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VALUATION OF ECOSYSTEM GOODS AND SERVICES FROM FORESTS IN MIZORAM

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INTRODUCTION

Mizoram is one of the seven sisters' states in the Northeastern India having a geographical area of 21,087 sq. km. It lies between 21°56' to 24°35'N Latitudes and 92°16' to 93°26'E Longitudes. The Tropic of Cancer passes through the state at 23° 30'N Latitude. The state has strategic importance because of its proximity to the international boundary with Myanmar to the east and south (404 km) and Bangladesh to the west (318 km).

Forests are the most important natural resource for the people as 91.44 % of the total area of the state is under forest and tree cover (ISFR, 2013). All natural resources, in and around a village, belong to the communities and everyone in the village has the right to utilize the land and cultivate it according to their needs as per the approval of the Village Council. The recorded forest area of the state is 9,587.08 sq. km. It consists of the Inner-line Reserved Forests notified under Indian Forest Act, 1878 by the then Assam Government, Riverine Reserved Forests and Road side Reserved Forests covering half a mile area respectively on both sides of 16 important rivers of the state and Silchar to Aizawl Road via Sairang, both notified under Mizoram Forest Act, 1955, few small patches of Reserved Forests in various forest divisions notified from 1964 to 1987, and compensatory afforestation areas transferred to the forest department *in lieu* of forest lands diverted for non forestry purposes under Forest (Conservation) Act, 1980.

Another important category of forests is the Safety and Supply Reserves, which have been maintained in most of the villages as a means to save them from natural disaster and to meet the requirement of fuel wood, timber, poles, bamboos and other non wood forest products. Besides this, there are two National Parks, eight Wildlife Sanctuaries and one tiger reserve covering an area of 1,728.75 sq. km. (Table 1).

MATERIALS AND METHODS

The various methods which were used for valuation are mentioned in Fig. 1 and Box 1. A questionnaire was developed, which consisted of three parts i.e. Part- I dealt with the details about the households i.e. number of family members, age, landholding, occupation, education status, annual income etc.; Part - II dealt with the details of various goods collected by households from forest, season of availability, time spent on collection, annual consumption, and their quantification and market values, and Part- III dealt with the perception of people about various ecosystem services from forest and their willingness to pay for improving the condition of forest to improve the flow of these services. The pretesting of the questionnaire was done in two randomly selected villages in Thenzawl Forest Division to get an idea of the perception of people about various goods and services derived from forest (Sheil *et al.*, 2002) and necessary modifications were made in it. It greatly helped in getting the actual feel of the area, topography, forest types, people, culture, perception and dependence on forest, ownership pattern, agricultural practices, socio-economics, and the goods and services derived from forest. It was a useful exercise in finalizing the questionnaire and planning the methodology for fieldwork.

Table 1: Details of notified forests in Mizoram

SN	Category	Area (sq. km.)	Year of Notification
1.	Inner-line Reserved Forests	570.00	878
2.	Riverine Reserved Forests	1832.50	965
3.	Roadside Reserved Forests	97.20	965
4.	Other Reserved Forests	1873.65	964 onwards
5.	Compensatory Afforestation Areas	89.98	993 onwards
6.	Non-notified Forest/ Tree Cover Areas	833.00	
7.	Protected Area Network	1728.75	994-2004
	Autonomous District Council Forest Areas		
8.	Chakma Autonomous District Council	1369.00	
9.	Lai Autonomous District Council	976.00	976
10.	Mara Autonomous District Council	217.00	981
11.	Village Safety and Supply Reserves	238 Nos.	996
	TOTAL	**9,587.08**	**45.46 % of G.A.**

(Source: E&F Statistical Handbook, Mizoram, 2011)

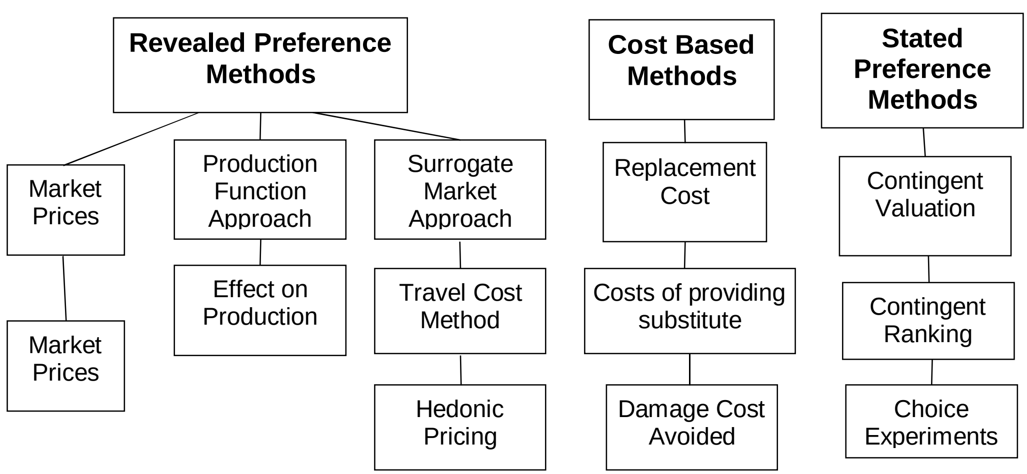

Fig. 1: Methods for economic valuation of ecosystem goods and services

Box 1: Common methods of valuation

Market Price Method: This method uses standard economic techniques i.e. consumer and producer surplus based on supply and demand curves. It is relatively easy to apply; however, seasonal variations and other effects on prices have to be considered. The limitation is that usually costs of transport to bring the goods to the market are not included and benefits may be overstated. Many goods and services do not have markets; therefore prices do not always reflect the true value of goods or services to the society.

Production Function Approach: Only resources and services that are marketed can be valued by using this method. It is able to quantify the biophysical relationship that link changes in supply or quality of goods or services with environmental changes or management options. However, it becomes complicated and difficult if changes in ecosystem affect market prices.

Travel Cost Method: It is limited to recreation values, and requires complex statistical analysis, large sets of data hence expensive and time consuming.

Cost based Methods: (e.g. Replacement cost. Cost of Mitigating Environmental Degradation and Damage Costs Avoided methods): The basic principal is that it is easier to measure costs of producing benefits than the benefits themselves when goods and services are not marketed. However, it provides only rough indicator of ecosystem values. Replacement cost is difficult to find perfect replacement hence chances of making undervaluation are high. It is often difficult to relate damages to changes in ecosystem as damage cost estimates normally remain hypothetical in most cases.

Contingent valuation (CVM): It is most widely used and accepted method for estimation of the total economic value including non use, option and bequest values. The results are highly sensitive to design of choice scenarios and how surveys are conducted.

Contingent ranking: A variant of CVM, it involves asking respondents to rank a series of alternate market goods. It has been suggested that the use of hypothetical bids in CVM may be inappropriate in remote rural areas in the developing world where people have little exposure to market economy (Emerton, 1996).

Choice experiment: It involves asking respondents to choose among alternative bundles of non market goods, which are described in terms of their attributes, including a hypothetical price (Hanley *et al*., 1998).

Hedonic pricing: This method is quite versatile, and can be adapted to consider several possible interactions between market goods and environmental qualities. It assumes that people have opportunity to select the combination of features they prefer within their paying capacity.

Geographical coverage and sampling design

The multi-stage stratified random sampling technique was used. The first stage of the sampling was the division of the state population into urban and rural areas based on 2011 census data. The second stage was the selection of forest divisions in each district, and the third stage was the selection of villages in each range based on the uniform distribution approach so that the entire district is covered. The life style of people is simple in rural area. People live close to forest; therefore, their dependence on forest was very high. They had good knowledge of forest in their surroundings, and as there was not much difference in the perception of people about forest and the goods and services from there, it was decided to maintain a sampling intensity of 1% and 0.5% respectively in the rural areas of the districts having up to 10,000 and above households. In urban areas, a sampling intensity of 1%, 0.5% and 0.25% was used for districts having up to 5,000, 5,000 to 15,000 and above 15,000 households respectively. The district wise and forest range wise details of urban and rural households covered under this study are mentioned in Table 2.

Table 2: District wise details of household covered during field works

Districts	**Number of total Households**		**Households covered**		**Total**	**No. of Ranges covered**
	Urban	**Rural**	**Urban**	**Rural**		
Aizawl	60,857	17,749	164	105	269	5
Champhai	9,148	14,639	52	84	105	8
Kolasib	9,098	758	52	74	126	9
Lunglei	13,040	19,642	44	106	150	5
Mamit	2,788	13,354	30	78	108	6
Serchhip	6,091	6,264	38	67	105	9
Lawngtlai	3,630	16,775	42	102	144	6
Saiha	6,468	8,077	48	86	134	3
TOTAL	**1,11,120**	**1,03,585**	**470**	**702**	**1,172**	**51**

The primary sampling unit was a household, which were selected based on the family size, occupation, age, literacy, annual income, gender and experience or knowledge about forests. Occupation wise there was not much variation in the villages. Agriculture was the main occupation of the people. Besides this, many of them were engaged in horticulture, animal husbandry, business and social services to earn additional income. The womenfolk were equally and actively involved in all agricultural and household activities. Therefore, at least one household each in the above-mentioned categories in every village was covered to account for all possible variations keeping in view the complexities of the systems under study (Cochran, 1977). All these factors played important role in their dependency, perception vis-à-vis their willingness to pay or willingness to accept to forgo certain services in terms of money; therefore, efforts were made to cover all categories of households during the fieldwork.

The services of the range forest officers were used for the collection of field data as they were familiar with the people and helped greatly for explaining all these terms in a simple manner in local language to the respondents. Every part of the questionnaire was explained to them and information were collected from the respondents about the goods and services derived from forests, quantity collected, average consumption of the goods, and their willingness to pay (WTP) for maintaining/ improving the flow of these goods and services as well as their willingness to accept the amount of money as compensation to forego the selected goods and services. Some *in depth* interviews were also conducted with the persons having special knowledge such as old persons, school teachers, social workers, medicine men, wherever available. Special attention was paid to cover sufficient number of womenfolk as they played very important role in the day-to-day work of the family and possessed outstanding knowledge on certain traditional practices, which men folk normally do not know.

The questionnaire was prepared by framing specific questions in simple language to extract the desired information. In some questions options were given in the form of 'yes' or 'no', while in other cases various functions of forest were explained in simple words either with the process or with examples. Secondary information was collected from sources such as publications and reports of the various departments of state and central govt., university, colleges, libraries etc. The details of ecosystem services covered, methodologies used and the economic values derived, are discussed below:

i. Carbon Sequestration Flow

It is estimated that the world's forests store approximately 638 Gt of carbon as a whole to a soil depth of 30 cm. Thus, forests contain more carbon than the entire atmosphere. Roughly, half of the total carbon is found in forest biomass and dead wood combined and half in soils and litter combined. Estimation of carbon stocks in forestry sector, present in biomass and soil, is based either on IPCC guidelines or through use of actual conversion and other factors on growing stock data of forest inventories. Analysis of the carbon stock of the forest of Mizoram was undertaken based on the growing stock data of the Forest Survey of India (FSI, 2003 and ISFR, 2013) by following Kishwan *et al.* (2009) methodology. The results are mentioned in Table 3.

Table 3: Forest Biomass Carbon of Mizoram

Items with symbolic description	**Factor**	**2003**	**2011**
Growing stock of the forests in million cubic meter		63.45	67.53
Mean Biomass Expansion Factor – EF	1.575		
Ration (Below to Above Ground Biomass) – RBA	0.266		
Above Ground Biomass (Volume) – AGB = GS x EF		99.93	106.36
Below Ground Biomass (Volume) – BGB = AGB x RBA		26.58	28.29
Total Biomass		126.51	134.65
Mean Density	0.7116		
Biomass in million tons (Mt) = Total Biomass x mean density		90.02	95.82
Ratio (Other forest floor biomass except tree to tree biomass)	0.015		
Total Forest Biomass in Mt (Trees + Shrubs + Herbs) – TFB		91.37	97.25
Dry Weight in million tons (80% of TFB) – DW		73.09	780
Carbon in million tons (40% of Dry Weight)		**29.29**	**31.12**

Results indicated that the forest biomass carbon increased from 29.29 million tons in 2003 to 31.12 million tons in 2011 (ISFR, 2013), thus showing an annual increment of 0.228 million tons of carbon per year or on average 0.832 million tons of carbon di oxide was sequestered annually by the forests of Mizoram. Putting a conservative value of US$ 5 per ton of CO_2 (1 US$ = Rs. 62.00), the contribution of state forests is estimated at **Rs. 25,79,20,000.00** per year.

ii. Climate Amelioration

Local weather and climate are determined by the complex interaction of regional and global circulation patterns with local topography, vegetation, albedo, as well as the configuration of hills, lakes and rivers. The services provided by this function relates to the maintenance of a favorable climate, both at local and global scales, which in turn is important for, among others, human health, crop productivity, recreation and even cultural activities and identity (Groot *et al.*, 2002). Krieger (2001) estimated the air quality value of a tree at US$ 4.16 by assuming that planting of five lakh mesquite trees in Tucson, Arizona at maturity will remove 6,500 tonnes of particulate matter for which Tucson spend US$ 1.5 million on an alternate dust control programme. Costanza *et al.* (1997) estimated that US forests yielded $ 18.5 billion per year as climate regulation benefits. Studies in urban settings concluded that one lakh properly planted mature trees in U.S. cities might save as much as US$ 2 billion in heating and cooling costs (Krieger, 2001). Powe and Willis (2004) assessed the value of forests in reducing air pollution through SO_2 and particulate matter absorption by trees in terms of extending life expectancy of the population and reducing hospital admissions. Working at a resolution of 1 km^2 with woodland over 2 ha, it was estimated that for Britain as a whole, woodland saved between 5 and 7 deaths and between 4 and 6 hospital admissions that would otherwise have been brought forward every year. The economic value of the health effect of woodland was estimated to be at least £9,00,000 per year. It was also suggested that smaller areas of woodland, often located close to population, sometimes strategically planted close to pollution sources, would generate additional air pollution absorption benefits to the societies. Researching such benefits would require more detailed data than is available at present for a national study. Liu and Xiao (1999) while evaluating the ecological and socioeconomic functions of farm forestry in Minquan County, Henan Province, China concluded that the village forests improved the living conditions of people including a reduction in medical expenditure, with a value estimated at PBY 6,268,900 annually.

Mizoram is a no industry state. Most of the villages are located close to forest. People enjoy clean air and pollution free environment and forest does play an important role in ensuring these amenities. The general health condition of people is good and normal monthly healthcare expenditure of most of the households is low as compared to the people living in big cities like Delhi and Kanpur. Another reason of the good health condition of the people is their food habit wherein they prefer boiled food with less oil and spices. The life expectancy is quite high and number of people in the old age group is comparatively high. Although, the general good health conditions of the people who live close to the forest in pollution free environment and clean air cannot be solely due to the impacts of forest but in the absence of appropriate methodologies at least some inferences can be drawn with the better environmental conditions and corresponding health status of the people, therefore, the amount saved on healthcare expenditure can be considered as the

Table 4: District wise details of willingness to pay for improving water supply

	Willingness to Pay		(Rupees Per month)				
District	**Yes[1]**	**No**	**10**	**20**	**50**	**100**	**500**
Aizawl	11.11		16.67	22.22	27.78	19.44	2.78
No. of HH	8733		13104	17466	21837	15281	2185
WTP (Rs.)			131040	349320	1091850	1528100	1092500
Total (1 year)	523980						**56601480**
Champhai	8.33	5.56	30.56	22.22	19.44	13.89	-
No. of HH	1981		7269	5285	4624	3304	
WTP (Rs.)			72690	105700	231200	330400	
Total	71574						**9738768**
Kolasib	14.28		35.71	14.28	28.57	7.14	-
No. of HH	2311		5779	2311	4623	1155	
WTP (Rs.)			57790	46220	231150	115500	
Total	75107						**6309204**
Lunglei	9.09	9.09	13.64	27.27	22.72	18.18	-
No. of HH	2971		4458	8912	7425	5942	
WTP (Rs.)			44580	178240	371250	594200	-
Total	132031						**15843612**
Mamit	8.7	-	17.4	30.43	21.73	13.04	-
No. of HH	1404		2809	4912	3508	2105	
WTP (Rs.)			28090	98240	175400	210500	
Total	213012						**6970916**
Serchhip	28.26	8.7	10.87	23.91	4.35	21.74	2.17
No. of HH			1343	2954	537	2686	268
WTP (Rs.)			13430	59080	26850	268600	134000
Total	213012						**8257464**
Lawngtlai	22.58	16.13	12.9	16.13	9.67	19.35	3.22
No. of HH	4607		2632	3291	1973	3948	657
WTP (Rs.)			26320	65820	98650	394800	328500
Total	336864						**15011446**
Saiha	27.28	24.24	24.24	6.06	9.09	9.09	-
No. of HH	3966		3526	881	1322	1322	
WTP (Rs.)			35260	17620	66100	132200	
Total	141269						**1695227**
					Grand Total		**120428117**
Average (%)	**16.21**	**7.98**	**20.26**	**20.32**	**19.92**	**15.24**	**1.02**

1= willingness to pay but no amount was mentioned by them

contribution of forest towards climate amelioration.

Gupta (2008) estimated that an average worker in a polluted city like Kanpur would gain Rs. 170.00 every year if air pollution is reduced to a safe level. Dasgupta (2004) estimated that the average per capita health cost related to diarrheal diseases in Delhi was to the tune of Rs. 2,200.00 per year. If we consider Gupta (2008) value of Rs. 170.00, which is saved by an average worker if pollution is to a safe level, and multiply it with 91.44% (forest and tree cover area of Mizoram) population of the state, the total economic value of this function of forest is estimated at **Rs. 16,95,95,910.00 per year**. It may be noted here that Gupta's value is eight years old now and must have gone high due to increase in the pollution level, but the same was used so as to get a minimum idea about the value of this function of forest.

iii. Water Regulation and Water Supply

It was observed during the reconnaissance survey that people were able to understand the role of forest in maintaining the flow of water in natural streams and rivers. Most of the respondents were of the opinion that the flow of water in natural streams and rivers has decreased due to the degradation of forests in the catchment areas. Since water supply is not satisfactory in most part of the state and since most of the rivers originate from forests, the economic value of the water retention and water supply function of forest was estimated by using contingent valuation method based on the WTP of local people in terms of money for improving the condition of forest so as to improve the availability of water in these springs or rivers. The WTP of respondents was measured by making five categories i.e. Rs. 10.00, Rs. 20.00, Rs. 50.00, Rs. 100.00 and Rs. 500.00 per month. It was also noticed that in rural areas many respondents found it difficult to express their WTP in terms of money. Many of them were actually willing to pay some amount for improving the supply of water; however, they could not reveal their WTP properly in terms of rupees per month probably due to a bit hesitation may be because of their poor economic status. Therefore, in all such cases where a respondent clearly expressed his/her WTP as 'Yes' but did not mention any amount, it was considered as a positive response and its value was estimated by multiplying it with the weighted average value of the total WTP of the district. However, when respondent did not give any answer for the queries, it was recorded as 'No response', and such responses were not considered for further estimation. The district wise details of WTP as revealed by the respondents are mentioned in Table 4.

Thus the total economic value of forests for water regulation and water supply for the state was estimated at **Rs. 12,04,28,117.00** per year. There have been few studies in India on valuation of role of forest for providing water retention and water supply function. Chaturvedi (1992) was probably the first to estimate the economic value of the role of forests in supplying water to the people of Almora town at Rs. 4,745.00/ha/yr. Ratna Reddy (1999) observed that on an average people were willing to pay five percent of their income for ensuring proper water supply in Rajasthan. Costanza *et al.* (1997) estimated values for water retention and water supply function of forest at US$ 8 and US$ 6, respectively.

iv. Prevention of Soil erosion and Landslides (Disturbance prevention)

Mizoram is a hilly state. The average annual rainfall is around 2,700 mm. People often suffer heavily due to landslides, which damage their agriculture fields, crops, houses, public properties etc. It also causes road blockade which means cut off from mainland resulting into shortage of supply of all essential goods and services. Most of them take preventive measures in their habitation areas and jhum fields to prevent the damage from landslides and runoff. Tilling is not done in jhum fields and sowing is done by dibbling of seeds. This practice is helpful in reducing soil erosion. They make barriers at selected places by using bamboos, burnt logs and poles to prevent landslides and soil erosion in their jhum fields. They plant multipurpose trees and bamboos along the boundary of their houses, and construct retaining walls to reduce the damage from landslides. Besides this, government also spend substantial amount of money for construction of retaining walls along the roads, office and residential buildings in the hilly areas to prevent such damages. The economic value of this function was estimated by using two different methods viz., avoided cost method and valuation based on estimation of past losses. The district wise details of the information collected during the survey are mentioned in Table 5.

Table 5: District wise details of measures taken for prevention of landslides in Mizoram

Query	**Aizawl**	**Champhai**	**Kolasib**	**Lunglei**	**Mamit**	**Serchhip**	**Lawngtlai**	**Saiha**	**Average**
Whether took any soil conservation measures for prevention of landslides?									
Yes	28.75	58.94	45.18	57.83	75.14	50.54	74.96	54.3	55.7
No	71.25	41.06	54.82	42.17	24.86	49.46	25.04	45.7	44.3
Number of days spent in a year for taking preventive measures to avoid such losses									
Nil	43.2	5.88	11.38	28.13	15.05	28.7	2.12	7.42	17.8
<10 days	25.54	54.58	51.4	48.15	46.8	41.8	56.77	53.7	47.4
10-20 days	22.35	28.24	26.58	12.46	29.38	16.78	29.36	22.78	23.6
>20 days	8.9	11.3	10.64	11.26	8.76	10.72	11.75	16.1	11.2
Whether any such losses occurred during last five years or not?									
Yes	51.3	54.33	47.67	0.79	62.1	50.25	62.08	52.07	54.2
No	48.7	45.67	52.33	46.21	37.9	49.75	37.92	47.93	45.8
If yes, the amount of losses incurred (in rupees)									
< Rs. 10000/	10.85	29.54	21.02	28.85	39.6	24.34	39.46	26.67	27.54
> Rs. 10000/	11.75	32	17.76	10	22.89	16.35	22.75	28.9	20.3

iv (a). Avoided cost method

With the pace of developmental activities and urban population increasing at a rapid rate, every available space has been occupied for some developmental activities. Construction of buildings, roads and other such activities are now taking place even at a steep slope and on loose sedimentary formation thus making areas prone to erosion and landslides. Therefore, people are quite conscious for taking preventive measures to avoid losses from soil erosion and landslides. Results indicated that on an average 55.70% households took some or other preventive measures to reduce losses from heavy rainfall and landslides. The maximum percentage of households who took such measures were from Mamit, followed by Lawngtlai, Champhai, Lunglei, Saiha, Serchhip, Kolasib and Aizawl, respectively having 75.14%, 74.96%, 58.94%, 57.83%, 54.30%, 50.54%, 45.18 and 28.75% respondents. The number of respondents who took such measures was more in rural areas than in urban areas as in rural areas people took lot of preventive measures in and around their jhum fields to avoid such losses.

It was observed that on an average 47.40% household spent up to 10 days; 23.60% households 10 to 20 days and remaining 11.20% households spent more than 20 days manual labour in a year to take preventive measures to reduce losses from soil erosion and landslides. The district wise details of the workdays spent by the households in a year for taking soil erosion and landslides prevention measures were estimated and multiplied with Rs. 220.00 (wage rate of unskilled labour approved by the govt.). The total economic value of the workdays put in by the people to avoid such damages was estimated at Rs. 371.81 million in a year. The highest value of Rs. 118.53 million (31.88% of the total value) was from Aizawl, followed by Champhai, Lunglei, Lawngtlai, Kolasib, Saiha, Mamit, respectively having 13.78%, 13.71%, 9.38%, 8.83%, 8.72%, 8.56% share in the total value, while the lowest value of Rs. 1.91 million (5.14%) was reported for Serchhip district.

iv (b). Valuation based on Estimation of losses occurred in the past

The respondents were asked to inform whether there were any incidence of landslides in their area during last five years and whether they suffered economic losses due to such incidences. Following choices were given to them based on the results of the pretesting of the questionnaire i.e. i). losses up to Rs. 10,000.00 during last five years, and ii). losses over Rs. 10,000.00. The mean value of all such losses under both the categories was estimated at Rs. 6,192.00 and Rs. 13,679.00, respectively and these values were multiplied with the average number of households indicating such losses under these two categories in all the districts (Table 6). The total economic value of the past losses, which had occurred due to soil erosion and landslides, was estimated at Rs. 779.70 million. Since these losses had occurred over a period of five years, it was **divided by five** to get the annual value. Thus the annual value of this function was estimated at Rs. 15,59,41,499.40. Therefore by combining these two values i.e. amount of labour put in for prevention of such losses and the average amount of losses occurred from soil erosion and landslides, the total value of this function of forest was estimated at **Rs. 52,77,52,499.40** annually.

Table 6: Estimation of value of labour put in by people to avoid losses from landslides

Districts	No. of households	No. of workdays	Total workdays	Value (Rs)	Proportion
Aizawl	20076 17568 6996	100380 263520 174900	538800	118536000.00	31.88
Champhai	12983 6717 2688	64915 100755 67200	232870	51231400.00	13.78
Kolasib, Lunglei, Mamit, Serchhip, Lawngtlai and Saiha					
		Grand Total		**37,18,11,000.00**	**100.00**

However, it does not include the amount of money spent by the state government and other agencies to avoid such losses e.g. construction of retaining walls along the national and state highways, office buildings, and residential quarters etc. This value may go very high if all such values are added to the value estimated in the present study. For example, National Highway from Lengpui to Aizawl, which was badly damaged during 2011 rains due to heavy landslides, is still under repair since last two years or so and the concerned department must have spent lakhs of rupees on construction of retaining wall and maintenance works, which have not been accounted for in this estimation. Kreiger (2001) estimated that in Tucson, Arizona, planting of half a million trees is expected to reduce runoff that would otherwise require construction of detention ponds costing US$ 90,000. Xue *et al.* (1999) estimated soil conservation value of Changbaishan Mountain Biosphere Reserve at 23 million Yuan (1.3% of total value), while Bin *et al.* (2002) estimated this value for the tropical forests in Hainan Island at 216.57 million Yuan (1.17% of total value). Wu *et al.* (2008) estimated that economic value of soil erosion function in Nongla restored secondary forest; China had a share of 35.49% in the total value. Kumar (2000) estimated the value of soil conservation function of forests by using replacement cost method at Rs. 21,583.00 per hectare in Doon Valley. Kumar (2004) mentioned that the cost of soil erosion is very high but it helps in rationalizing the cost of conservation projects.

v. Food and Livelihood Security

v (a). Production function approach

The productivity of jhum lands directly depends on the length of jhum cycle, and since all these lands were forest in the past, and cultivation on these lands is providing food and livelihood security to a large population of the state, production of paddy and other vegetable crops from these areas can be considered as 'contribution of forest'. After jhum cultivation, the area is left abandoned for few years to regain its fertility. This practice can be sustainable if the nutrients lost or displaced during cropping phase are balanced during the fallow period. Since there is great variation in the types and numbers of vegetables cultivated by the jhumias, area covered under each vegetable, time taken for maturity, productivity of individual crops, demand and prices in the markets, as well as the value of labour spent on cultivation of jhum areas by the farmers, it was practically not possible to collect such data, therefore the economic value of this function was estimated by assuming that the productivity of paddy in jhum lands, which is more or less stable at 1.2 tonnes per hectare since many years (ESM, 2013) was mainly due to the nutrients released by the burning of trees and other biomass which grew there naturally when the area is left abandoned after jhuming. It was multiplied with the current market price of rice and the annual jhum area of the state. The current price of rice is approximately Rs. 30.00 per kg, and by multiplying it with the annual jhum area i.e. 23,150.00 Ha, the total economic value of food security function of forest was estimated at Rs. 83,34,00,000.00. (23,150 Ha x 1,200 kg x Rs. 30.00). Since the **average jhum cycle** is **four years**, the annual value of food security from jhum areas was estimated at **Rs. 20,83,50,000.00** by dividing this value by four.

v (b). Replacement cost method

Results of Tawnenga *et al.* (1997) were used for estimation of the quantity of total nitrogen, extractable phosphorous and exchangeable potassium present in the abandoned jhum lands before slashing of vegetation on an old and new jhum area. The details of calculations are mentioned at Table 7.

Table 7: Estimation of economic value based on replacement cost of N, P and K in old and new jhum fields (quantity in kg ha-1)

Nutrients	Old jhum	New jhum	Difference	Requirement of fertilizer (kg/ha)	Current prices (Rs./kg)	Per hectare value (Rs.)
N	3,660.00	3,300.00	360.00	652.17	5.70	3,717.37
P	29.00	17.30	11.70	65.00	22.00	1,430.00
K	626.00	469.00	157.00	78.33	16.25	1,272.86
					Total:	**6,420.23**

Thus by multiplying this value with the current annual jhum area i.e. 23,150 Ha (ESM, 2013), the economic value of nutrient cycling function of forest for NPK was estimated at Rs. 14,86,28,324.00. Since as per Tawnenga *et al.* (1997), the difference between new jhum and old jhum areas was 14 years, it can be assumed that accumulation of these nutrients took 14 years. However, studies have shown that accumulation of nutrients is faster in the initial years, and the rates slow down gradually. Therefore, it was assumed that most of these nutrients get accumulated in a period of three to four years, which is the average jhum cycle in the state. Based on this, the annual value of the nutrient released function for the jhum cultivation areas of the state was estimated at Rs. 3,71,57,081.00 by dividing the total value by four. This value can go even higher if values of other nutrients is included in this assessment.

v (c). Livelihood security

Another important contribution of jhumlands is that now many farmers especially those living near Aizawl and other town areas prefer cultivation of vegetables especially off season vegetables rather than growing paddy. These vegetables have high demand in the markets and fetch good returns to them. During 2008, 79,960 households were engaged in jhum cultivation, 8,889 were doing WRC or terrace cultivation, while 3,479 were operating in both Jhum and WRC practices (GOM, 2008). Daily many people come to Aizawl and other towns with fresh farm produce and sell them in the market. Besides this, many people sell their farm produce in local markets as well as in front of their houses along the highways. Another good practice in Mizoram is that the Saturday is a market day in the entire state and cultivators from all parts of the state come to Aizawl or go to other towns and markets in large number to sell their farm produce. The competition is so high that many of them come to market on Friday evening to occupy a proper space to sell their produce.

It was difficult to estimate the exact number of people involved in these activities, however, if we assume that 10% of these households i.e. 7,996 families actively sustain their livelihood by selling NTFPs collected from forests or fresh farm produce cultivated on jhumlands. Since it is not a full time job for most of them, it was assumed that these families are able to earn a minimum of 100 days livelihood in a year by such activities, the economic value of role of forest in providing livelihood support to these families was estimated at Rs. 17,59,12,000.00 annually. In addition to this, many families who have their houses along the road sides/highways sell these products from their houses itself or sell them to the regular venders at low prices who in turn sell them at proper market place and earn their livelihood through this activity. Besides this, many secondary livelihood opportunities such as restaurants, transporters of farm produce and other subsidiary services have also emerged in a big way to support organize Saturday markets in the state. In addition to this, forest department spent an amount of Rs. 20,58,87,444.00 under wages during 2014-15 under various schemes of the department. Thus approximately 9,35,852 mandays were generated by the department which is equivalent to providing round the year livelihood opportunities to over 2,000 people. Thus by adding all these values, the total value of food and livelihood function of forests was estimated as **Rs. 62,73,06,525.00** annually.

vi. Biological Control

Agricultural production relies not only on crops but on associated biodiversity too. Pests, diseases and weeds limit crop production, and are themselves limited by the action of their natural enemies, mostly arthropods and micro-organisms. Predators, parasitoids and pathogens attack insect crop pests, while plant feeding insects and pathogens attack weeds of crops. These natural enemies have a clear and direct biological control function and contribute greatly to the maintenance of complex communities at relatively stable levels. Outbreaks of particular species may occur in nature, but these tend to be suppressed over time by the density and spatially dependent, regulatory processes, which characterize natural biological control (van Driesche and Bellows, 1996). According to Ehrlich (1986), natural ecosystems control more than 95% of all the potential pests of crops and carriers of disease to human beings.

In Mizoram, farmers do not use any insecticides/ pesticides in jhum cultivation areas and rely entirely on natural or biological control mechanism for protection of their crops from diseases. These farmers mainly grow local crops from seeds, which they have been collecting from the best plants through selection, thus minimizing the chances of attack by disease causing organisms. It was observed that normally there was not much damage from diseases (fungi and insects) in jhum cultivation areas. It may be because of the fact that burning and re-burning of jhum lands before planting kill all spores and propagules of disease causing fungi and bacteria as well as insects of the area; therefore, it takes time for migration of disease causing organisms from other areas and development of new infection. Another reason may be that due to mixed cropping i.e. simultaneous cultivation of 20 to 30 different crops, the disease causing organisms are not able to spread due to physical barrier created by other crops, which may not be a suitable host for a particular pathogen. Another important reason which keeps incidence of disease under control is that there are always patches of natural forest or abandoned jhum areas of different ages near the current year jhum cultivation areas. These areas keep the population of disease causing insects/fungi under control through natural control mechanism.

The economic value of this function was estimated by taking average value of the insecticides/fungicides used by the farmers in wet rice cultivation areas in Champhai and North Vanlaiphai. Since these areas are plain areas, intensive cultivation of paddy is done here and farmers use fertilizers, insecticides and fungicides for improving crop productivity. The details about the average quantity of insecticides and pesticides used by the farmers of Champhai region for WRC areas were collected and average per hectare market cost of applying these items were estimated. It was also assumed that in jhum cultivation areas where farmers do not use any insecticides or pesticides, this function is being performed naturally through biological control mechanism, therefore per hectare value of the cost of insecticides and fungicides as saved by the farmers of jhum areas was considered as the value of natural biological control and extrapolated to the current year jhum area to estimate its total economic value.

It was estimated that on an average farmers of Champhai were spending approximately Rs. 250.00 annually for the purchase of fungicides/insecticides to prevent losses from diseases. It was multiplied with the current annual jhum cultivation area of the state where no such expenditure was made and the natural biological control mechanism through nearby forests played a role in preventing the losses from disease causing insects and fungi. Accordingly, the total economic value of this function was estimated at **Rs. 57,87,550.00** per annum.

vii. Pollination

Pollination is a critical link in the functioning of ecosystem. At global level, 75% of the primary crop species and 35% of crop production rely on some level of pollination (Klein *et al.,* 2007). Without pollination food supply would be hugely reduced thus endangering the survival itself. It has been classified as a supporting service (MEA, 2003) and as regulation service that contributes to human welfare by maintaining or enhancing other services *(de* Groot *et al*., 2002). Its economic value was estimated by assuming that the productivity of various agriculture and horticultural crops was mainly due to the pollination services provided by bees, insects, butterflies, moths and birds, which inhabit the patches of forest left in and around jhum cultivation areas. For example, production of squash, passion fruits, kiwi etc., which play important role in the economy of the state, is dependent on pollination by these agents. Four categories of pollinators based on the impacts of pollinators in improving production and the quality of produce were used in this study (Klein *et al.* 2007). These were i). Essential: production reduction by 90% or more without pollinators (++++); ii). High: 40% to less than 90% reduction (+++); iii). Modest: 10% to 40% reduction (++), and iv). Little i.e. less than 10% reduction in production without natural pollinators (+).

The details of pollinators' impacts on vegetables, horticultural and food crops were collected from different sources (en.wikipedia.org; Gallai *et al*., 2009). The economic value of pollination services were assessed by estimating the annual production of important crops, multiplied by the pollination impact factor and their average market prices. The latter were collected from Aizawl market and 10%, 20%, 30% and 40% of the market prices of these crops were considered as the contribution of pollination in crop productivity respectively for +, ++, +++ and ++++ categories, and the remaining values were assumed to be responsible due to other factors such as manpower inputs by farmers, quality of planting materials, fertilizers etc. The details are mentioned in Table 8. The economic value of pollination services for selected fruit and vegetable crops was estimated at Rs. 72,53,76,000.00 annually. This value was maximum for ‘squash’, followed by bitter gourd, oranges, pumpkin etc. The total value may go higher, if pollination impact factors of other food crops is studied and included in the valuation.

Table 8: Estimation of economic value of pollination services of selected crops in Mizoram

Crops	Production (Ton)	Pollination impact factor	Average price (Rs.)	Price taken for valuation (Rs.)	Economic value (Rs.)
Bean	5040	+	20	2	10080000
Bitter gourd	19570	++++	15	6	1.17E+08
Brinjal	13500	++	15	3	40500000
Squash	66500	++++	10	4	2.66E+08
Chillies (dried)	9790	+	100	10	97900000
Kiwi	100.00 qt	++++	200	80	800000
Mango	100	++++	20	8	800000
Okra	19790	++	20	4	79160000
Orange	22230	+	25	2.5	5.56E+08
Papaya	18190	+	25	2.5	45475000
Pumpkin	5,000.00	++++	5	2	10000000
Guava	150	++	15	3	450000
Passion fruits	1470.00 qt	++++	20	8	1176000
Sesame	20.00 qt	++	50	10	20000
Tamarind	100.00 qt	+	20	2	20000
			TOTAL		**72,53,76,000.00**

Ricketts *et al.*, (2004) estimated that enhanced pollination of coffee plants near forest edge led to 20.8% higher yield in comparison with coffee plants at the centre of the fields. The forest patches provided habitat to non-native honey bees as well as 10 native species of stingless bees, that all pollinate coffee. The value of annual surplus generated by forest patch was estimated at US$ 62,000. In Maoxian County, China, after the local pollinators became extinct, farmers have no option but to pollinate apple orchards by hands. In California, which accounts for 80 percent of the world's almond production, shortage of bees have forced growers to hire beehives for pollination @ $150 per hive to save their $ 2.5 billion crop (www.telegraph.co.uk). Some farmers had to pay even $200 per hive, which were imported from Australia as well. Collectively, California growers spent about $250 million on bees during 2013 (articles.latimes.com). Globally, Costanza *et al.* (1997) estimated the value of pollination services at $ 117 billion per year, while Gallai *et al.* (2009) estimated it at Euros 153 billion considering impacts on agriculture only. In Himachal Pradesh, India honeybee colonies are being used for pollination of apple since 1996. Farmers have reported 20% to 30% increase in apple production as a result of use of honeybees for pollination. It has also resulted in improvement in the fruit quality. The charges for renting bee colonies are Rs. 600.00 to Rs. 800.00 per colony for the flowering period of apple and the same practice has been started in Uttarakhand too. The total contribution of this service in Himachal and Uttarakhand has been estimated at US$ 363.79 and 166.69 million, respectively by Partap (2011).

viii. Recreation

There are many spots in the state where one really enjoys the beauty of nature and large numbers of local as well as outside people visit these areas e.g. Blue mountain, Chalfilh, Hmuifang, Reiek, Tamdil etc. The tourism department has developed lodges and other facilities in these areas to promote tourism in the state. Although all these areas provide good destinations to nature lovers yet the numbers of domestic as well as outside tourist visiting these areas is not very high. Hence, it was not considered appropriate to apply the popular valuation methods such as travel cost or contingent valuation method for estimation of economic value of this function. The recreation value was estimated based on the figures of tourist department on the numbers of domestic and external tourists visiting and staying at various spots and the revenue earned from their visit (ESM, 2013). Currently the tourism department is maintaining 39 tourist lodges at different places, which are having 364 rooms and 782 beds. The details of domestic and international tourists visited in the state during last seven years and the revenue earned thereof is mentioned in Table 9.

Table 9: Details of tourists visited and revenue earned

Year	**Number of tourists**		**Revenue (Rs. in Lakh)**
	Domestic	**International**	
2008-09	56793	842	110.00
2009-10	57639	675	123.51
2010-11	57623	619	148.15
2011-12	53512	744	153.64
2012-13	48416	511	145.40
2014-15[1]	51901		173.73
2015-16[2]	44,702		183.20

[1 = Figures up to December 2014; 2 = up to January 2016]

If we extrapolate the figure of 2013-14 up to March, it comes to approximately Rs. 173.73 lakh, and by taking the average annual value, the income generated by the tourism sector of the state is estimated at Rs. 142.40 lakh per year. Since all tourist destinations are located near forests, it can be assumed as the economic value of the recreation function of the forests of the state. It does not include the value of money spent by the local visitors who make day visits in large numbers and do not stay in these tourist lodges.

Thus the total value of selected ecosystem goods and services provided by the forests of Mizoram was estimated at Rs. 516.94 crore per annum. Out of this, share of the goods and services were Rs. 272.10 crore (52.64%) and Rs. 244.83 crore (47.36%) respectively (Table 10).

Results indicated that the share of fuel wood was the maximum i.e. 21.75% in the total value of goods and services from forest. It was due to the fact that almost all rural families, i.e. 47.89% of the total population, were using fuel wood as a medium for cooking food. Besides this, large quantity of fuel wood was used for cooking of pig's food. It was followed by timber, small wood and poles, pollination, food and livelihood security, prevention of soil erosion and landslides, fodder, carbon sequestration, NTFPs, climate amelioration, fresh bamboo shoots, water retention and water storage, bamboo culms, charcoal, recreation, and biological control, respectively having a share of 15.91%, 14.04%, 12.14%, 10.21%, 5.02%, 4.98%, 4.86%, 3.28%, 2.96%, 2.32%, 1.62%, 0.52%, 0.27% and 0.11% (Table 10).

Table 10: Economic value of selected goods and services provided by forests in Mizoram

Items	**Methods used**	**Value (Rupees)**	**% share**
Fuel wood	Market price	112,47,67,383.00	21.75
Timber, small wood and poles	-do-	82,14,56,630.00	15.91
Pollination	Production Function	72,53,76,000.00	14.04
Food and livelihood security	Production Function & Replacement Cost Methods	62,73,06,525.00	12.14
Prevention of soil erosion and landslides	Damage Cost Avoided & Estimation of Past Losses	52,77,52,499.00	10.21
Fodder	Market Price Method	25,93,73,230.35	5.02
Carbon sequestration	Production Function	25,79,20,000.00	4.98
NTFPs	Market Price	25,14,71,000.00	4.86
Climate amelioration	Benefit Transfer Method	16,95,95,910.00	3.28
Bamboo shoots	Market Price	15,28,91,000.00	2.96
Water retention and water supply	Contingent Valuation	12,04,28,117.00	2.32
Bamboo culms	Market Price	8,40,40,500.00	1.62
Charcoal	Market Price	2,70,00,000.00	0.52
Recreation	Production Function	1,42,40,500.00	0.27
Biological control	Contingent valuation	57,87,500.00	0.11
GRAND TOTAL:		**516,94,06,794.75**	**100.00**

Xue *et al.* (1999) estimated the value of various functions of forests of Changbaishan Mountain Biosphere Reserve, China at 1,765 million Yuan per year, of which, values for water conservation; soil conservation to control erosion; carbon fixation for reducing green house effect; nutrient retention for N, P and K, and SO_2 degradation and control of diseases and pests were respectively 39.49%, 1.30%, 49.68%, 2.43% and 0.90% of the total value. Nayak (2001) estimated the total economic and ecological values of Paralakhemundi Forest Division in Odisha at Rs. 64,132 per hectare based on the secondary data. It was revealed that the total value of annual flow of productive and consumptive benefits, environmental services, option and existence preferences were far higher than the govt. revenue and estimated income. Singh (2007) estimated the economic value of ecosystem services from Uttarakhand, India by using Costanza *et al.* (1997) values at Rs. 107 billion per year. It was assumed that the ecological characters of the Himalayan forests were closer to the tropical forests than the temperate forests (Zobel and Singh, 1997). It was also pointed out that because of a number of rivers originate in Himalayas, ecosystem services flowing from the state have played a major role in shaping the rise of culture in the great Gangetic plains, which is inhabited by nearly 500 million people. It was suggested that the Himalayan forests should be conserved, and people living in Himalayan regions be given appropriate economic incentives for their conservation efforts. Bahuguna and Bisht (2013) have estimated the total value of goods and services from Indian forests to the tune of Rs. 6.96 lakh crore annually.

Recently Verma *et al* (2015) estimated the economic value of annual flow of goods and services from six tiger reserves (TR) of India which varied from a minimum of Rs. 0.50 lakh/ha/year for Sundarbans to a maximum of Rs. 1.90 lakh/Ha/year for Periyar TR. The other selected tiger reserves viz., Corbett, Kanha, Kaziranga and Ranthambore were respectively having per hectare annual flow of goods and services worth Rs. 1.14 lakh, Rs. 0.80 lakh, Rs. 0.95 lakh, and Rs. 0.56 lakh per hectare. In the present study, many of these values have not been included as most of the respondents, especially rural people, were not able to understand these services, therefore, they were not in a position to reveal proper WTP for these benefits.

In the present study the value of direct benefits was higher as compared to other studies. It was mainly due to the fact that the dependence of local people was very high for collection of various goods from forests such as fuel wood, timber, small wood and poles, bamboos, NTFPs etc., while in case of ecosystem services, only eight ecosystem services were selected for valuation, which were directly related to the day to day life of local people such as food and livelihood security, prevention of soil erosion and landslides, water retention and water storage, pollination, biological control etc. Local people were able to appreciate the role of forest in maintaining the flow of these services; therefore, they could provide valuable information (data) for their valuation by using different methodologies. This issue was examined, and following reasons have been assigned for assessing the low economic value for the ecosystem services from Mizoram:

Ownership pattern

Most of the areas including forests are owned by the communities, and everyone in the village has a right to collect forest produce such as timber, fuel wood, fodder, bamboo shoots, bamboo culms and non timber forest products for their bonafide use. In addition to this, due to abundance of forest area in and around most of the villages, people consider these goods as 'free gift' of nature. Therefore, their willingness to pay values was quite low as compared to other studies / regions.

Remoteness of the region

Mizoram is located in the eastern most corner of the country and many areas are yet to be connected with the mainstream. An idea of the remoteness can be held from the fact that till date majority of the population have not seen the train. In rural areas, people spend a tough life managing food, shelter and other basic amenities depending on their income and status in the society. For rural people, especially cultivators, earning money is not an easy task. Most of the time, they have to spend a large amount of their income on the education of their children or on medical treatment of their family members. Therefore, WTP and WTA values of most of the rural households were low.

Good governance

The governance system is quite good in the state because of overall culture, traditional value system, impacts of churches and YMA on the society. Due to this, most of them expect govt. to take care of all their problems. For example, while asking their WTP for improvement of forest for improving the flow of goods and services many respondents replied that it was the duty of the govt. and forest department to do that. They are being paid for that duty. Due to this reason, WTP value of most of the respondents was low thus affecting the overall value of goods and services from forest.

Condition of forest

Mizoram has 91.44% of its geographical area under forest and tree cover. 61.74% of this area falls under open forest category, while only 0.65% area is under very dense forest category. The open forests have been developed mainly due to jhum cultivation practice. These areas are now occupied by all useless species e.g.

Macaranga, *Mikenia*, *Saccharum spontaneum* etc., which instead of providing goods and services to the people become a fire hazard during dry season.

Area considered for valuation

Most of the goods and services covered under this study have been extrapolated to the current jhum cultivation area of the state i.e. approx. 230 sq. km., which is hardly 2.5% of the notified forest area of the state or to the notified forest area which is 45.46% of the geographical area of the state thus affecting the value of the goods and services flowing from these areas. The total value may become even higher is these values are extrapolated to the forest area as per ISFR (2013), which is 79.30% of the geographical area of the state.

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