean, maize, amaranthus and other crops) met the major portion of consumption requirement of families. Paddy was cultivated with irrigation facility provided by the canals running near the villages.

Paddy, sugarcane and ragi were the major crops in zone-3. As this zone is bestowed with irrigation facility and the farmers are mainly profit oriented, cultivation of paddy and sugarcane, which covered 51.15 per cent and 27.70 per cent respectively of the total area, was a common phenomenon. Ragi occupied 21.15 per cent of the total cultivated area under major crops. Ragi is a staple food crop of the region and it is a common practice to grow ragi in drylands as it is a hardy crop and needs less care.

Similar to zone-3, paddy, sugarcane and ragi were the major crops in zone-4. This zone enjoys good irrigation facilities in the form of irrigation canals, village tanks and private irrigation (open wells, tube wells, etc.). With plenty of resource availability and profit orientation, farmers cultivated paddy and sugarcane under assured irrigation. Ragi occupied only 10.58 per cent of the total cultivated area of households in zone-4.

6.1.6 Yields of major crops

The development of agriculture is largely reflected in terms of productivity of crops. Thus, higher agricultural development denotes higher level of yields. This was largely demonstrated in zone-4 where agriculture is well developed. Consequently yields of major crops were also highest. In zones 1 and 2, the yield of ragi was comparatively lower, ostensibly due to the fact that farmers in these zones were carrying out agriculture largely on traditional lines. The resource use pattern across the zones revealed that farmers in zone-3 and zone-4 were applying purchased inputs. Hence they realised higher yields.

6.2 Sustainability and resilience of farms

6.2.1 Sustainability

In recent years, concern for sustainable development of agro-ecosystems is gaining momentum worldwide in view of various negative externalities created by HYVs and monocropping systems. Existence of BDOAF may facilitate sustainability of agro-ecosystems. Thus, in the present study, an attempt has been made to relate the presence of biodiversity on sustainability of agro-ecosystems by developing appropriate indicators.

The concept of sustainability is very broad and defined according to the context it is addressing. The term 'sustainability' is commonly used to infer temporal phenomenon. In recent years, recognition of spatial scale of sustainability is also gaining importance. The notion of spatial sustainability has been employed by many researchers, particularly, on human settlements and habitations (Izac and Swift, 1994; Jansen et al, 1995). Due to lack of comparable of base data of sufficient length of time on relevant variables pertaining to the study region, we attempted influence on sustainability of farms on spatial dimension by developing appropriate indicators in order to reflect the influence of the degree of biodiversity in the four zones.

The indicators developed for inferring the sustainability of farms have been listed in Table 10. A perusal of the table reveals that the degree of crop heterogeneity (number of different crops) on the farms was the highest in biodiversity rich zones (zone-1 and zone-2) than in biodiversity poor zones (zone-3 and zone-4). This was primarily due to non-commercial nature of farming in zone-1 and zone-2 wherein farmers accorded importance to meet their subsistence requirements through mixed farming. Thus, the dependence on external sources for inputs as well as for their livelihoods was less. This was also reflected by the indicator - proportion of expenditure on food items from external sources was lower in zone-1 and zone-2 when compared to that in zone-3 and zone-4. The fact that the farms in zones 1 and 2 are ecologically sustainable does not necessarily imply that these farms will be economically sustainable in the long run and consequently tribal livelihoods. However, as these farm families are depending less on external sources, they are less affected by the fluctuations in the market environment. To that extent, livelihoods of tribal people are insulated against external shocks in the short run. But in the long run, due to pervasive nature of market forces, livelihoods of these people may also be influenced by them.

Though the households have access to income from various sources, it may not serve as an indication of sustainability unless substantial amount (> 10 %) is derived from a source. The income diversity index for zone-2 (3.89) implies that the households derived considerable amount of income from different production activities. Though, in general all the zones had an income diversity index of more than two, the magnitude of these values is smaller in zones 3 and 4 implying fewer range of livelihood options. A wider range of livelihood options will exert a lower degree of pressure on farm sources, which may indirectly contribute to ecological sustainability of farms. Hence, it could be inferred that by having a wide range of livelihood options, farms (systems) in zones 1 and 2 were more likely to be ecologically sustainable in the long run than farms in zones 3 and 4.

The energy balance ratio per acre of ragi across zones indicated that zone-1 had a highly favorable ratio of 3.90. This zone had lowest energy input into the system (1147.70 MJ). Both zones 3 and 4 had improved varieties of ragi which required higher energy input for production. Total energy requirement increased progressively with the level of mechanization of the operations in crop production. There is a need to replenish the soil fertility by adopting technologies like green manuring, organic cycling and application of biofertilizers to reduce the dependency on chemical fertilizers which heavily depend on imported energy like petroleum products in zone-3 and zone-4. Modern agro-technology should not be assessed only in monetary terms but also in energy terms so as to make the farming community more energy conscious for the sustainability of the agriculture.

The per cent area under input-intensive crops is an important indicator of sustainability of farming systems. It varies inversely with the level of biodiversity implying that farms in biodiversity rich zones cultivated less input intensive crops, thereby lower level of use of chemical based inputs. Further, the magnitude of application of non-ecofriendly inputs like fertilizers and PPC per acre was almost nil or very low in zone-1 and zone-2. Thus, the degree of dependence on external inputs was greater in zone-3 and zone-4, which resulted in high share of purchased inputs in total cost. Even for household consumption requirement, the degree of dependence on market was higher in zone-3 and zone-4 than in zone-1 and zone-2. The application of eco-friendly input viz., farmyard manure in zone-1 was negligible. This is because the soil in this zone is rich in nutrients and does not require supplementary nutrients through eco-friendly inputs like FYM, compost and green manure. Thus, based on the foregoing discussion it could be inferred that farms in biodiverse rich zones were relatively more sustainable ecologically than farms in biodiverse poor zones, primarily due to the existence of a large variety of biodiversity on and around farms. However, mere ecological sustainability may not sustain economic sustainability in the long run because ecological and economic optima do not converge. Hence, there is a need for ecological and economic trade-off in order to sustain livelihoods of households particularly in zones 1 and 2. However, such trade-off need to be within sustainable limits.

6.2.2 Resilience

The BDOAF performs various ecological functions, which enable farms to overcome the environmental, economic and physical adversities, or shocks, which are akin to resilience. The resilience has been viewed in terms of stability of farms to absorb any external shocks and continue the farming business. For instance, a lower amount of cash expenditure implies greater degree of resilience since farmers can recover quickly from financial losses if expenditure is lower. In line with this rationale, other indicators have been developed to measure the resilience of farms under the four zones and results are presented in Table 11.

It is evident from the Table 11 that average cash cost per kilogram of ragi output was lowest in biodiverse rich zones (zone-1 and zone-2) as compared with the biodiversity poor zones (zone-3 and zone-4). The sensitivity analysis of market price changes on net returns revealed that the percentage reduction in net income due to rise in input price or fall in output prices by 25 per cent showed that effect of such price variations would be lower on farms in zone-1 and zone-2 when compared to farms in zones 3 and 4. The zone-3 was the most vulnerable to variations in input price changes due to problematic soils, which affected the productivity and hence incurring higher costs. Farmers in zone-1 and zone-2 largely used local seeds and inputs including family labour. There was no hiring of labour in zone-1 because of availability of adequate family labour to meet the labour requirement in the production of crops and other household chores. In the other zones, dependence on markets for inputs for crop production resulted in higher cash costs in zone-3 and zone-4, which contributed to a lower degree of resilience.

The Herfindahl Index primarily reveals the crop concentration on farms. The converse of the same indicates the crop diversity. The value of index was lowest on zone-1 revealing a high degree of crop diversity on farms. A high level of crop diversity is an informal insurance strategy against risk in agriculture. Thus, existence of a large number of crops on farms is an indicator of resilience. In zone-1, the value was 0.63, which implied farms in zone-1 had the greatest resilience compared to other zones.

The threshold yield indicator shows the maximum yield required to cover the total costs. It was lowest in zone-1, implying that farmers produced farm output in the most economical way, thereby strengthening resilience of farms.

The Simpson Index indicated that the species diversity was the highest in zone-1 (0.56) and least in zone-4 (0.20). Higher crop and species diversity will add to the resilience of farming systems. Thus, on this measure also farms in zone-1 exhibited a greater level of resilience.

Supplementary income from BDOAF will strengthen resilience of farm households. Households having access to different sources of income can cope better with variations in farm income. Thus, households in zone-1 and zone-2 realized Rs.5,265.68 and Rs.3,019.01 respectively from non-crop activities (BDOAF), while, the households in zone-3 and zone-4 realized comparatively lower supplementary benefits to the tune of Rs.129.47 in zone-3 and about Rs.88.33 in zone-4. The supplementary benefits substantially contributed to the household consumption and income requirements. Based on these indicators, it could be inferred that farms (households) in zone-1 and zone-2 possessed a higher level of resilience than farms in zone-3 and zone-4. A caution needs to be exercised while inferring the resilience of farms. Because, a higher degree of resilience may act as some sort of insurance against risks and external shocks only. But it will not fully reflect the certainty of livelihoods. Thus, farmers with a low degree of resilience might also be having livelihood certainty and vice-versa.

6.3 Institutional and social factors influencing sustainable extraction of NTFPs and traditional farming practices.

Households in zone-1 and zone-2 were extracting / collecting various NTFPs from surrounding biodiversity. However, it is a moot point whether present extraction levels of NTFPs is carried out in a sustainable manner or not. In order to examine this issue, it is necessary to analyze the extraction pattern on a definite time scale based on household data. Due to non-availability of the same on a time scale, we used aggregate data for five years maintained by the LAMPS.

The data furnished in Table 12 on the collection of NTFPs revealed divergent trends in the extraction pattern. For instance, gooseberry showed a declining trend for the first four years and then showed a spurt in the collection during the fifth year (1995-96 to 1999-2000). In the case of honey, initially increasing pattern was seen but later on, it exhibited a declining trend. Similar is the case with alale. This is mainly because of cyclical nature of bearing of NTFPs often spanning a period of 2-5 years as in the case of gooseberry, antavala, alale , etc. Further, the scientific data on growth and regeneration rates was not available. Hence, it could not be inferred whether extraction of NTFPs is sustainable or not except gooseberry. In the case of gooseberry, though the cyclical nature of bearing was evident, the collection of the same regained its original status implying sustainable extraction. But in the case of other NTFPs such trend was not evident. However, institutional agencies operating in the BRT region have not only undertaken many programmes educating the soliga tribe on the sustainable extraction methods and practices but also involving these communities in the participatory resource monitoring. In addition, the traditional customs and social norms were also playing an enhancing role in sustainable extraction of NTFPs and sustaining traditional farm practices. The specific programmes of institutions and traditional customs and norms of soliga community in this direction are discussed below.

6.3.1 Institutions

The important formal institutions operating in the study area are Vivekananda Girijana Kalyana Kendra (VGKK), Ashoka Trust for Research in Ecology and the Environment (ATREE), Forest Department and Soliga Abhiruddi Sangha at podu (settlement) level.

The VGKK is playing a commendable role in the overall upliftment of the Soliga community. Under the Integrated Tribal Development Programme (ITDP), the VGKK has initiated various activities, which cover education, health, community organization, vocational training, biodiversity, agriculture, social forestry, housing etc. In relation to biodiversity, the formal education includes a course on environmental education at the school run by VGKK. VGKK also offers a job-oriented course in Forestry for the tribals. The course was started with an intention of preserving the traditional knowledge of the tribals about the biodiversity in the area. In addition, the course aims at providing the tribal youth with employment opportunities in the Forest Department. The institution has also documented the flora and fauna prevalent in the area. Based on the population, flora and fauna is classified into rare, endangered and threatened ones. In the case of threatened ones, exsitu conservation of species is practiced. The institution has created awareness on the importance of sustainable harvest of non-timber forest products (NTFPs) among the tribal community (Table 13).

The other formal institution operating in the BRT region is ATREE. The institution is mainly research oriented and links research with the development of the soliga community. ATREE has adopted Participatory Resource Monitoring (PRM) programme under which the community is involved in monitoring of the natural resources. Using PRM, before the harvest of any NTFP, the people are involved in productivity estimation by mapping for determining the extraction levels. If the productivity is good, they harvest more after leaving some portion for regeneration. If the harvest is not good and there are only a few trees in a particular patch of forest area the people are advised to leave more fruits (in the case of gooseberry) so that it will enable in it’s regeneration. Similarly, in the case of harvest of roots and tubers, the collectors are advised to leave a few roots / tubers for regeneration. Awareness is created with regard to the proper extraction of lichens without removing the orchids, which are generally found to be associated with lichens. They are advised not to cut the larval / pupae portion while extracting honey for better productivity in future.

The programmes initiated by ATREE have resulted in notable achievements in natural resource conservation by adopting non-destructive harvesting techniques. A report of ATREE (1999-2001) claims that it's programmes have resulted in enabling to realize increased returns from NTFPs to harvesters.

Soliga Abhivruddi Sangha at the podu (settlement) level is an institution formed by the Soliga members themselves in which they have a village leader who takes decisions regarding the issues concerning the settlement. They meet as and when it is necessary to take decisions regarding agriculture, extraction of NTFPs and other activities. The Sanghas at podu levels are also involved in monitoring of the resources (especially NTFPs). If there are any violations with regard to collection i.e., the podu's people entering the forest area of some other podu, the violators are orally cautioned/warned. The Sanghas also emphasize the importance of sustainable harvest of NTFPs and preserving biodiversity.

6.3.2 Social norms and customs

Soligas have their own social norms in which they give due regard to Mother Nature for the benefits they derive in the form of agricultural crops, NTFPs etc. They celebrate many festivals to thank the nature.

The soliga community has certain religious beliefs, which are important from the point of view of biodiversity. For example, before the harvest of crops, extraction / collection of NTFPs etc., they offer puja and start their work. In the case of gooseberry, after the harvest, they throw a few fruits in the forest mainly for the forest God (Karaya- King of Forest), which in turn helps in regeneration of the species. They worship trees namely, sampige, nerale, tare and ficus species and animals like tiger and elephant. Generally, the soliga community has inherent knowledge about the importance of biodiversity/forests, their role in their livelihoods and need for living in harmony with the nature. Thus, the formal institutions as well as social and religious norms and practices have played an important role in reinforcing the values of biodiversity.

6.4 Economic, environmental and supplementary benefits from BDOAF vis-à-vis commercial farming

6.4.1 The economic value of direct use benefits from BDOAF

6.4.1.1 Non Timber Forest Products (NTFPs)

A significant number of people in India (about 50 million) rely on the extraction of forest-based products for their livelihoods. However, there is little information on the pattern and magnitudes as to how geographically these people derive their annual income from forest resources. Nevertheless, the dependence on forest products such as non-timber forest products (NTFPs) is greater among marginalized rural and tribal populations who have inadequate access and entitlement to productive resources, notably to land resources (Fernandes et al, 1988). The dependence of these communities on NTFPs assumes even greater significance in an eco-system characterized by rich biodiversity around farms and regions because of open access nature of these resources.

Ecologists and economists suggest that extraction of plants and animals can be a useful means to raise rural incomes, particularly to marginal communities because the benefits directly go to extractors (Godoy and Bawa, 1993). Such recommendations apparently emanate due to the recognition of the ability and capacity of rich biodiversity around farms to offer a plethora of economic, environmental and other services to proximate households and communities that are closely dependent on these farms.

In the BRT area, abundant biodiversity on and around farms in zone-1and zone-2 enabled the tribals to derive direct use benefits from the collection of NTFPs, which is lacking in zone-3 and zone-4. On an average, the tribals collected 18 NTFPs in zone-1 and zone-2. Various uses of these NTFPs have been indicated in Appendix-5. The biodiversity in the form of NTFPs supported livelihoods of tribal people in many ways.

Firstly, it provided income to households by way of sale proceeds from NTFPs. It created self-employment in the form of collection of these products. It also supported direct subsistence needs of tribal families through the collection of roots, tubers, fruits, vegetables and other supplementary products.

These direct benefits were categorized as cash income and non-cash income. The associated costs were calculated in terms of opportunity cost of labour and incidental expenditure. The particulars of NTFPs collection are furnished in Table 14. It could be observed from the Table 14 that the soliga tribe in zone-1 collected 16 NTFPs for commercial and subsistence requirements. However, 11 products were economically useful and only four of them fetched bulk of soligas' NTFPs income. A majority of respondent tribal families collected seven major NTFPs, among which fuel wood, lichens, honey and gooseberry were the major NTFPs in both zone-1 and zone-2. The average time spent for collection of each product varied between five and 76.78 days in a year. The average time spent on the collection reveals abundance or scarcity of the product and consequently sustainable extraction. Tribals spent highest time in the collection of lichens.

Tribals in these zones were allowed by the state to enjoy usufruct benefits from BDOAF by collecting NTFPs. Households in zone-1 exclusively collected and consumed greens (Rs. 142.33), mushrooms (Rs. 306.00) and roots and tubers (Rs. 451.66 per household per annum). The tribals in zone-2 extracted relatively a lower quantity of greens and mushrooms. But, they extracted a larger amount of roots and tubers than households in zone-1. The tribals were allowed to pick dead and dry branches and twigs from the forest as logging of timber was prohibited. The fuelwood (Rs. 2951.30) was the major source of non-cash income to the households. Girish (1998) also reported that fuelwood was the major non-cash income generator among the tribal households in Western Ghats region of Karnataka. Green fodder contributed only Rs. 161.53 to the total non-cash income as it was not harvested and the livestock was left to graze. Hence, with a standard procedure (Singh, 1989) indicated in the methodology, the value of green fodder was estimated.

The products like alale, gooseberry, lichens, makaliberu, moss and bee wax were exclusively marketed. The tribals also gathered antlers of deer along with the collection of other non-timber forest products. The highest share of cash income was from the sale of lichens - Rs.1,795.83 (29.27 %) followed by moss with Rs.1,502.11 (24.49 %). The total cash income from the sale of non-timber forest products was Rs. 6,133.38 (58.43 %) and the total non-cash income was Rs. 4,363.32 (41.57 %) per annum to the households in zone-1, thus adding to a total income of Rs. 10,496.70. The associated cost in terms of opportunity cost of labour and incidentals was Rs. 2,948.83.

Among the different products, the highest cost was incurred (in terms of labour) towards the collection of fuelwood (Rs. 972.95) and the least was for the beewax (a by-product of honey) and makaliberu (Rs. 7.50). Generally, green leafy vegetables were collected along with other products, and the amount of time spent in gathering it is also indicated as cost (opportunity cost). The commodity-wise lowest benefit-cost ratio was in the case of dhoopa (0.49). All other products except antavala and makaliberu had a B:C ratio of above 2 (Table14).

In zone-2, households on an average spent about 110 man days and 78 woman days per annum in the collection of NTFPs. The tribals in zone-2 collected 16 NTFPs except dhoopa and moss similar to that in zone-1. The highest non-cash income was in the form of fuelwood (Rs. 1,483.17) followed by green fodder (Rs. 285.83). Girish (1998) made a similar observation in his study on the tribal economy in Western Ghats region of Karnataka. In this zone, only a few households marketed fuelwood to the non-tribals in the locality. The highest share of cash income was from sale of gooseberry at Rs.737.33 (33.02%). The total cash income from sale of NTFPs was Rs. 2,232.99 and non-cash income was worth Rs. 2,739.26. The associated cost in terms of opportunity cost of labour and other incidentals was Rs. 2,691.83 per household. In this zone also, cost of fuelwood collection was the highest at Rs. 994.68. Among the different products, the highest benefit-cost ratio was for antavala (17.68) followed by alale (6.23). All other commodities had a B:C ratio of less than 2.5.

The total consumptive use value (gross) obtained from NTFPs collection by the households in the two zones amounted to Rs. 10, 496.70 and Rs. 4,972.25 respectively for zone-1 and zone-2. The market value realized was greater in zone-1 (58.43 %) than in zone-2 (44.91 %). NTFPs were marketed through LAMPS, which are established for catering to the multiple needs of the soliga tribe. In addition, the societies also undertake collection, processing and marketing of NTFPs. However, the cooperative societies process only a few products with limited value addition.

6.4.1.2 Benefits and costs from agriculture

In the study region, important occupations were agriculture based particularly in zones 4, 3 and 2. Hence, agriculture is the major source of livelihood for households in these zones. Details of the cropping pattern and costs and returns from agriculture in the four zones are presented in Table 15. It is evident from the table that ragi is the common crop in all the zones, as it is the staple food crop of the study region. While paddy was grown in zones 2, 3 and 4, sugarcane was an important commercial crop in zones 3 and 4. Coffee was an emerging commercial crop in zone-1. The selection of varieties and method of cultivation varied among these zones. In zone-1, five types of local varieties of ragi namely sanna ragi, dodda ragi, nadu ragi, gidda ragi and male ragi were grown. Ragi crop was cultivated as a mixed crop with pulses and other crops like redgram, horsegram, maize, niger and mustard. In zone-2, local as well as high yielding varieties of ragi were grown. Ragi crop is mostly grown as a rainfed crop in the study region.

The economics of crop production presented in Table 15 reveals that farmers in zone-3 realized a maximum gross income of Rs.4,008.85 per acre followed by farmers in zone-4 (Rs.3,416.20), zone-2 (Rs.3,235.50) and zone-1 (Rs.590.75). However, households in zone-4 realized highest net income of Rs.1,074.70 per acre. Households in zones 1 and 2 realized lower net income due to a lesser use of purchased inputs. The per acre income from coffee was Rs.3,573.20 and the cost was Rs.1,949.90, while the B:C ratio was 1.83 implying that per rupee of investment on coffee yielded a return of 1.83.

A comparison of costs and returns of paddy cultivation across the four zones revealed that per acre income was lowest in zone-2 (Rs. 4,387.95) while the highest was in zone-4 (Rs. 11,917.15). Even net income was higher in zones 3 and 4, perhaps due to a large-scale irrigation facility in these zones, which facilitated adoption of package of practices.

Cultivation of sugarcane was highly profitable in zone-4, which had a B:C ratio of 2.15, as compared to zone-3 (2.48). Per acre cost of cultivation of sugarcane was Rs. 14,302.32 in zone-3 while it was Rs. 17,308.97 in zone-4. The net income realised in zone-4 and zone-3 was Rs. 20,027.03 and Rs. 21,276.98 respectively. Thus, based on the results it can be inferred that farming was more profitable with commercial crops like sugarcane and paddy in zone-3 and zone-4 compared to that in zone-1 and zone-2 which mainly concentrated on subsistence crops. Due to lower incomes from agricultural sources, the marginal farmers in zone-1 and zone-2 depended on the surrounding BDOAF to support their livelihoods.

6.4.1.3 Benefits and associated costs of livestock diversity

Livestock enterprises such as dairy, sheep, goat rearing and poultry rearing were the important subsidiary activities in all the zones. However, in zones 1 and 2, there were some restrictions for rearing livestock enterprises as it may affect forest growth. Moreover, livestock is prone to attacks by wild animals. Hence, livestock enterprises have not developed extensively on large scale except poultry, which is an important subsidiary occupation.

A comparison of costs of and returns from livestock enterprises across the zones revealed that it was profitable to maintain livestock in all the zones (Table 15). The highest return (Rs. 5,346.67) from livestock was found in zone-3 followed by zone-4 (Rs. 4824.07). The households in zone-1 incurred very little expenditure (Rs.184.48) for maintaining livestock compared to the other three zones. This is mainly due to the fact that the households maintained more of poultry birds, goat and sheep on the farm whereas in other zones livestock was mostly crossbred cows and buffalo and therefore higher expenditure. Further, local breeds of cows were left for grazing in zone-1and was not fed with concentrates. Hence, cost of maintaining livestock was lower in this zone.

6.4.1.4 Benefits from kitchen gardens

A unique feature of households in zones 1 and 2 was that, they were maintaining kitchen gardens in the backyards of their homes. Thereby, they were able to supplement their consumption requirement, which ensured a balanced intake of nutritional food (vegetables and fruits). The benefits thus obtained by maintaining kitchen garden was higher in zone-1 compared to zone-2 (Table 15). This practice may add to sustainability and self-reliance to the households apart from improving the nutritional status.

6.4.1.5 Economic benefits from maintaining trees on farms

The households in all the zones maintained both naturally occurring and planted trees to meet the household and farm requirements. The tenurial rights permit only harvesting of fruits and collecting dry twigs in zone-1 and zone-2. The households in zone-3 and zone-4 realized higher benefits from trees on farms compared to zone-1 and zone-2 due to difference in the composition of plant species. However, the households in zone-1 and zone-2 realised benefits from various types of tree species almost without any costs as the trees grow naturally around the farms (Table 15).

6.4.1.6 Total income of respondents from various sources

The occupational structure of households in the study region largely influenced the magnitude of income. The traditional activity of soligas was collection of NTFPs and that of non-soligas was agriculture. Accordingly, these were the major sources of income for the households in the study region with the exception of soligas in zone-2 wherein agriculture is emerging as another important source of income over the years.

A scrutiny of Table 16 reveals that farmers in zone-4 realized highest income of Rs.65,066.39, followed by households in zone-3 (Rs.56,181.10), zone-1 (Rs.21622.37) and zone-2 (Rs.18,889.54). On the aggregate, biodiversity related occupations (NTFPs, wage employment, subsidiary activities, etc.) contributed more than 50 per cent of soliga household income in zone-1. Whereas, in zone-2, households derived about 28 per cent of their income from biodiversity and related activities. On the contrary, households in zones 3 and 4 derived almost their entire income from agriculture and related activities. They obtained about 86.15 and 85.10 per cent of their household income from agriculture alone. Thus, based on the results it could be inferred that marginal tribal communities who do not have access to and property rights to productive assets depend intensively on biodiversity (collection of NTFPs and related activities) and other natural resources for their livelihood. Kant and Mehta (1993), Kinhal and Narayan (1994), Pradhan (1995), Hedge et al (1996), Sekar et al (1996), Thomas (1996), Ganapathy (1998) and Girish (1998) also reported that NTFPs was the major income generator in their studies. This phenomenon is contrasted by a different behavior of soligas in zone-2 who had relatively greater livelihood security in terms of agriculture and consequently had a lower dependency on biodiversity.

Wage income was also an important means of livelihoods of tribal households as 25.16 and 17.28 per cent of tribal incomes in zone-1 and zone-2 respectively was obtained from this source.

An attempt was made in the present study to examine changes in structural pattern of income sources and importance of biodiversity on livelihoods of the soliga tribe by comparing results of the present study with that of a research work by Hegde et al (1996) who conducted a survey in the same region in 1993. Table 17 summarizes results of both the studies. It is evident from the table that over a period of seven years, the contribution of NTFPs (biodiversity source) to household income of soligas had declined in zone-1 and zone-2 giving a strong credence to a proposition that a greater exposure to development process will lead to diversification of livelihood options and dependence on the extraction of plants and animals as means of livelihood declines. During this period, several economic development, welfare and educational programs initiated by various non-governmental organizations (NGOs), research organizations and state forest departments might have influenced behavioral changes and outlook of soligas towards their livelihoods.

6.4.2 Environmental Benefits

6.4.2.1 Nature and pattern of flow of environmental services

Biodiversity on and around farms performs numerous environmental functions and provides various tangible and intangible benefits. Table 18 shows the flow of these benefits in various zones in the study region. These benefits were expressed on a four point scale based on the field observations and interactions with respondents. It could be seen from the table that due to rich biodiversity in zone-1 and zone-2, households derived a multitude of environmental services. However, these services are not limited to households in BRT because they are pervasive in nature and hence a large population surrounding BRT will also benefit from these services.

6.4.2.2 Valuation of environmental benefits and services

Although various environmental benefits are evident from BDOAF, due to various constraints particularly, lack of access / absence of information on various functional relationships between soil flora and fauna and environmental functions and other variables, the quantification of all benefits could not be attempted. Further, difficulties in administering surveys based on behavioral linkage approaches to soligas also acted as constraints in valuing various environmental services. Therefore, valuation of only three environmental goods and services namely chemical free products, medicinal plants and eco-tourism was attempted using Contingent Valuation Method (CVM), Replacement Cost Approach (OC) and Travel Cost Method (TCM) techniques respectively.

6.4.2.2.1 Chemical free products

Many of NTFPs have a wide range of household and medicinal applications. Hence, there is a good market for these products. Most of these products are collected and processed at the level of tribal co-operative societies without any additives or flavoring agents. Hence, products are organic in nature and quality is good. A consumer survey was carried out to know the price premium that consumers were willing to pay for these high quality products. Using the contingent valuation method, consumers' WTP was elicited in the selected localities of Bangalore city.

The willingness to pay (WTP) for chemical free (organic) products viz., honey, soapnut, turmeric and makaliberu powder was assessed and results are presented in Table 19. The respondents were willing to pay a premium of Rs. 4.50 per kg of pure honey. The Average Willingness To Pay (AWTP) for soapnut powder and turmeric was Rs. 2.66 and Rs. 2.95 respectively. The consumers were willing to pay a maximum of Rs. 30 premium per kg of honey followed by soapnut and turmeric at Rs. 20 per kg each. The high willingness to pay for these products may be a reflection of poor quality (pesticide residue/adulteration) of the products already available and traded in the market. Thus, the WTP differs with the product group based on the importance attached to such products, the quantity consumed and nature of the commodity.

The willingness to pay for organic (pesticide free) products according to income groups is indicated in Table 20. Majority of the respondents were in low (less than Rs.7,500 per month) and middle income (Rs. 7,501-Rs. 15,000) categories. The respondents in high-income group (above Rs. 15,000) had the willingness to pay highest premium for chemical-free products. Accordingly, the WTP was Rs.6.56 per kg of honey, Rs.3.5 per kg of soapnut and Rs.3.78 per kg of turmeric compared to other income categories. However, these estimates were not tested for various biases inherent in CVM estimations. The behavior of consumers is a reflection of their awareness about the benefits of consuming organically produced products. The consumers' WTP was higher for the commodities, which can be easily adulterated with chemicals. In general, the consumers placed a higher value (premium) for all the commodities considered in the study because the products originated from biodiversity rich area and a pollution free environment.

6.4.2.2.2 Medicinal plants

The rich biodiversity in zone-1 and zone-2 has a large repository of vast medicinal wealth. It has been identified that about 300 plant species can be used for medicinal purposes economically. However, only about 60 plant species are being exploited for extracting medicines as reported by tribal people. Table 21 summarizes common ailments among tribals and number of plant species used for their treatment. These ailments have been classified as those needing primary health care, gynaecological cares and major diseases. 34 plant species were used as medicines for curing common ailments while for gynaecological problems and major diseases a fewer number of species, six and 20 species respectively, have been identified.

It was revealed by tribal people during the discussion that they preferred using herbal medicines over allopathic medicines for treating common ailments like stomach disorders, minor injuries, common cold, gynaecological problems like inadequate breast milk for babies and diabetic problems. The herbal medicines were normally prepared and administered by one or two knowledgeable members of a podu (village settlement) at a nominal fee of Rs.5 to Rs.12. The use of herbal medicine for common ailments instead of allopathic medicine resulted in a considerable monetary saving. Using replacement cost approach, consumptive use value in the form of use of plant origin medicines was estimated. However we did not attempt to quantify future values of drugs, due to lack of scientific data and other information needed for such estimation. It was estimated that on an average, each household in zone-1 and zone-2 was able to save Rs.748.60 and Rs.360 annually. The savings included allopathic medicines, incidentals and other costs. However, we did not consider the opportunity cost of time (duration of illness) for estimation. Thus, the consumptive use values from medicinal plants by soliga tribe worked out to Rs.748.60 and Rs.360 per household per annum in zone-1 and zone-2 respectively.

Medical and para-medical facilities are provided by the NGOs located in the BRT sanctuary. The tribal people make visits to mobile health units and a hospital at BRT for major diseases and to get treatment for injuries caused by wild animals. In zone-3 and zone-4 due to poor biodiversity, the existence and availability of medicinal plants was very low. Hence households in zone-3 and zone-4 derive very low magnitude of these benefits. Consequently, they spent considerably higher amounts on health care to the extent of Rs. 757.67 and Rs. 350.83 per annum in zone-3 and zone-4 respectively.

6.4.2.2.3 Eco-tourism (Recreational benefits from BDOAF)

One of the important services that biodiversity provides is the aesthetic value which offers vast potential for recreation. The BRT hills located in the eastern regions of Western Ghats in Karnataka has a game sanctuary. It is a place for many wild animals and has been declared as a game sanctuary since 1975. Located at a distance of about 190 kms from Bangalore City, it has a very high tourism potential. Besides game sanctuary, the hilly terrain, bio-diversity of different types and a spot near Biligiri Rangaswamy Temple present a scenic beauty. The high point near the temple, which epitomizes scenic beauty is the major attraction for tourists besides offering prayers at the temple, which is centuries old. A significant number of tourists from surrounding areas and also from Bangalore and other distant places visit the site for both recreational and religious purposes. This has created a tourist industry albeit at a very small scale at BRT. Thus, there is a potential for developing the site into a major tourist centre.

The non-consumptive use values derived by tourists from visiting the BRT was determined based on revealed preferences. The demand for eco-tourism service and its use values were estimated by applying the travel cost method. For this purpose, a demand function (visit rate per annum) was fitted with explanatory variables of age, distance travelled and educational level of respondents. A semi-log functional form was found to be the most appropriate. The results of the regression analysis and consumer surplus estimates are presented in Table 22. Variable distance travelled was found to be statistically significant. The variable distance traveled was used as a proxy variable for travel cost by multiplying it with the average cost per kilometer traveled to estimate consumer surplus values.

The average consumer surplus for each visitor worked out to Rs.351.69 based on the estimated function. The estimated upper and lower values of consumer surplus were Rs.217.45 and Rs.919.09. The consumer surplus so estimated gives a non-consumptive use values of biodiversity in BRT region. Consumer surplus can be useful in formulating appropriate policies for management and preservation of such areas. The non-consumptive use values estimated were compared with visitors WTP for maintenance and protection of BRT wildlife sanctuary. TCM estimates and the visitors WTP values can be used to relate construct validity and convergent validity of these estimates. The average value of WTP of visitors was Rs.204.75, which was substantially lower than the consumer surplus estimate of Rs.351.69 from TCM. Thus, there is a lower convergent validity between two estimates. Nevertheless, use value obtained from revealed preferences of visitors was greater than the use value obtained through stated preference. This implies that stated preference is an underestimate of their actual behavior. Relatively high consumer surplus values obtained reveal that BRT has a high tourist potential.

Visitors were also asked to indicate as to how much they were willing to pay for the maintenance and preservation of the biodiversity and sanctuary at BRT. These figures are furnished in Table 23. The minimum and maximum WTP varied between 0 and Rs. 5,000. However, the mean WTP as expressed by the respondents for maintenance and preservation of BRT sanctuary area was Rs. 204.75. The results revealed that a large majority of respondents (78.75 %) had a annual income of Rs. 36,000 or less and their WTP was Rs. 200.32, which is quite low considering the consumer surplus estimates. However, respondents with higher income were willing to pay larger amounts towards maintaining the BRT sanctuary area.

6.4.3 Supplementary Benefits

The existence of rich biodiversity on and around farms in zone-1 and zone-2 enabled tribal farmers to extract different kinds of benefits whereas households in zone-3 and zone-4 could realise only a narrow range of benefits from surrounding BDOAF. In addition to NTFPs, the soliga tribe realized many tangible benefits from BDOAF, which can be termed as supplementary benefits that are mostly used for household consumption. These benefits supplemented household non-cereal food items such as vegetables, fruits and others. These products also add to nutritional supplements of households. It could be observed from Table 24 that households in zone-1 and zone-2 realised a wide range of supplementary benefits from BDOAF. It is interesting to note that households in zone-1 and zone-2 realised even medicines from plant sources to an extent of Rs.748.60 and Rs.360 respectively, while households in zone-3 and zone-4 realized only marginal benefits from BDOAF. The major supplementary benefits obtained from NTFPs and kitchen garden amounted to Rs.4,363.32 and Rs. 779.36 respectively in zone-1 and Rs.2,739.36 and Rs.220.58 respectively in zone-2. However, households in zone-3 and zone-4 did not realize these benefits due to very poor degree of bio-diversity on and around farms. The total value of supplementary benefits obtained by households in zone-1was higher (Rs.6,014.20) than that of zone-2 (Rs.3,379).

6.5 Intersectoral flow of resources and backward and forward linkages in village economy

Social Accounting Matrix (SAM) analysis was performed to study the linkages that exist among the various sectors of the village economy. This helps to prioritise the investment decisions. According to the sample data, though ragi was the major crop in zone-1, but while constructing SAM for the zone as a whole, population data for the main village has to be considered as the same data is not available at the podu / settlement level. Therefore, while constructing the matrix, other crops that are cultivated in the main villages do enter the SAM (Table 25). This is the reason for inclusion of maize, groundnut and cotton crops in the SAM for zone-1. Similarly, is the case for the other zones.

6.5.1 Production multiplier analysis for zone-1

The production multiplier matrix reveals the most profitable sector in the economy, so as to direct new investment to be made in the economy and to improve the village economy. Dairy sector had the highest production multiplier (2.76) in zone-1 (Table 26). This implies that for every one rupee increase in final demand of dairy sector, the total production would increase by Rs. 2.76. In the case of agriculture, ragi sub-sector had the highest multiplier of 2.69. For every one rupee increase in final demand for ragi, the total production for the area under consideration would increase by Rs. 2.69. In the case of NTFPs, food sub-sector had the highest multiplier of 2.49 implying that for every one rupee increase in final demand, its total production would increase by Rs. 2.49. Hence, investments should be directed towards dairy sector, ragi crop sub-sector, and improving NTFPs availability through sustainable extraction methods.

6.5.2 Household income multiplier matrix for zone-1

The household income multiplier matrix (Table 27) indicates the share of different households out of the expected increase in income due to new investment. Fodder and non-food sub-sectors of NTFPs had the highest income multiplier of 1.75. Out of the expected increase in income from non-food sub-sector, 34.86 per cent will go to marginal households, 28.57 per cent each to small and large households and eight per cent to landless. Out of the expected increase in income from fodder sub-sector, 36 per cent will go to the large households, 28.57 per cent to the small households, 27.43 per cent to the marginal households and eight per cent to the landless households. In the case of agriculture, ragi sub-sector had the highest multiplier of 1.62. For every one rupee of investment, the income would increase by Rs. 1.62. Of the expected increase in income, 48.77 per cent will go to marginal households, 25.31 per cent will go to small households, 10.49 per cent will go to large households and 15.43 per cent will go to landless households. Ragi was followed by maize, groundnut and cotton with multiplier values of 1.59, 1.53 and 1.46 in that order. In the case of dairy sector, every one rupee investment would increase the income by Rs. 1.61. Marginal households were expected to derive maximum share of this increased income followed by small households. In general, it was observed that, marginal households were expected to obtain maximum percentage share of the increased income, for investments made in any of the sectors / sub-sectors except fodder sub-sector of NTFPs.

6.5.3 Production multiplier analysis for zone-2

Even in zone-2, dairy sector had the highest production multiplier of 4.39 (Table 29). This implies that for every one rupee increase in final demand of dairy sector, the total production would increase by Rs. 4.39. In the case of NTFPs, food sub-sector had the highest multiplier of 3.51 implying that a rupee increase in final demand would increase the total production by Rs.3.51. In the case of agriculture, ragi sub-sector had the highest multiplier of 3.26 implying that a rupee increase in final demand for ragi would increase the total production by Rs.3.26. The other sub-sectors of agriculture viz., groundnut and paddy had multipliers of 2.99 and 2.94 respectively. The other two NTFPs sub-sectors viz., non-food and fodder had multipliers of 3.46 and 2.96 respectively. Hence, even in zone-2, investments should be made in dairy sector, ragi crop sub-sector and improving NTFPs availability through sustainable extraction methods.

6.5.4 Household income multiplier analysis for zone-2

The dairy sector had the highest income multiplier of 2.37 in zone-2 (Table 30). This implies that a rupee investment made in it would increase the income by Rs. 2.37. Out of this expected increase in income, a major portion will go to marginal households followed by small households. In NTFPs sector, food sub-sector had an income multiplier of 2.34, while the non-food sub-sector and fodder sub-sector had income multipliers of 2.24 and 2.11 respectively. Out of the expected increase in income, for the investment made in these sub-sectors, the major share will go to marginal households. In case of agriculture, ragi sub-sector had the highest income multiplier of 2.10. Of the expected increase in income, major percentage (50.48 %) will go to marginal households followed by small households (25.24 %). Ragi sub-sector was followed by groundnut and paddy sub-sectors with multipliers of 1.93 and 1.89 respectively. In general, marginal households were expected to derive maximum percentage share of the increased income, due to investment made in any of these sectors / sub-sectors.

6.5.5 Production multiplier analysis for zone-3

The NTFPs sector does not exist in this zone because of very low BDOAF. Ragi sub-sector had the highest production multiplier of 2.13 in this zone (Table 32). This implies that for every one rupee increase in final demand for ragi, the total production would increase by Rs.2.13. Within agriculture, paddy sub-sector stood second with a multiplier value of 1.97. The second most important sector in this zone was dairy sector with a multiplier value of 2.10, implying that for every one rupee increase in final demand of dairy sector, the total production would increase by 2.10. Hence, investments should be directed towards ragi crop sub-sector and dairy sector as these will generate relatively greater returns when compared to that in other sectors / sub-sectors.

6.5.6 Household income multiplier matrix for zone-3

Ragi had the highest income multiplier of 1.16 (Table 33). Of the expected increase in income from the ragi sub-sector, 41.38 per cent will go to marginal households, 37.07 per cent will go to landless households, 14.65 per cent will go to small households and 6.90 per cent will go to large households. Sugarcane sub-sector followed ragi sub-sector with income multiplier of 1.15 and of the expected increase in income, highest share (33.91 %) will go to marginal households. Groundnut and paddy sub-sectors had multiplier values of 1.11 each. Dairy sector had income multiplier of 1.11 and of the expected increased income, maximum percentage share (51.35 %) will go to marginal households. In general, of the expected increase in income due to investment in any of these sectors would benefit the marginal households the most when compared to other households.

6.5.7 Production multiplier analysis for zone-4

As observed in zone-3, zone-4 is also devoid of NTFPs sector due to very low BDOAF. Dairy sector had the highest production multiplier value of 2.38 (Table 35). This implies that for every one rupee increase in final demand of dairy sector, the total production would increase by Rs.2.38. In the case of agriculture, ragi sub-sector had the highest multiplier of 2.16. For every one rupee increase in final demand for ragi, the total production would increase by Rs.2.16. Ragi sub-sector was followed by paddy and groundnut sub-sectors with multiplier value of 2.15 each and sugarcane sub-sector with 2.11. Hence, investment in this zone should be directed towards dairy sector and ragi crop sub-sector as these investments would generate relatively greater returns when compared to that in other sectors / sub-sectors.

6.5.8 Household income multiplier matrix for zone-4

Ragi sub-sector had the highest income multiplier of 1.27 (Table 36). Out of the expected increase in income from ragi sub-sector, maximum percentage share (33.07 %) will go to the marginal households, 25.98 per cent will go to large households, 22.05 per cent will go to small households and 18.90 per cent will go to landless households. The dairy sector had income multiplier of 1.22. Out of the expected increase in income from this sector, 45.08 per cent of it will go to marginal households, 27.05 per cent will go to small households, 15.57 per cent will go to large households and 12.30 per cent will go to landless households. To sum up, marginal households would benefit the most due to investment in any of these sectors / sub-sectors.

6.5.9 Backward and forward linkages

Dairy sector had the highest backward linkage value of 6.17 in zone-1. This implies that for every one present increase in final demand of dairy sector, the economy must grow by 6.17 per cent. Similarly, for every one percent increase in final demand of either food or non-food sub-sector, the economy must grow by 6.14 per cent. The fodder sub-sector had a linkage value of 6.12. In case of agriculture, ragi sub-sector had linkage value of 6.09 implying that for every one per cent increase in the final demand of ragi, the economy must grow by 6.09 per cent. The other sub-sectors of agriculture viz., maize, groundnut and cotton sub-sectors had linkage values of 5.90, 5.68 and 5.65 respectively.

Even in the case of forward linkages, dairy had the highest linkage value of 5.51 implying that for one per cent increase in its production, the growth in the economy will be stimulated to the extent of 5.51 per cent. In the case of agriculture, ragi sub-sector had a forward linkage value of 3.26 implying that for every one per cent increase in production of ragi, the economy will be stimulated to grow at the rate of 3.26 per cent. The other sub-sectors of agriculture i.e., groundnut, maize and cotton sub-sectors had linkage value of 2.81, 2.63 and 1.02 respectively. In case of NTFPs, non-food sector had a linkage value of 3.13 which implies that for one per cent increase in production of non-food sector, the economy will be stimulated to grow at the rate of 3.13 per cent. The other sub-sectors of NTFPs viz., fodder and food sub-sectors had linkage values of 2.10 and 1.78 respectively.

Even in zone-2, dairy had the highest backward linkage value of 9.33 implying that for every one per cent increase in final demand of dairy sector, the economy must grow by 9.33 per cent. In case of NTFPs, food sub-sector had a backward linkage of 8.38 which implies that for every one per cent increase in final demand, the growth in the economy must be 8.38 per cent. Non-food and fodder sub-sectors had values of 8.29 and 7.37 respectively. In case of agriculture, the backward linkage was highest (7.69) in case of ragi sub-sector implying that the economy must grow by 7.69 per cent for every one per cent increase in final demand of ragi. Ragi was followed by groundnut and paddy sub-sectors with 7.03 and 6.95 respectively as their linkage values.

With regard to forward linkages, paddy had the highest value of 10.56 implying that for one percent increase in production of paddy, the economy will be stimulated to grow at the rate of 10.56 per cent. Paddy was followed by ragi and groundnut sub-sectors of agriculture with 5.33 and 4.39 respectively. In case of NTFPs, non-food sub-sector had the highest forward linkage of 2.82 implying that the economy is stimulated to grow at 2.82 per cent if there is one per cent increase in production of non-food sub-sector of NTFPs. This is followed by fodder and food sub-sectors with 1.79 and 1.74 linkage values respectively. In case of dairy, one per cent increase in production of dairy sector stimulated growth in the economy to the extent of 2.75 per cent.

In zone-3, ragi sub-sector had the highest backward linkage of 4.64 implying that for one per cent increase in final demand of ragi, the economy must grow by 4.64 per cent. Ragi was followed by paddy, sugarcane, groundnut and mulberry sub-sectors with backward linkage values of 4.38, 4.38, 4.32 and 4.30 respectively. In case of dairy, for every one per cent increase in final demand of dairy, the economy must grow by 4.55 per cent. With regard to the forward linkages, paddy had 2.54 value which implied that the economy will be stimulated to grow at 2.54 per cent if there is one per cent increase in paddy production. Paddy was followed by groundnut, ragi, sugarcane and mulberry sub-sectors with forward linkage values of 2.23, 1.79, 1.01 and 1.00 respectively. In case of dairy sector, one per cent increase in its production will stimulate the economy to grow by 2.49 per cent.

Dairy had the highest backward linkage value of 5.01 in case of zone-4 implying that for every one per cent increase in final demand of dairy sector, the economy must grow by 5.01 per cent. In case of agriculture, ragi sub-sector had a linkage value of 4.83 implying that for a one per cent in final demand, the economy must grow by 4.83 per cent. Ragi was followed by paddy, groundnut and sugarcane sub-sectors with linkage values of 4.66, 4.66 and 4.62 respectively. In case of forward linkages, paddy sub-sector had the highest linkage value of 3.97, implying that one per cent increase in production of paddy will stimulate the economy to grow by 3.97 per cent. Paddy was followed by ragi, groundnut and sugarcane sub-sectors with forward linkage values of 2.21, 2.03 and 1.06 respectively. In case of dairy, a one per cent increase in production of dairy sector stimulated growth to the extent of 2.21 per cent.

6.6 Magnitude of dependencies of farm families on BDOAF

Farm families largely depend on natural and biological resources on and around farms for their livelihoods in the absence of secure livelihood sources. This was clearly evident from the results of the present study where in households in zone-1 and zone-2 were depending on biodiversity in many ways to support their livelihoods. The existence of abundant BDOAF signifies many alternatives for livelihoods. Thus, it is hypothesized that higher the degree of BDOAF, the larger is the dependency of farm family on the same. In the present study, the dependency of farm families on BDOAF was analysed in terms economic benefits, employment pattern and consumption pattern and the same is discussed below.

6.6.1 Economic benefits

It is evident from the Table 37 that the total value of benefits realized by the households from BDOAF was inversely related to the degree of BDOAF. The households in zone-1 derived more than 75 per cent of the total economic value from different BDOAF sources, whereas, it constituted less than two per cent in zones 3 and 4. Thus, it could be inferred that the presence of biodiversity opened up multifarious livelihood avenues for households in zone-1 and zone-2. Hence, the degree of dependence on BDOAF was conspicuous in zones 1 and 2 compared to zones 3 and 4. The results of the study support the proposition that marginal and tribal households depend largely on natural resources such as biodiversity in the absence of property rights and secured livelihood options.

An interesting result that emerged from the study reveals that soliga tribe in zone-2 extracted NTFPs largely for home consumption (55.09 %) whereas soligas in zone-1 extracted mainly for commercial purpose (58.43 %). Furthermore, people in zone-2 extracted in aggregate a lower value of NTFPs (Rs.4,972.25) than did soligas in zone-1 (Rs.10,497 per household). These results suggest that the degree of dependence on the extraction of NTFPs declines as people find alternative ways to switch over to more profitable occupation. It is suggested that policies and programmes have to be initiated to enhance non-NTFP based livelihoods to augment livelihood certainties of these marginal households so that dependence and exploitation on surrounding forests is lessened in order to ensure long term sustainability of biodiversity resources.

6.6.2 Employment pattern

The total employment generated from various activities in the study region is presented in Table 38. The total employment generated was highest in zone-1 (681.5 days per annum) and the magnitude of employment generated from BDOAF related activities formed about 37.56 per cent. In zone-2, the BDOAF related activities constituted 32.52 per cent of the total employment of 578 days. However, in zone-3 and zone-4, there was no BDOAF related activities and hence they largely depended on agriculture and livestock. It is interesting to note that in zone-1 and zone-2, BDOAF related activities was the most important source of employment in the case of women (38.59 % and 37.86 % respectively). A noteworthy aspect of employment generation from BDOAF was the provision of employment all round the year, that is, during the months of November to March, the soliga tribe was engaged in the collection of NTFPs, while in the remaining period of the year, they were mostly employed in the forest management related activities. Kant and Mehta (1993), Pradhan (1995), Hedge et al (1996), Sekar et al (1996), Thomas (1996), Ganapathy (1998) and Girish (1998) also reported that NTFPs was the major employment generator in their studies.

6.6.3 Consumption pattern

The household consumption pattern is influenced by income earnings and income elasticities for food and normal goods vary with level of income. That is, at higher income levels, the share of wild plants and plant products consumption declines and that of other goods increases because people substitute forest products with cheaper modern goods. This is partly because forest based products are often difficult to find and expensive due to processing and transportation problems (Godoy and Bawa, 1993). We hypothesize in the present study that the consumption basket of soliga tribe mainly consists of forest based products and that of non-soliga tribe largely of market based ones. The particulars of consumption pattern of households are presented in Table 39.

It is interesting to note that households in zone-1 met their consumption requirements to the extent of 58.68 per cent and 56.46 per cent, respectively, mainly from products derived from BDOAF. However, in biodiversity poor zones (zone-3 and zone-4), the households met comparatively lesser amount of consumption requirement from BDOAF and farm sources. This signifies the importance of BDOAF in meeting the consumption requirements of marginal households. Households in zone-1 derived a large variety of plant-originated products besides the staple food of ragi from their farms. Thus, the foregoing discussion suggests that dependency of households for their livelihoods on BDOAF was stronger in zone-1 and zone-2 and this supports our hypothesis that people with lower incomes consume more of self procured plant and plant-based products rather than market-based products.

6.7 Resource use and allocative efficiency of crops in different zones\

6.7.1 Resource use pattern in cultivation of crops

The nature of cropping pattern determines the resource use pattern in crop production. Empirical studies reveal that the resource use is intensive in commercial crops and is extensive in subsistence crops. In the present study, an attempt was made to examine how the resources were used in BDOAF farms vis-à-vis commercial farms. The resource-use pattern for various crops in the four zones is presented in Table 40. A close examination of the table reveals that in zone-1 and zone-2, cropping pattern was largely in the form of subsistence crops of ragi, paddy, pulses and other household requirements. Whereas in zone-3 and zone-4 in addition to food crops, commercial crop namely sugarcane was also cultivated. Consequently, resource use varied across the zones.

In zone-1, for ragi and inter-crops, farmers used local varieties of seeds and family labour. They did not purchase any inputs for crop production. Hence, their dependence on external inputs was absolutely nil. They did not apply even FYM for ragi crop. This might be largely due to the fact that lands in zone-1 are relatively more fertile than those in zone–2, zone-3 and zone-4. However, in zone-3 and zone-4, the use of inputs was largely dictated by the nature of the crop, i.e., for a commercial crop like sugarcane, farmers applied larger quantities of purchased inputs compared to food crops. It was observed that on an average, the application of FYM, fertiliser and labour was much higher than that for paddy and ragi crops. Further, it was observed that fertilizer was used in greater amounts in zone-3 and zone-4 for all crops as compared to zone-2. Perhaps, excessive use of fertilizers might have a bearing on the sustainability of farms in these two zones. Moreover, lack of abundant biodiversity has resulted in reduced use of eco-friendly inputs and consequently lower ecological sustainability of farms. Hence, it can be concluded that the dependence on external inputs for crop production was greater in biodiversity poor zones.

6.7.1.1 Resource productivity in ragi cultivation

In the present study, the productivity of resources for ragi (Table 41) was analyzed, as it was the only common crop grown in all the zones. It was found that land had a significant positive influence on returns in zone-4. It could be inferred that one per cent increase in area under ragi would increase the returns by 0.75 per cent.

The productivity analysis for ragi in zone-3, showed that land under ragi had a negative influence on returns and was statistically significant. The elasticity coefficient for land was -1.15 which implies that one per cent increase in area under ragi would decrease returns by 1.15 per cent. The negative marginal productivity of land could be attributed to the poor soil conditions in zone-3. For, these lands may be sub-marginal lands in which the productivity tends to be less than investment. Fertilizers showed negative influence on returns and elasticity coefficient was -0.01, which indicated that one per cent increase in fertilizer usage would decrease the returns by 0.01 per cent.

The productivity analysis for zone-2 and zone-1 indicated that the independent variables included in the model were not adequate to explain the variability in returns as revealed by low R^2 values. It was found that seeds used was able to explain the variation in returns and the elasticity coefficient was 0.60 in zone-2. This indicated that increase in seed cost by one per cent will increase returns by 0.60 per cent. Similarly, the elasticity coefficient for seed was 0.71 in zone-1. This implies that only the basic input, i.e., seed is the major input influencing returns in zone-1. This may be because of the rich ecological and environmental benefits existing in these zones (rich biodiversity on and around farms) in the form of recycling of crop residues and biomass. It could also be due to use of local varieties, the productivity of which was lower than high yielding varieties.

6.7.2 Resource-use and allocative efficiency of resources in different zones

Allocative efficiency of resources was examined to assess whether farmers were optimally allocating resources in crop production at the prevailing input and output prices and to know the potential for enhancing returns by optimal allocation of resources. The allocative efficiency of resources was assessed by computing MVP:MFC ratios for each resource used in the production of ragi crop (Table 42).

Allocative efficiency of resources for ragi in zone-4 indicated that there was scope for increasing area under ragi. This is quite acceptable, because ragi was grown in dry patches of zone-4, as the crop required less care and protection. Hence, additional investment made in ragi, that is, increasing the area under ragi in drylands would generate higher returns. The other variables were found insignificant in ragi cultivation.

The analysis of data revealed that in zone-3, the MVP:MFC ratio for fertilizers was -9.22, whereas it was -3.59 in zone-4, indicating excessive use of fertilizers in these two zones. As in zone-4, it was also found that the MVP:MFC ratio was positive with respect to farmyard manure and was more than one in both the cases. This indicated there was scope for increasing the use of farmyard manure in zone-3 and zone-4 in order to enhance total returns. This is an indication of low soil health prevailing in the rainfed areas of zone-3 and zone-4, which could be linked to the low degree of vegetation on and around farms and consequent lesser quantity of eco-friendly inputs into the soil.

Allocative efficiency for zone-2 and zone-1 with respect to ragi indicated that an additional rupee invested on seeds would generate returns by more than a rupee. It was Rs.28.44 and Rs.6.83 in zone-3 and zone-4 respectively. The usage of other resources was negligible in ragi production in these zones. Hence, it is the richness of the BDOAF in zone-1 and zone-2, which enabled the farmers to harvest a good crop with minimal use of external inputs in ragi production. On the whole, the figures indicated that resources were used at sub-optimal level in zone-1 and zone-2, whereas the resources were used close to optimal level in zone-3 and zone-4.

6.8 Environmental Economics Component

The environmental economics aspects of the present study were analysed in terms of the following components and are discussed below.

6.8.1 Economic value of reduction in dependence of farms on external inputs due to environmental and economic benefits from traditional farming system of BDOAF

The reduction in dependency on external inputs for ragi crop was examined in all the four zones and the results are indicated in Table 43. The reduction in dependency was examined mainly in terms of expenditure on fertilizers, pesticides and hired labour. It could be observed from the table that in zone-1, farmers did not incur any cost on external inputs, as they use only farm resources including labour. On the contrary farmers in the remaining three zones used purchased inputs and hired labour at varying levels. Consequently, the dependency of farms on external inputs for ragi crop increased as the agriculture moved from biodiversity rich zones to biodiversity poor zones. Thus, non-dependence on external inputs was 100 per cent in zone-1, whereas in zone-2, it was about 35 per cent. Thus, it could be inferred that dependency of farms on external inputs was least in biodiversity rich areas. This could be attributed to relatively better soil conditions, less-frequent occurrence of pests and diseases and availability of sufficient family labour in zone-1 and zone-2. A reduced dependence on external inputs signifies a better ecosystem health or indirectly sustainable practice because it implies higher flow of eco-friendly inputs into the system, leading to long run sustainability. Therefore, farming systems in zone-1 and zone-2 can be considered as having a stronger ecological foundation as compared to zones 3 and 4.

However, the productivity and income levels from agriculture in zone-1, in particular, were very low forcing these households to extract / collect NTFPs from surrounding BDOAF. Thus, despite being on strong ecological sustainability, the income levels of these households from agriculture were very low. Therefore, in order to augment income levels of households in zone-1, productivity of agriculture need to be enhanced without affecting ecology of the region excessively. However, such possibility appears to be remote since forest authorities are discouraging expansion of agriculture both in terms of scale and intensity in the core areas in order to protect forest (biodiversity) resources. Therefore, alternative income earning sources have to be explored for *soliga* tribe to raise their living standards.

6.8.2 Ecosystem health

The agro-ecosystem health in the present study was viewed with respect to the kind of inputs and farming practices that do not interfere adversely with the ecology of the system. It is important to study agro-ecosystem health because of the need to improve agro-ecosystem condition in terms of the system's ability to produce agricultural products and at the same time protect the system (Yiridoe and Weersink, 1997). Keeping this in view, the indicators were developed to reflect agro-ecosystem health Table 44.

It could be observed from the Table 44 that the number of farmers reporting plant protection measures for crops was relatively higher in zones 3 and 4, implying relatively poor ecosystem health and need for plant protection chemicals to keep away the pests and diseases. However, usage of external inputs/energy such as plant protection chemicals, fertilizers and mechanical power was absolutely nil in zone-1 and zone-2 compared to zone-3 and zone-4. This was partly due to a high proportion of commercial crops / input-intensive crops in zone-3 and zone-4 which warranted application of energy intensive inputs including mechanical power for carrying out farm operations. However, it is beyond the purview of the present study to examine the negative eternality induced by these inputs.

The eco-system health was also indicated through tree diversity on farms using Simpson index. The index showed that diversity was relatively higher in zone-1 and zone-2. The diversity helps in maintaining the natural predator-prey relationships and ecosystem health.

The number of crops grown per farm was relatively higher in zone-1 and zone-2. Thus, these indicators suggest that ecosystem health is relatively better in zone-1 and zone-2 compared to that in zone-3 and zone-4. However, caution need to be exercised while inferring the relationship between ecosystem health and livelihood options. Because a high degree of ecosystem health need not result in assured livelihoods as in the case of zone-1 and zone-2. On the contrary, households in zones 3 and 4, despite poor ecosystem health were able to pursue assured livelihoods. Thus, there will be some degree of trade-off between the extent of ecosystem health and level of livelihood.

6.8.3 Quality of Life

The quality of life across the zones was focused primarily by comparing food items being consumed in order to highlight the influence of BDOAF. The other components of quality of life such as clothing, education, entertainment etc. were also considered to assess the overall level of consumption pattern of households.

The presence of rich biodiversity on and around farms had an influence on the consumption habits of the households and thus the quality of food taken. This is evident from the manner in which households in zone-1 and zone-2 fulfilled their consumption requirements. The results presented in the Table 45 showed that more than 58 per cent of the total consumption requirement of households in zone-1 was met by the farm sources itself, whereas in the case of zone-3, only 34.22 per cent of consumption requirement was obtained from farm sources. Further, it can be observed that households in zone-1 and zone-2 had access to different types of fruits and vegetables at the farm level obviously due to rich biodiversity on and around farms. It could be noted that the average value of vegetable consumption in zone-1 and zone-2 was substantially higher than that of zone-3 and zone-4. This was due to the fact that almost all households in zone-1 and a substantial number of households in zone-2 obtained different types of vegetables, roots and tubers from BDOAF, besides obtaining vegetables from kitchen garden, whereas households in zone-3 and zone-4, did not have this opportunity. Similarly, households in zone-1 and zone-2 also produced pulses. But, households in the remaining two zones were not producing pulses at all. Thus, the intake of plant sources of nutritious food was considerably higher in zone-1 and zone-2 than in zones 3 and 4. In addition, these produce were chemical-free, thus contributing to the health of the people.

Though households in zones 1 and 2 did consume a variety of greens, vegetables and fruits, in the aggregate, the amount of nutritional food intake was much lower than the households in zones 3 and 4 due to their low disposable income. For instance, households in zones 3 and 4 consumed greater amount of high value nutritious foods such as milk, fruits, vegetables and non-vegetarian foods than households in zones 1 and 2 as revealed by a greater per cent of consumption expenditure on these items (Table 46). The expenditure on human development activities like education, medicines etc. was lower in zones 1 and 2 as compared to zones 3 and 4. While more than 97 per cent of cash income of *soligas* was spent on consumption, the households in the other zones spent between 40 and 45 per cent. This reflects low spending on human development components of life among households in zones 1 and 2. Thus, it could be inferred that though a wide range of livelihood options was available for the *soliga* tribe, the quality of life was not on par with those of households in zones 3 and 4.

6.8.4 Direct use value of selected benefits from BDOAF

As discussed in the earlier sections, a plethora of economic and environmental benefits and functions was being realized by households in the BRT area and surrounding areas. However, due to information constraints and problems in administering behavioral linkage approaches to the respondents, we could address only four benefits (functions) from BDOAF. We focused only on direct use values derived by the households. The particulars of selected use values derived from BDOAF are presented in Table 47

The direct use values of selected benefits from BDOAF presented in the table reveal that the consumptive use value (net) per household per annum from NTFPs extraction was the highest (Rs.4,914) which accounted for about 50 per cent of the household income in zones 1 and 2. This value was computed based on the price paid by LAMPS to collectors. It is not quite clear whether collectors decision to harvest NTFPs in a given year is based on market forces (price signals). If it is so, then the use values may change significantly. The price paid for collectors of NTFPs is based on the bidding price offered by traders and quantity of NTFPs to be extracted in a given year. Further, the quantity of NTFPs collection in a year is also influenced by price offered by LAMPS to collectors and efforts needed for collection. For instance, in the case of gooseberry, higher prices lead to a greater collection. Therefore, direct use values from NTFP vary over time across commodities. Therefore, values presented in the table reflect only current year direct use values. The other important consumptive use value derived from BDOAF was from medicinal plants (use value of Rs.554.30 per household) to cure common ailments. These estimates are based replacement cost and opportunity costs. Hence, these values may not fully reflect actual market values. Nevertheless these values may serve as proxy indicator of utilities derived from BDOAF. The premium for the chemical-free products ranged between Rs.1 to Rs.4.50 per kg of the product. Depending on the quantity consumed, these values would change. The non-consumptive use value (consumer surplus estimates) of Rs.351.69 reflect actual expenditure (revealed preference) incurred by the tourists. Therefore, this value indicates a surrogate for recreation use values derived from BDOAF. These estimates support that BRT area has a potential for developing it into an eco-tourism center.

CHAPTER VII: RECOMMENDATIONS

The results of the study will be useful in evolving policy recommendations in Environmental Economics related to management of biodiversity resources. These resources assume characteristics of a public good. Hence, utilization of these resources needs to be regulated in order to ensure intergenerational equity and sustainability. The following recommendations have been drafted in the area of Environmental Economics based on the findings of the present study.

1. The sustainability and resilience indicators show that dependency of households on external sources for both farm and household requirement was quite high in zone-3 and zone-4. Developing additional BDOAF in zone-3 and zone-4 can reduce the dependency perceptibly, thereby increasing the economic as well as ecological sustainability and resilience of farms in these zones. Further, developing BDOAF in these zones may help in supplementing dietary composition of households. Hence, educational and participatory programmes may be formulated and implemented to create awareness about importance and need for establishing adequate BDOAF.

2. Presently, agriculture in zone-1 and zone-2 is being carried out in a traditional manner. Therefore, it has resulted in lower household incomes. Consequently, there is a perceptible degree of dependence on NTFPs for their livelihoods. The production multiplier matrices (SAM analysis) of zone-1 and zone-2 revealed that dairy sector and ragi crop sub-sector of agriculture were found to generate relatively greater returns when compared to that in other sectors. Hence, investments should be directed towards these sectors. Such investments will not only transform the traditional crop and dairy enterprises into more viable economic activities on the one hand but also reduce the pressure on forests for NTFPs on the other hand. The household income multiplier matrices (SAM analysis) of zone-1 and zone-2 indicated that out of the expected increase in income due to new investment in dairy sector and ragi crop sub-sector of agriculture, the marginal households were expected to

benefit the most followed by the small households. This will result in more equitable distribution of income in the economy.

3. The rich biodiversity around farms in zone-1 and zone-2 provides usufruct utilities to tribal households. However, it is not very clear whether all NTFPs are being extracted in a sustainable manner by the *soliga* tribe. There is always an apprehension that due to open access / public good nature of NTFPs, these resources are prone to over extraction. Consequently, it may lead to decline or even disappearance of biodiversity. Therefore, it is worthwhile to examine whether NTFPs are being extracted in a sustainable manner without affecting ecology of the system by analyzing influence of market and institutional factors on the extraction patterns.

4. Tribal people in zone-1 and zone-2 are extracting a variety of medicines that cure simple ailments to major diseases. A systematic documentation and extraction mechanism can be developed so that valuable medicines can be extracted with major share of proceeds from such mechanisms being directed towards the tribal welfare. Local institutional network may be involved to a larger extent to facilitate documentation although currently this activity is being undertaken by one NGO. The systematic documentation of traditional medicinal practices is essential because the knowledge of use and preparation is known to only a few people and the same is passed on orally to the next generation. It is a serious concern that this knowledge may be lost due to insufficient flow of information.

5. Long term research forays need to be initiated to determine optimal mix and level of BDOAF, which ensures and / or maximizes social welfare in tune with ecological harmony. Thus, policy and management decisions have to be brought in to encourage BDOAF in zone-3 and zone-4 and to maintain BDOAF in zone-1 and zone-2.

6. Though farming systems in biodiversity rich zones (zone-1 and zone-2) are in harmony with nature and households are deriving many usufruct benefits from BDOAF, their cash income and quality of life are low. In this regard, cash income

generating activities may be initiated to augment their meagre income levels. This may also reduce pressure on BDOAF.

7. In general, tourism potential and in particular eco-tourism needs to be exploited in India. Of late, eco-tourism is gaining popularity. As evident from the results of the present study, there is a vast potential for eco-tourism. Sites that have such potential including the BRT area can be developed into good eco-tourism centers. The biodiversity rich zone can be developed into a good eco-tourist site by creating appropriate tourism facilities. This was evident by the willingness to pay by the tourists for the maintenance of the recreation site. This was also reinforced by the use values (consumer surplus) estimated from the study, for the BRT sanctuary area.

8. In order to know the total value of BDOAF, a multidisciplinary study can be initiated so that total impact in terms of climate, soil, physical and other aspects of BDOAF can be quantified.

CHAPTER VIII: REFERENCES

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APPENDIX

Appendix 1: Multiplier values, backward and forward linkages for various sectors of the economy in zone-1

	Fodder	Food	Non-Food	Ragi	Maize	Groundnut	Cotton	Fertilizers	PPC	Dairy	C / F
Fodder	1.06	0.06	0.06	0.07	0.06	0.06	0.06	0.01	0.01	0.25	0.01
Food	0.04	1.05	0.05	0.06	0.05	0.04	0.04	0.00	0.00	0.05	0.00
Non-Food	0.11	0.13	1.12	0.16	0.13	0.12	0.12	0.01	0.01	0.15	0.01
Ragi	0.18	0.16	0.16	1.13	0.14	0.14	0.12	0.01	0.01	0.15	0.01
Maize	0.12	0.11	0.11	0.09	1.10	0.10	0.09	0.01	0.01	0.13	0.01
Groundnut	0.12	0.11	0.11	0.10	0.10	1.13	0.09	0.03	0.03	0.10	0.03
Cotton	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.00	0.00
Fertilizers	0.02	0.02	0.02	0.06	0.08	0.05	0.08	1.00	0.00	0.02	0.00
PPC	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	1.00	0.00	0.00
Dairy	0.29	0.29	0.29	0.37	0.31	0.29	0.32	0.03	0.03	1.27	0.03
C / F	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.00	0.00	0.09	1.00
F. Labour	0.49	0.87	0.83	1.22	0.80	0.75	0.83	0.05	0.05	1.29	0.05
H. Labour	0.09	0.09	0.09	0.31	0.19	0.18	0.20	0.01	0.01	0.17	0.01
Profit	1.17	0.79	0.82	0.09	0.60	0.61	0.43	0.02	0.02	0.14	0.02
Landless	0.14	0.13	0.14	0.25	0.18	0.17	0.18	0.01	0.01	0.18	0.01
Marginal	0.48	0.63	0.61	0.79	0.60	0.56	0.59	0.03	0.03	0.79	0.03
Small	0.50	0.50	0.50	0.41	0.43	0.42	0.39	0.02	0.02	0.44	0.02
Large	0.63	0.48	0.50	0.17	0.38	0.38	0.30	0.01	0.01	0.20	0.01
Savings	0.13	0.12	0.12	0.07	0.10	0.09	0.08	0.00	0.00	0.08	0.00
Trade	0.54	0.58	0.58	0.71	0.60	0.58	0.60	0.28	0.28	0.66	0.28
B. linkage	6.12	6.14	6.14	6.09	5.90	5.68	5.65	1.54	1.54	6.17	1.54

contd…..

Appendix 1: contd…..

	F. Labour	H. Labour	Profit	Landless	Marginal	Small	Large	Savings	Trade	F. linkage
Fodder	0.06	0.05	0.06	0.04	0.06	0.06	0.06	0.00	0.02	2.10
Food	0.05	0.07	0.04	0.07	0.05	0.06	0.02	0.00	0.01	1.78
Non-Food	0.15	0.20	0.11	0.23	0.17	0.13	0.07	0.00	0.03	3.13
Ragi	0.14	0.10	0.18	0.08	0.12	0.15	0.22	0.00	0.05	3.26
Maize	0.09	0.08	0.12	0.07	0.08	0.10	0.15	0.00	0.05	2.63
Groundnut	0.10	0.11	0.12	0.11	0.10	0.10	0.13	0.00	0.10	2.81
Cotton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02
Fertilizers	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.00	0.01	1.48
PPC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.09
Dairy	0.29	0.23	0.29	0.18	0.30	0.30	0.29	0.00	0.12	5.51
C / F	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.00	0.01	1.38
F. Labour	1.47	0.40	0.49	0.36	0.46	0.49	0.51	0.00	0.19	11.60
H. Labour	0.08	1.06	0.09	0.05	0.07	0.08	0.11	0.00	0.04	2.93
Profit	0.19	0.23	1.17	0.25	0.20	0.18	0.14	0.00	0.08	7.16
Landless	0.13	0.67	0.14	1.06	0.08	0.08	0.10	0.00	0.04	3.70
Marginal	0.86	0.63	0.48	0.25	1.31	0.32	0.34	0.00	0.13	9.48
Small	0.50	0.24	0.50	0.19	0.20	1.20	0.20	0.00	0.08	6.78
Large	0.24	0.16	0.63	0.16	0.14	0.14	1.12	0.00	0.06	5.74
Savings	0.10	0.02	0.13	-0.02	0.09	0.13	0.15	1.00	0.02	2.43
Trade	0.66	0.92	0.54	1.07	0.73	0.54	0.42	0.00	1.12	11.69
B. linkage	5.17	5.18	5.12	4.17	4.20	4.12	4.09	1.00	2.15	

Note: NTFPs sector consists of fodder, food and non-food sub-sectors,

Agriculture sector consists of ragi, maize, groundnut and cotton sub-sectors , C / F- Concentrates and feeds

Appendix 2: Multiplier values, backward and forward linkages for various sectors of the economy in zone-2

	Fodder	Food	Non-Food	Paddy	Ragi	Groundnut	Fertilizers	PPC	Dairy	C / F
Fodder	1.03	0.03	0.03	0.03	0.04	0.03	0.01	0.01	0.32	0.01
Food	0.04	1.06	0.06	0.04	0.05	0.04	0.01	0.01	0.08	0.01
Non-Food	0.09	0.15	1.15	0.09	0.12	0.10	0.02	0.02	0.19	0.02
Paddy	0.59	0.68	0.68	1.55	0.60	0.55	0.18	0.18	0.86	0.18
Ragi	0.29	0.32	0.31	0.26	1.28	0.26	0.06	0.06	0.43	0.06
Groundnut	0.17	0.23	0.22	0.17	0.20	1.21	0.10	0.10	0.27	0.10
Fertilizers	0.07	0.08	0.07	0.14	0.12	0.10	1.02	0.02	0.10	0.02
PPC	0.01	0.01	0.01	0.02	0.01	0.01	0.00	1.00	0.01	0.00
Dairy	0.12	0.12	0.12	0.12	0.14	0.11	0.03	0.03	1.11	0.03
C / F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	1.00
F. Labour	0.94	2.83	2.66	0.99	1.67	1.12	0.21	0.21	3.75	0.21
H. Labour	0.17	0.18	0.18	0.25	0.39	0.25	0.04	0.04	0.36	0.04
Profit	1.00	-0.67	-0.52	0.65	0.03	0.56	0.08	0.08	-1.74	0.08
Landless	0.16	0.24	0.24	0.21	0.32	0.21	0.04	0.04	0.39	0.04
Marginal	0.72	1.53	1.46	0.72	1.06	0.78	0.14	0.14	1.94	0.14
Small	0.54	0.69	0.68	0.47	0.53	0.49	0.08	0.08	0.71	0.08
Large	0.69	-0.12	-0.04	0.49	0.19	0.45	0.07	0.07	-0.67	0.07
Savings	0.09	0.09	0.09	0.08	0.08	0.08	0.01	0.01	0.08	0.01
Trade	0.63	0.92	0.89	0.68	0.83	0.69	0.52	0.52	1.13	0.52
B. linkage	7.37	8.38	8.29	6.95	7.69	7.03	2.61	2.61	9.33	2.61

contd…

Appendix 2: contd….

	F. Labour	H. Labour	Profit	Landless	Marginal	Small	Large	Savings	Trade	F. linkage
Fodder	0.03	0.03	0.03	0.02	0.03	0.04	0.03	0.00	0.02	1.79
Food	0.05	0.06	0.03	0.06	0.05	0.05	0.02	0.00	0.02	1.74
Non-Food	0.12	0.14	0.09	0.15	0.13	0.14	0.06	0.00	0.04	2.82
Paddy	0.64	0.53	0.59	0.44	0.69	0.63	0.55	0.00	0.44	10.56
Ragi	0.30	0.22	0.29	0.15	0.32	0.30	0.28	0.00	0.14	5.33
Groundnut	0.20	0.22	0.17	0.22	0.22	0.19	0.15	0.00	0.25	4.39
Fertilizers	0.07	0.06	0.06	0.05	0.08	0.07	0.06	0.00	0.05	2.22
PPC	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	1.10
Dairy	0.12	0.09	0.12	0.07	0.12	0.12	0.12	0.00	0.07	2.75
C / F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07
F. Labour	1.96	0.86	0.84	0.77	1.00	0.99	0.75	0.00	0.52	22.28
H. Labour	0.17	1.14	0.16	0.11	0.18	0.17	0.15	0.00	0.11	4.12
Profit	0.11	0.09	1.10	0.07	0.13	0.07	0.10	0.00	0.19	1.41
Landless	0.20	0.73	0.15	1.11	0.16	0.15	0.13	0.00	0.09	4.60
Marginal	1.15	0.88	0.67	0.47	1.63	0.61	0.48	0.00	0.35	14.89
Small	0.62	0.34	0.54	0.25	0.34	1.32	0.26	0.00	0.21	8.24
Large	0.26	0.14	0.74	0.12	0.18	0.14	1.14	0.00	0.17	4.08
Savings	0.09	0.09	0.09	0.09	0.09	0.09	0.09	1.00	0.03	2.28
Trade	0.78	1.01	0.61	1.13	0.85	0.70	0.51	0.00	1.30	14.25
B. linkage	6.91	6.63	6.31	5.29	6.21	5.79	4.90	1.00	4.03	

Note: NTFPs sector consists of fodder, food and non-food sub-sectors,

Agriculture sector consists of paddy, ragi and groundnut sub-sectors, C / F- Concentrates and feeds

Appendix 3: Multiplier values, backward and forward linkages for various sectors of the economy in zone-3

	Groundnut	Ragi	Paddy	Mulberry	Sugarcane	Fertilizers	PPC	Dairy	C / F
Groundnut	1.10	0.08	0.07	0.07	0.07	0.02	0.02	0.15	0.02
Ragi	0.05	1.05	0.05	0.05	0.05	0.01	0.01	0.09	0.01
Paddy	0.09	0.10	1.11	0.09	0.10	0.02	0.02	0.15	0.02
Mulberry	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Sugarcane	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.00	0.00
Fertilizers	0.06	0.06	0.09	0.09	0.09	1.00	0.00	0.02	0.00
PPC	0.00	0.01	0.02	0.00	0.00	0.00	1.00	0.00	0.00
Dairy	0.11	0.15	0.14	0.11	0.11	0.01	0.01	1.10	0.01
C / F	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.13	1.00
F. Labour	0.19	0.32	0.15	0.17	0.12	0.01	0.01	0.75	0.01
H. Labour	0.38	0.72	0.42	0.17	0.31	0.02	0.02	0.22	0.02
Profit	0.54	0.13	0.54	0.79	0.72	0.02	0.02	0.14	0.02
Landless	0.23	0.43	0.25	0.10	0.18	0.01	0.01	0.13	0.01
Marginal	0.40	0.48	0.39	0.39	0.39	0.02	0.02	0.57	0.02
Small	0.24	0.17	0.23	0.30	0.27	0.01	0.01	0.28	0.01
Large	0.24	0.08	0.24	0.34	0.31	0.01	0.01	0.13	0.01
Savings	0.08	0.07	0.08	0.09	0.09	0.00	0.00	0.07	0.00
Trade	0.59	0.75	0.60	0.51	0.56	0.28	0.28	0.61	0.28
B. linkage	4.32	4.64	4.38	4.30	4.38	1.46	1.46	4.55	1.46

contd…

Appendix 3: contd….

	F. Labour	H. Labour	Profit	Landless	Marginal	Small	Large	Savings	Trade	F. linkage
Groundnut	0.08	0.08	0.07	0.08	0.09	0.08	0.05	0.00	0.09	2.23
Ragi	0.07	0.04	0.06	0.02	0.07	0.07	0.05	0.00	0.03	1.79
Paddy	0.12	0.10	0.10	0.08	0.13	0.11	0.07	0.00	0.10	2.54
Mulberry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01
Fertilizers	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.00	0.01	1.53
PPC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06
Dairy	0.12	0.08	0.10	0.05	0.13	0.12	0.08	0.00	0.06	2.49
C / F	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	1.29
F. Labour	1.10	0.07	0.09	0.05	0.11	0.10	0.07	0.00	0.05	3.38
H. Labour	0.11	1.09	0.10	0.07	0.12	0.11	0.07	0.00	0.08	4.02
Profit	0.09	0.08	1.08	0.07	0.10	0.09	0.06	0.00	0.09	4.59
Landless	0.07	0.65	0.06	1.04	0.07	0.07	0.04	0.00	0.05	3.41
Marginal	0.73	0.45	0.40	0.07	1.14	0.13	0.08	0.00	0.08	5.77
Small	0.37	0.10	0.36	0.04	0.07	1.06	0.04	0.00	0.05	3.59
Large	0.15	0.04	0.45	0.03	0.05	0.05	1.03	0.00	0.04	3.22
Savings	0.09	0.07	0.11	0.06	0.08	0.08	0.16	1.00	0.02	2.15
Trade	0.65	0.87	0.50	0.96	0.76	0.54	0.29	0.00	1.12	10.16
B. linkage	3.78	3.75	3.52	2.64	2.96	2.64	2.11	1.00	1.86	

Note: Agriculture sector consists of groundnut, ragi, paddy, mulberry and sugarcane sub-sectors , C / F- Concentrates and feeds

Appendix 4: Multiplier values, backward and forward linkages for various sectors of the economy in zone-4

	Paddy	Ragi	Groundnut	Sugarcane	Fertilizers	PPC	Dairy	C / F
Paddy	1.19	0.19	0.18	0.18	0.13	0.13	0.31	0.13
Ragi	0.08	1.09	0.07	0.08	0.04	0.04	0.14	0.04
Groundnut	0.06	0.07	1.07	0.07	0.04	0.04	0.08	0.04
Sugarcane	0.00	0.00	0.00	1.01	0.00	0.00	0.00	0.00
Fertilizers	0.10	0.08	0.07	0.12	1.02	0.02	0.04	0.02
PPC	0.02	0.01	0.00	0.00	0.00	1.00	0.01	0.00
Dairy	0.10	0.10	0.09	0.08	0.05	0.05	1.09	0.05
C / F	0.01	0.01	0.01	0.01	0.01	0.01	0.12	1.01
F. Labour	0.13	0.22	0.12	0.10	0.04	0.04	0.70	0.04
H. Labour	0.41	0.43	0.47	0.38	0.07	0.07	0.28	0.07
Profit	0.65	0.62	0.59	0.72	0.10	0.10	0.24	0.10
Landless	0.22	0.24	0.26	0.21	0.04	0.04	0.15	0.04
Marginal	0.37	0.42	0.37	0.35	0.07	0.07	0.55	0.07
Small	0.26	0.28	0.24	0.27	0.05	0.05	0.33	0.05
Large	0.34	0.33	0.31	0.37	0.06	0.06	0.19	0.06
Savings	0.02	0.02	0.02	0.02	0.00	0.00	0.02	0.00
Trade	0.72	0.71	0.74	0.69	0.88	0.88	0.76	0.88
B. linkage	4.66	4.83	4.62	4.66	2.62	2.62	5.01	2.62

contd…

Appendix 4: contd….

	F. Labour	H. Labour	Profit	Landless	Marginal	Small	Large	Savings	Trade	F. linkage
Paddy	0.23	0.19	0.18	0.15	0.25	0.21	0.14	0.00	0.17	3.97
Ragi	0.10	0.08	0.08	0.05	0.11	0.09	0.06	0.00	0.06	2.21
Groundnut	0.08	0.06	0.07	0.05	0.08	0.09	0.05	0.00	0.06	2.03
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.06
Fertilizers	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.00	0.02	1.65
PPC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07
Dairy	0.09	0.08	0.08	0.06	0.10	0.09	0.06	0.00	0.06	2.21
C / F	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	1.25
F. Labour	1.09	0.07	0.07	0.05	0.09	0.08	0.05	0.00	0.06	2.97
H. Labour	0.14	1.11	0.11	0.09	0.15	0.13	0.09	0.00	0.10	4.10
Profit	0.19	0.16	1.16	0.12	0.21	0.19	0.12	0.00	0.14	5.41
Landless	0.07	0.61	0.06	1.05	0.08	0.07	0.05	0.00	0.05	3.25
Marginal	0.69	0.52	0.31	0.09	1.15	0.14	0.09	0.00	0.10	5.35
Small	0.44	0.13	0.38	0.06	0.10	1.09	0.06	0.00	0.07	3.87
Large	0.20	0.09	0.59	0.07	0.11	0.10	1.06	0.00	0.07	4.00
Savings	0.02	0.02	0.02	0.02	0.02	0.02	0.02	1.00	0.00	1.24
Trade	0.71	0.94	0.53	1.05	0.84	0.61	0.36	0.00	1.18	12.49
B. linkage	4.10	4.09	3.67	2.93	3.33	2.97	2.23	1.00	2.16	

Note: Agriculture sector consists of paddy, ragi, groundnut and sugarcane sub-sectors, C / F- Concentrates and feeds

APPENDIX-5

Uses of NTFPs

Alale: Used as a basic ingredient in ayurvedic medicines and fruits are used in tanning industries.

Antavala: Dried fruits are crushed into powder and used for washing clothes as well as the body.

Beewax: Byproduct of honey used in manufacturing of candles and also used in medicine.

Broom: Used for sweeping purposes.

Dhoopa: Used in ceremonies.

Fuelwood: Used mainly as fuel in cooking activities

Gooseberry: Fruits are used as ingredient in ayurvedic medicines. Also used in preparation of pickles.

Green fodder: Refers to the green fodder available in the forest. Generally, livestock are left to graze freely in the forest.

Greens: Edible ones are plucked and consumed by the households.

Honey: Consumed as food and used as an ingredient in medicines.

Horns: Have high commercial value.

Makaliberu: Used in preparation of pickles as well as an ingredient in medicines.

Moss: Used as spice.

Mushroom: Consumed as food.

Roots and tubers: Consumed as food.

Soapnut: Dried nuts are powdered and used to wash clothes, body and hair.