Paper presented in

Seventh Biennial Conference

Indian Society for Ecological Economics (INSEE)

Host:
Tezpur University

Global Change, Ecosystems, Sustainability

Cohost:
OKD Institute of Social Change and Development

December 4-8, 2013

OPTIMIZING RESOURCE EXTRACTION BEHAVIOUR OF FOREST DEPENDENT COMMUNITIES IN A MINE SPOILED DEGRADED ECOSYSTEM

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1. Introduction

Mining stimulates local as well as the national economy. In the short run, mining supports the livelihood of local people, but at the cost of degrading the ecosystems. Mining is a finite phenomenon and minerals are finite in supply. In long run, the mines are abandoned and overburden dumps are created which make it impossible for the ecosystems to be resilient. The physical perturbations of mining operations, as well as the chemical alterations in soil and water affect the ecosystem largely. The primary operation of mining activities involves removal of topsoil. The alterations and removal of topsoil disrupt nutrient dynamics and can introduce toxic metals and acids, which reduces land productivity and impact livelihood negatively. The continuing interaction between the biotic and abiotic components helps ecosystems to be functional. This interaction decreases as a result of depletion of soil nutrients and increased acidification. As a result, the amount of plant life that can colonize a location declines. Less carbon is processed through photosynthesis, which reduces plant biomass leading to low level of oxygen production and less amount of standing biomass. This results in low level of transfer and cycling of nutrients. In an ecosystem's water cycling, plants play an important role by regulating it as a way of utilizing moisture in photosynthesis and transpiring water vapor back into the atmosphere. Therefore, the loss of plants in an ecosystem by human intervention like mining can reduce the ecosystem services by limiting its multiple functions.

The livelihood of indigenous people depends upon the stock of resources available in the forest. In a natural state of forest ecosystem, resources are abundant and enough to support the livelihood of the local population. But once human intervention like mining degrades the ecosystem, the natural growth rate declines and remains much below the extraction rate of resources, undermining the livelihood base. Then because of resource scarcity, people start migrating to other industrial areas in search of jobs and alternative sources of livelihood.

The State of Environment Report of Orissa state (2006) reveals that modern mining in Orissa as per available records started in 1909, when coal was first excavated in the Rampur area of the Ib river valley. Tata Iron and Steel Co Ltd (TISCO) mines for iron ore at Gorumohisani and manganese mine in Goriajhar (Gangpur State) started in 1910 followed by dolomite and limestone mining in 1914 at Panposh and Bisra respectively. Mining of chromite in Baula area started much later, in 1942. Purnapani Limestone and Dolomite Quarry (PL&DQ) was started initially as a captive manual mine of the Rourkela Steel Plant (RSP). Manual mining operation of PL& DQ was started in September 1958 and the mechanized mining, in 1965. The total land contributed by Purnapani villagers for mining, township and railway line construction was 569.64 acres. In 2003, there was a closure of the operation of mines and about 2000 workers, working in the mines lost their livelihood. The State of Environment Report of Orissa state (2006) also presents that up to the late 1950s, when the mines were small and mostly manual; their environmental impact was not very significant. However, after 1958, large scale mechanized mines came up with the establishment of large industries. These mines and the beneficiation plants/washeries, waste dumps and effluents discharged increased pollution in and around the mines. The mines mostly being located in and around forest areas were considered responsible for increased deforestation and degraded ecosystem leading to unsustainable livelihood of indigenous and other forest dependent communities.

In this paper we presented review of literature in section 2 and explain objective, methodology and data source in section 3. The resource extraction model is described in section 4 followed by empirical investigation and estimation of the model in section 5 and 6 respectively. Section 7 and 8 contains result and discussion, and conclusion and policy recommendation respectively.

2. Review of Literature

2.1 Resource Extraction

Forests are generally the important source of livelihood for indigenous and other forest dependent people. These people extract resources like timber, fuel wood, fruits etc.

from forests. Keeping in mind resource availability, time, and distance to the forest, they take household level decisions regarding when and from where to extract resources. Based on this premise sophisticated household level resource extraction models were developed by Amacher *et al*. (1996), Bluffstone (1995), and Dayal (2006). Amacher *et al*. (1996) model household utility as a function of fuelwood, leisure and other goods while Bluffstone (1995) models household utility as a function of cooked food. The extraction model of Bluffstone (1995) being a model of household agro-forestry system under open access with a perfect off-farm labour market depends on the sum of the present discounted values of consumption of cooked food, which depends on the amount of fuel wood energy collected and purchased, and the sum of purchased and home-produced food grains. But Dayal (2006) develops a model that shows household utility as a function of energy and nutrition. Using this model he empirically analyses biomass extraction behavior in a sample of 227 households living in, and close to, Ranthambhore National Park, India. He finds that village location, ownership of biogas, and caste are correct explanatory variables of forest biomass extraction. Lopez and Wilen (2008) have modeled resources of marketable non timber forest product (NTFP) taking space in a single dimension and they find that extraction takes place in day trips and the only variable input that extractors control is the allocation of their time. Bardhan *et al*. (2001) and Chopra & Dasgupta (2008) also use a model similar to Dayal (2006) and Lopez & Wilen (2008). Bardhan *et al*. (2001) in fact, tries to analyze the role of different determinants of deforestation by using household data concerning collection of firewood. However, they do not find any evidence in support of the leading hypothesis of environmental degradation. Assuming the stock of resource and the annual flow of products and services to be given within the framework of a one period labour allocation model, Chopra & Dasgupta (2008) find that households typically divide time between collections from commons, working for a wage income and leisure. Robinson *et al*. (2008) have also designed a resource extraction model to show the spatial-temporal pattern of extraction. Their model demonstrates that when the location of resource implies a distance cost to extraction, the spatial pattern of extraction varies period by period leading to a multi-period and cyclical steady state including periods in which no extraction occurs in any cluster of the resource while that resource regenerates.

However, in each of the above models priority has been given only to resource extraction as a means of livelihood and the decision regarding efficient allocation of time and effort for generating livelihood. Much of the literature like Robinson *et al.* (2008) has focused on the role of community management institutions for controlling deforestation by using spatial-inter-temporal resource extraction models. A survey of available literature related to resource extraction reveals little evidence regarding impact of degraded forest ecosystem services (consequence of human intervention like mining, urbanization, and industrialization etc) on resource extraction and livelihood.

2.2 Ecosystem and Economy Linkages

Every socio-economic and industrial development has been achieved at the cost of degrading ecosystems. The Millennium Ecosystem Assessment (MA) indicates that approximately 60% of the ecosystem services are being degraded or used unsustainably. MA (2005) also indicates that over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel. Population pressure and economic activity beyond the carrying capacity of natural environment threatens the earth's ecosystems by over utilization of resources. Imprudent use of the environmental resource base may irreversibly reduce the capacity for generating material production in the future. All of this implies that there are limits to the carrying capacity of the planet (Arrow, 1995). The loss of ecosystems also threatens the growing human population and its increasing consumption. According to Arrow *et al*. (1995) and Norgaard (1994), economic activity is stressing the biological resources and jeopardizing the ecosystem services to the point where production processes and consumers' well being are being negatively impacted (Eichner and Tschirhart, 2007). Human activities are impairing the flow of ecosystem services on a large scale and many of the human activities that modify or destroy natural ecosystems may cause deterioration of ecological services whose value, in the long term, dwarfs the short-term economic benefits society gains from those activities (Daily, 1997). So on the one hand degradation of ecosystem is because of human intervention and on the other hand loss of human well-being and community welfare is as a result of degraded ecosystem. These mutual threats exist because human economies and natural ecosystems are inextricably linked: common economic variables such as incomes and prices affect and are affected by common ecosystem variables such as resiliency and species populations (Tschirhart, 2000). In spite of the existence of this inextricable link, many relations between the two systems have not been explored so far. Models of economies and ecosystems largely disregard one another (Tschirhart, 2000) though the biological underpinnings are encompassed in the phrase ecosystem services, which refers to a wide range of conditions and processes through which natural ecosystems, and the species that are part of them, help sustain and fulfill human life (Daily, 1997). Bioeconomic models that do merge economic and ecosystem concepts tend to address isolated markets and very few species. They do not address the myriad ways in which changes in an economy influence ecosystem functions, and in turn how changes in ecosystem functions feedback to the economy (Tschirhart, 2000).

Many authors like Norgaard (1994), Arrow *et al*. (1995), Daily, (1997) and Eichner and Tschirhart (2007) have emphasized that economic activities are responsible for degradation of ecosystems and the degraded ecosystem in turn has a negative impact on production processes and consumer well being. Though, there is enough literature pertaining to impact of mining or degraded forests on livelihood, few scholars have studied the quantitative relationship between them through household level resource extraction decision.

2.3 Human Intervention and State of Ecosystem

Biodiversity loss due to human intervention threatens the stability of ecosystems with the destruction of natural habitats and species extinction. Olfa and Pierre (2004) have observed two approaches, the ecological (and biological) and the economic approach for biodiversity measurement. They opined that the ecological approach is based on species richness and abundance and emphasizes the fact that abundant species must contribute more than rare species to the measure of biodiversity. Economists take into account the contribution of each species to biodiversity and the economic approach is based, mostly, on the work of Weitzman (Weitzman 1992, 1993, 1998) who developed an axiomatic analysis to measure biodiversity using a distance function based on pair wise dissimilarity between species according to their attributes. Nehring and Puppe (2002) extend this idea to consider many attributes. The intuition behind the dissimilarity approach is "more diversity is better than less". Olfa and Pierre (2004) have observed that the natural (virgin) state of biodiversity, as an important issue is not considered in these two approaches. They explore that all measures miss out an important element of biodiversity valuation that is the reference value of biodiversity relative to each ecosystem. Indeed, not all ecosystems are the same and their biodiversity must be different. Constructing a biodiversity measure they find that the closer the biodiversity is to its natural state the higher is its value. Human activity alters the local resource base, which results in the shifting of ecosystem services from one state to another. These mutual linkages are because of demands human beings in the economy make from the ecological system and the supply of the ecosystem goods by the natural environment. According to Eichner and Tschirhart (2007) if natural biodiversity is associated with resiliency of ecosystems and relatively stable populations, then the natural state potentially may provide the greatest flow of ecosystem services. But the very act of establishing an economy and drawing upon these services necessarily diminishes naturalness. A useful measure of naturalness, therefore, should account for the tradeoffs between using ecosystem services provided by natural ecosystems and the degree to which naturalness is lost in the process.

3. Objective, Methodology and Data Source

Temporal change of resource extraction, which has an impact on community welfare, is highly dependent on state of ecosystem. This paper works with the economic hypothesis that (i) adequate amount of resources are available for extraction in natural state relative to degraded state of forest ecosystem, and (ii) a mine spoiled degraded forest ecosystem has a negative impact on resource extraction. In this context we try to study the welfare of the communities derived from extraction of forest resources over a period of time, which is expected to decline due to mining activities. Then taking into account mining activities we try to explore various possible determinants of community welfare.

We have selected Purnapani area (see Fig.1) of Sundergarh district of the state of Orissa, where the Purnapani Limestone and Dolomite Quarry (PL&DQ) is situated between latitudes of $22^{0}24^{'}50^{''}$ and $22^{0}24^{'}00^{''}$ and longitudes $84^{0}51^{'}40^{''}$ and $84^{0}53^{'}25^{''}$. The Purnapani area is situated between latitudes 22° 24' 38" and 22° 24' 52" north and longitudes 84° 51' 42" and 84° 54' 23"east. The area consists of four villages viz. Purnapani, Gattitangar, Bhojpur, and Karkatnasa; one abandoned mine, and one reserved forest[1]. The total geographical area of the study is 1552 hectare along with 10.77 hectare of forest and 230.53 hectare of mine-spoiled area. The study area consists of total cultivated area of 1310.7 hectare with a population size of 7743 persons as per 2001 census. The inhabitants of Purnapani area were dependent on the forest for their livelihood, as there existed a reserved forest inside the area. Hence, these indigenous people were an integral part of the local forest ecosystem. The local reserved forest is now in a degraded state due to the mining activities.

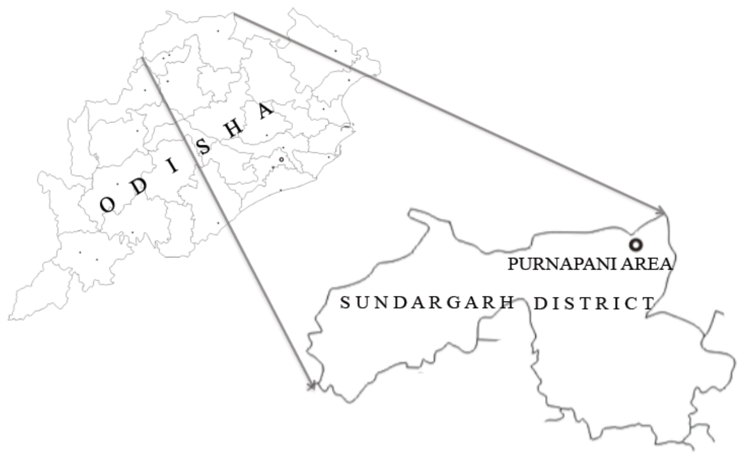

Fig. 1: Location map of Purnapani Area inside the Sundargarh District

In order to collect data for our study we conducted a primary survey in the area by following the method of Repeated Cross-sectional Waves with Retrospective one-shot Study (RCWRS). In RCWRS the total time period is to be divided into various sub-periods. For each sub-period a new sample is selected at random from the same sampling frame without repetition. Questionnaire survey was conducted to gather cross-sectional waves of information from each respondent selected based upon their age for a particular sub-period. Th questionnaire was the same for each sub-period. Along with the senior members, selected based upon their age, other existing family members were also included in the survey to draw accurate information on the variables of interest for that particular sub-period. The information drawn from this type of survey is recall based and would show the average value of the variables for that sub-period. In

[1] As per the wildlife (protection) act, 1972 "reserve forest" means the forest declared to be reserved by the State Government under sec.20. of the Indian Forest Act, 1927 (16 of 1927). As per Indian forest act, 1927, the State Government may constitute any forest-land or waste-land which is the property of Government, or over which the Government has proprietary rights, or to the whole or any part of the forest-produce of which the Government is entitled, a reserved forest in the manner hereinafter provided.

Purnapani area the respondents were interviewed only once during March to August 2009 to provide their household data for a particular sub-period.

Taking into account the mining activities in Purnapani area, the total time period is divided into four sub-periods: pre-mining, transition, mining and post-mining period. Because there was no human intervention during pre-mining period, we assume that the forest ecosystem was in a natural state. Therefore, pre-mining period is considered as a period of natural state of forest ecosystem. Considering the mining activity based upon manual and mechanized operations and their environmental impacts, the period from 1955 to 1960 is termed as the transition period-- the period when the local economy was moving from being forest dependent to mining dependent. The manual mining activities had started during the middle (1958) of the transition period but it was not significant. Therefore, it was during the transition period that human intervention in terms of manual mining activities began. During this period, the ecosystem was moving from its natural state to a degraded state. Therefore, the state of ecosystem between natural and degraded state has been termed as a transition state of ecosystem. The period from 1960 to 2003 is called the "mining period" when the mining operation was active with heavy population pressure leading to severe deforestation. The period after 2003 is called the "post-mining period" when the mining operation was inactive but its impact was there in terms of abandoned mines, over burden dump, and degraded forest. Therefore, during mining and post-mining period the state of forest ecosystem is degraded.

4. The Resource Extraction Model

The community welfare function for the indigenous and other forest dependent communities for four discrete time periods can be written as:

$$W = W(U_t) \quad \textit{for } t = 0, 1, 2, 3 \tag{4.1}$$

Where, W is social welfare function of the communities for the time period zero to three with utility being U. Considering the time preference of the communities the community welfare function in its discounted utility form can be written as:

$$W = U_0 + \frac{U_1}{1+\rho} + \frac{U_2}{(1+\rho)^2} + \frac{U_3}{(1+\rho)^3} \qquad (4.2)$$

However, utilities are unobservable. So replacing sum of discounted utilities with sum of discounted Net Economic Benefit (NEB), we can obtain Net Present Value (NPV) of the communities in place of community welfare function as:

$$NPV = \pi_0 + \frac{\pi_1}{1+\rho} + \frac{\pi_2}{(1+\rho)^2} + \frac{\pi_3}{(1+\rho)^3} \qquad (4.3)$$

Where, π : Net Economic Benefit from extraction of forest resources

ρ : Social Discount Rate

NPV : Net Present Value

The indigenous households extract forest resources and get the net economic benefit, which is functionally related to stock of forest resource abundance and extraction level at time *t*.

$$\pi_t = \pi(F_t, R_t) \qquad (4.4)$$

The level of extraction *(R)*, which is affected by unsustainable mining activities, can be compared for different time period. The mining activities impacted the resource extraction level over a period of time by directly degrading forest ecosystem services, which leads to different time path for the forest resource stock, F_t. Suppose that R_{it} denotes extraction level results in F_{it}, where *i* is the state of ecosystem that is *i=0 (natural state),1(transition state) and ,2(degraded state)* and *t=0,1,2,3*. Here we shall calculate the net present value of extraction level in different state of ecosystem over the time horizon, *t=0,1,2,3*.

4.1 Category of Net Present Value (NPV)

The NPV of the households can be classified into various categories depending upon state of ecosystems and consumption and sales behaviour of the households.

The consumption and sales behaviour of resources and impact of state of ecosystem give rise to twelve types of NPV for the households. Households of these communities extract resources in different time period. Here our basic objective is to find out the time period when resource extraction is optimal which will maximize the NPV of the communities.

Table 4.1: Category of Net Present Value (NPV)

Period	Impact of State of Ecosystems (ISE)	Extraction of resources for		
		Only consumption	*Only Sale*	*Both Consumption and Sale*
Pre-mining (Before 1955)	*Natural*	NPV-0	NPV-4	NPV-8
Transition (1955-1960)	*Transition*	NPV-1	NPV-5	NPV-9
Mining (1961-2003)	*Degraded*	NPV-2	NPV-6	NPV-10
Post-mining (2003-2005)	*Degraded*	NPV-3	NPV-7	NPV-11

In the empirical analysis part we are analyzing NPV from resource extraction by the communities in various state of ecosystems and trying to highlight when it is maximized for the communities, which is because of the advantage of state of ecosystem prevailing in that time period.

5. Empirical Investigation

The sum of discounted net economic benefit, which is otherwise known as NPV derived from extraction of forest resources can be modeled for empirical investigation as:

$$NPV = f(NWM, ANC, DFF, LOH, PFL, ATW, ATS) \qquad (5.1)$$

The variables used in the model are given in the following section taking into account the hypothesis that *NPV* are being impacted by the predictor variables.

5.1 Response Variable

The response variable, *NPV*, is an unordered categorical variable. Considering consumption and sale behavior and ISE the households in the study area can be classified into 12 categories as shown in table 4.1.

5.1.1 Referent Group and Replicates

We have computed NPV in order to justify our categories of response variables. First we computed real gross economic benefit (GEB) derived from the forest resources at 2008 price by following the market price approach[2]. Then we computed total extraction cost (TEC) of forest resources by multiplying time devoted by the household members for extraction of resources into its real opportunity cost[3]. Then the Net Economic Benefit (NEB) is calculated as:

$$NEB = GEB - TEC \tag{5.2}$$

The NEB presented in eq.-5.2 is computed for each household of all the four time periods. Then in order to know the level of welfare derived from forest resources by the communities, we discounted the sum of household level NEB for each time period by considering the discount rate[4] (ρ) as 4.3. Then we computed four NPV for entire time periods as shown in table 5.1. Based upon the level of welfare derived by the communities in terms of NPV, we categorized it into four categories viz. NPV-0, NPV-1, NPV-2, and NPV-3 for pre-mining, transition, mining, and post-mining periods respectively.

Here, *NPV-0* is taken as referent group with which other replicates of the response variables are to be compared. In this case the household extract forest resources only for self-consumption purpose. This is the period of pre-mining with natural state of ecosystems. During this period, the ecosystem was in natural state and was producing adequate amount of resources relative to demand conditions of the indigenous and other forest dependent communities. Therefore, people would have to spend less time inside the forest for collection of required amount of resources. So in this model the sum of net economic benefit of the communities are categorized as *NPV-0*.

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[2] In order to derive GEB, we followed only market price approach. We ignore other non-market valuation technique due to resource and time constraint. In order to compute real GEB we considered a set of constant prices (2008 as the base year) of forest resources extracted by the households. These prices were collected from the local market of Purnapani area during primary survey.

[3] We assume real wage rate (wage rate at 2008 prices=Rs.40/-) as the opportunity cost of time devoted to extract resources from the forest.

[4] We considered real rate of interest of the year 2008 as the discount rate (Source: World Bank).

Table 5.1: Frequency distribution of available replicates

Period	NPV (ρ=4.3) (in Rs.)	Impact of State of Ecosystem (ISE)	Consumption behavior	Freq.
Pre-mining (Before 1955)	270477	*Natural*	*NPV-0*	78
Transition (1955-1960)	50876	*Transition*	*NPV-1*	78
Mining (1961-2003)	7661	*Degraded*	*NPV-2*	*78*
Post-mining (After 2003)	1380	*Degraded*	*NPV-3*	*78*
Total	330394		NPV_j	*312*

Source: Primary survey by author

The *NPV-1* is one replicate of the response variable. Here the households collect resources only for self-consumption. During this time the ecosystem was in a transition state. The state of ecosystem is neither in natural state nor is fully degraded during transition period. The amount of collectable resources available in the forest is just equal to the demand for it by the indigenous and other forest dependent people. So in this model the sum of net economic benefit of the communities are categorized as *NPV-1*.

In this analysis, *NPV-2* and *NPV-3* are taken as another replicates of the response variables. As discussed earlier, the households extracts resources from the forest only for self-consumption and not for sale in the market. In these case the ecosystems is degraded state. The periods with degraded state of ecosystems were mining and post mining period when production of resources was inadequate relative to demand conditions of the indigenous and other forest dependent communities. In fact people would have to spend more time inside the forest for extraction of required amount of resources. So in this model the sum of net economic benefit of the communities derived from forest are categorized as *NPV-2* and *NPV-3* for mining and post-mining period respectively.

Besides, the sum of net economic benefit of the communities derived from forest is also categorized as *NPV-4* to *NPV-11* (eight categories) in the model as shown in table 4.1. However, we did not get these types of *NPVs* in the sample. The reason is that none of the households were collecting firewood and other forest products to sell in the market. In fact no phenomenon like: (i) collection of firewood exclusively for sale in the market and (ii) collection of firewood for both sale and self-consumption were found in our sample. Also, we did not get any household exclusively purchasing firewood and other forest product from the market to be considered as a distinct household type. Therefore, only four replicates like *NPV-0* to *NPV-3* were explicitly taken in to account with a set of predictor variables for econometric analysis.

5.2 Predictor Variables

The detailed descriptive statistics of predictor variables are explained in the following sections.

Number of working Members (NWM)

Number of working members in Purnapani area includes members of the households who are working either to earn wages or are involved in self-employment activities. These members after their regular work extract resources from forest to supplement their livelihood. During pre-mining period the average number of working members per household was 3.5, which increased by 23 percent during transition period and declined by 28 percent both during mining and post-mining period relative to pre-mining period.

Amount of nuts collected from the forest (ANC)

Nuts like *char*, cashew nut, *kusum nut* and other wild nuts are collected by the forest dependent communities from the forest in Purnapani area. During pre-mining period the average amount of nuts collected by the households was 15.82 kilogram per annum, which declined by 85 percent during transition period, 89 percent during mining and 55 percent during post-mining period relative to pre-mining period. This declining trend of nuts in Purnapani area is because of degraded forest ecosystem due to mining activities.

Land owned by the households (LOH)

Land owned by the households in Purnapani area is consisting of high, medium and low land for agricultural purpose only. During pre-mining period the average amount of land owned by the households was 3.82 acres, which declined by 9 percent during transition period, 47 percent during mining and 27 percent during post-mining period relative to pre-mining period. This declining trend in Purnapani area is because of contribution of land for mining activities by the households.

Average time spend for earning wages (ATW)

Average time spend by the household for earning wages varies depending upon the amount of time devoted for extracting resources from the forest. During pre-mining period the average time spend by the household for earning wages was 6.96 hours per day, which increased by 3 percent during transition period and declined by 20 percent and 17 percent both during mining and post-mining period respectively relative to pre-mining period. During mining and post-mining period the average time spend for earning wages is declined because more time is devoted for extracting resources from forest relative to pre-mining and transition period. This is because during the latter two periods resource scarcity occurred due to degraded forest ecosystems and mining activities.

Table 5.2: Mean values of predictor variables (Mean ± SD)

Explanatory Variables	Pre-mining Period (Before 1955)	Transition Period (1955-1960)	Mining Period (1961-2003)	Post-mining period (After 2003)
NWM	3.5 ± 1.97	4.32 ± 2.37	2.53 ± 1.58	2.51 ± 1.51
ANC	15.82 ± 23.78	2.36 ± 6.85	1.71 ± 3.31	7.14 ± 13.60
LOH	3.82 ± 4.81	3.47 ± 4.89	2.02 ± 2.95	2.77 ± 5.37
ATW	6.96 ± 2.63	7.18 ± 2.44	5.54 ± 3.72	5.79 ± 3.6
ATS	5.01 ± 5.17	4.53 ± 4.10	4.13 ± 3.61	3.62 ± 3.29
DFF	0.26 ± 0.44	0.28 ± 0.45	0.26 ± 0.44	0.26 ± 0.44
DFF-1 (Freq.)	20	22	20	20
DFF-0 (Freq.)	58	56	58	58
PFL	0.14 ± 0.35	0.17 ± 0.38	0.22 ± 0.42	0.22 ± 0.42
PFL-1 (Freq.)	11	13	17	17
PFL-0 (Freq.)	67	65	61	61

Source: Primary survey by author

Average time spend in self-employment activities (ATS)

Similarly, average time spend by the house hold in self-employment activities varies depending upon the amount of time devoted for extracting resources from the forest. During pre-mining period the average time spend in self-employment activities was 5.01 hours per day, which declined by 10 percent during transition period, 18 percent during mining and 28 percent during post-mining period relative to pre-mining period. The declining trend of average time spend by the household in self employment activities is because of resource scarcity due to degraded forest ecosystems and mining activities.

Distance of the households from Forest (DFF)

Forest resources are more accessible for those households who are staying inside the forest than those who are staying outside the forest area. During transition period out of 78 households, 28 percent were staying inside the forest and some 72 percent were staying outside the forest area. However, during pre-mining, mining and post-mining periods, 26 percent households were staying inside the forest and some 74 percent were staying outside the forest area.

Possession of forestland by the household (PFL)

In Purnapani area households clear forest land for cultivation purpose. During pre-mining and transition period, 14 percent of households and 17 percent of households had possessed some amount of forestland where as the remaining 86 percent of households and 83 percent of household had not possessed any amount of forestland respectively. However, during both mining and post-mining periods, 22 percent of households had possessed some forestland where as the remaining 78 percent of households had not possessed any amount of forestland. During the latter two periods number of households possessing forest land is increased due to mining activities undertaken in their own land.

6. Estimation of the Resource Extraction Model

We categorize the NPV into 12 categories from 0 to 11 as discussed in table 4.1 and use multinomial logistic regression (MNLR) analysis to estimate the extraction model. The objective of using MNLR model is first, response variable is unordered categorical, second, multiple predictors are taken into account, third, this model is heteroscedasticity consistent (Aldrich & Nelson, 1984 and Mahapatra & Kant, 2005), and fourth, results of this model are found to be more informative and robust compared to the results of dichotomous logistic and ordinary least square (OLS) regression methods and it always provides more accurate results than the multinomial probit regression method (Hilbe,2009). The multinomial logistic model with j categories of response variable can be written as:

$$\ln\left[\frac{p(Y_i)}{p(Y_j)}\right] = \alpha_{i0} + \alpha_{i1}X_1 + \alpha_{i2}X_2 + \ldots + \alpha_{ik}X_k + \varepsilon_i \quad (6.1)$$

Where, *Y=NPV for j=0,1,2,3; Y_i= NPV-1, NPV-2 or NPV-3; and Y_j=NPV-0,* and X_1 to X_k are explanatory variables as given in the resource extraction model in eq.-5.1. As there are four categories of the response variable there will be three logits, *NPV-1/NPV-0, NPV-2/NPV-0 and NPV-3/NPV-0*. Thus, *NPV-0* is the base category with which other categories of NPV are to be compared.

7. Results and Discussion

The results of the MNLR model are given in table 7.1. The coefficient of predictor variables of the MNLR model represent the change in log odds associated with one unit change in the predictor variable. A positive coefficient of the variable increases the log odds, while a negative coefficient decreases it when other predictors are held constant. However, it is easy to interpret Relative Risk Ratio (RRR) rather than log odds. The base of natural log raised to the power equal to the magnitude of the coefficient denotes the factor by which the RRR change when the explanatory variable increases by one unit. For example the relative risk ratio (RRR) of the number of working members suggest that ceteris paribus with an increase in one number of the working member, the relative risk of NPV derived from forest during transition period relative to pre-mining period is likely to be increased significantly by 130 percent. However during post-mining period, the relative risk of NPV had declined relative to NPV of pre-mining period by 80 per cent with one number of increases in working member. However, the number of working member does not significantly affect (p-value=0.170) NPV during mining period relative to pre-mining period.

The number of working member is a significant predictor of net present value because the households of the community with more number of working member will access forest land more for extracting forest resources during transition period relative to pre-mining period. More access of forest land for extracting resources during transition relative to pre-mining period will bring higher level of community welfare through greater achievement of NPV. Because during transition period the forest was not degraded enough and forest ecosystems were producing adequate amount of resources required by demand of the local communities. However, during post-mining period forest degradation and degradation of ecosystem services due to abandoned mines and over burden dumping leads to scarcity of forest resources. So community welfare in terms of net present value is likely to be declined significantly during post-mining period relative to pre-mining period with one more increase in working member of the households of the communities.

The amount of nuts collected (ANC) is a significant predictor of net present value (NPV) derived from the forest by the communities. The relative risk ratio of amount of nuts collected from the forest suggest that with an increase in collection of one more kilogram of nuts, the relative risk of NPV derived from forest during transition, mining and post-mining period relative to pre-mining period is likely to be declined significantly by 91 percent, 89 percent and 97 percent respectively, keeping all other things constant. This is because during transition, mining and post-mining period, degradation of forest ecosystem services due to unsustainable mining activities and its abandonment leads to resource scarcity. Thus collection of nuts like resources from the forest during these periods were taking more time and effort so that its collection cost was comparatively higher leading to decline in NPV in relation to pre-mining period.

Distance from forest (DFF) does not affect NPV significantly during transition period relative to pre-mining period. However, other thing being given DFF is a significant predictor of NPV of the communities during mining and post-mining period relative to NPV of the communities during pre-mining period. The relative risk ratios of DFF suggest that community welfare in terms of NPV is likely to be increased more significantly by 226 percent during mining period and 219 percent during post-mining period relative to pre-mining period respectively for those households of the communities who were residing inside the forest relative to for those who were residing far away from the forest. Because, households residing inside the forest are more likely to access forest resources than those residing far away from forest even during mining and post-mining period relative to pre-mining period.

Table 7.1: Result of Multinomial Logistic Regression (*N=312*)

Equations	Variables	Coef.	Std. Err.	RRR	
NPV-1/NPV-0	NWM	0.2636072	0.1280726	1.301617	***
	ANC	-0.0988711	0.0199126	0.9058595	***
	DFF	0.228598	0.5898655	1.256837	
	LOH	-0.0466606	0.0394183	0.9544113	
	PFL	0.851138	1.194561	2.342311	*
	ATW	-0.05731	0.0708113	0.9443013	
	ATS	-0.0451046	0.0493016	0.9558975	
NPV-2/NPV-0	NWM	-0.1684638	0.1037504	0.8449619	
	ANC	-0.1185045	0.0243107	0.8882478	***
	DFF	0.8156886	1.109945	2.260732	*
	LOH	-0.1697529	0.049775	0.8438733	***
	PFL	1.032421	1.424252	2.807855	**
	ATW	-0.1771924	0.0583338	0.8376186	**
	ATS	-0.0057946	0.0540849	0.9942222	
NPV-3/NPV-0	NWM	-0.2261545	0.093528	0.7975949	*
	ANC	-0.031478	0.0115185	0.9690123	***
	DFF	0.7874738	1.037456	2.197837	*
	LOH	-0.0642497	0.0382294	0.9377708	
	PFL	0.7656221	1.019852	2.150332	*
	ATW	-0.1617158	0.0564632	0.8506829	**
	ATS	-0.0899027	0.0474214	0.9140201	*

*a) *** indicates sig. at 10%, ** indicates sig. at 5% and * indicates sig. at 1% level*
b) Out of total sample size (household) of 312, STATA 11 considered only 311household as valid observation and ignored remaining 1 household because of existence of missing values

Land owned by the household (LOH) does not affect NPV significantly during transition and post-mining period relative to pre-mining period. However, other thing being given LOH is a significant predictor of NPV of the communities during mining period relative to NPV of the communities during pre-mining period. The relative risk ratios of LOH suggest that community welfare in terms of NPV is likely to be decreased more significantly by 84 percent during mining period relative to pre-mining period if one more acre of land is owned by the household of the communities. Because, in order to own one more acre of land for agriculture[5], the household will have to clear one acre of forest land, which is leading to deforestation and further degradation of ecosystem services. Thus, NPV is likely to be declined significantly during mining period relative to pre-mining period due to degradation of ecosystem services leading to resource scarcity.

The possession of forest land (PFL) is a significant predictor of net present value (NPV) derived from the forest by the communities. The relative risk ratio of possession of forest land suggest that NPV derived from forest during transition, mining and post-mining period relative to pre-mining period is likely to be increased significantly by 234 percent, 281 percent and 215 percent respectively for those household who have possessed some amount of forest land relative to those who do not have possessed any amount of forest land, keeping all other things constant. This is because those household of the communities who have possessed some amount of forest land are more likely to access forest resources as it is available near to their land relative to those who do not possess it.

Average time one spend for earning wages (ATW) does not affect NPV significantly during transition period relative to pre-mining period. However, other thing being given ATW is a significant predictor of NPV of the communities during mining and post-mining period relative to NPV of the communities during pre-mining period. The relative risk ratios of ATW suggest that community welfare in terms of NPV is likely to be declined more significantly by 84 percent during mining period and 85 percent during post-mining period relative to pre-mining period respectively if one more hour is spent for earning wages by the members of the household. Because, more hours spend for earning wages leads to less availability of time for extracting resources from forest during mining and post-mining period relative to pre-mining period. Thus NPV is declined during these periods relative to pre-mining period.

Average time one spends in self-employment (ATS) does not predict NPV significantly during transition and mining period relative to pre-mining period. However, ATS is a significant determinant of NPV during post-mining period relative to pre-mining period. The relative risk ratio of ATS revealed that with one more hour of increasing average

[5] No sample household have purchased agricultural land from others.

time for self employment activities the NPV is more likely to decline significantly by 91 percent during post-mining period relative to pre-mining period, other things being given. Because, more hours spend in self-employment activities leads to less availability of time for extracting resources from forest during post-mining period relative to pre-mining period. Thus NPV is declined during this period relative to pre-mining period due to less amount of resource extraction from the forest.

8. Conclusion and Policy Recommendation

We measured the welfare of Purnapani forest dependent communities in terms of NPV. Our analysis explore that the community welfare derived from forest during transition period relative to pre-mining period was likely to be increased significantly with increasing working members in the family. During transition period the forest resource base was not degraded enough so that with more number of working people more resources were likely to be extracted leading to rise in community welfare. However keeping all other things constant during post-mining period, community welfare was declined significantly relative to pre-mining period with increases in working members in the family. During post-mining period unsustainable mining activities, over burden dump and degraded state of ecosystem services were leading to scarcity of resources in the forest. In spite of rising working members in the family collection of forest resources were not likely to be adequate due to it scarce availability.

Ceteris paribus the collection of nuts like resources from the forest during transition, mining and post-mining periods were taking more time and effort relative to pre-mining period. Thus, the opportunity cost of collection of nuts were relatively more likely to be higher than the opportunity cost of collection during pre-mining period leading to decline in community welfare.

Other things remaining constant the community welfare was likely to be increased more significantly during mining and post-mining period relative to pre-mining period respectively for those households who were residing inside the forest relative to for those who were residing far away from the forest. Households residing inside the forest were more likely to access forest resources than those residing far away from forest even during mining and post-mining period relative to pre-mining period so that they obtained a higher level of welfare.

Other things being given the community welfare was likely to be decreased more significantly during mining period relative to pre-mining period with increasing acres of land owned by the households. In order to own more acre of land for agriculture, the households were likely to clear forest land, which was leading to deforestation and further degradation of ecosystem services. Thus, community welfare was likely to be declined significantly during mining period relative to pre-mining period due to degradation of ecosystem services and resource scarcity.

The community welfare derived from forest during transition, mining and post-mining period relative to pre-mining period was likely to be increased significantly for those household who had possessed some amount of forest land relative to those who had not possessed any amount of forest land, other things being given. The households possessing some amount of forest land were more likely to access forest resources as it is available near to their land relative to those who do not possess it.

Other thing being given the community welfare was likely to be declined more significantly during mining and post-mining period relative to pre-mining period with spending more hours to earn wages by the members of the household. More hours of spending for earning wages were leading to less availability of time for extracting resources from forest during mining and post-mining period relative to pre-mining period so that welfare was likely to be declined.

Other things being given with spending more hour of average time for self employment activities, the community welfare was likely to be declined more significantly during post-mining period relative to pre-mining period. More hours of spending in self-employment activities resulted in less availability of time for extracting resources from forest during post-mining period relative to pre-mining period so that community welfare was more likely to be declined.

The community welfare-ecosystem nexus is much more important than profit making of any public or private enterprise contributing national economic growth through resource extraction activities like mining. Economic development should not be compromised in order to maintain ecosystem services, but there should always be a balance between economic development and conservation of ecosystem services. In Purnapani area the communities were more vulnerable during mining and post-mining period due to mine spoiled degraded ecosystems. However, this kind of vulnerability of the communities can be corrected through policy changes of adopting drastic and large-scale ecological restoration in the mine spoiled degraded site. Without large-scale ecological restoration it would be very difficult to save and protect forest dependent communities in Purnapani area. Being an integral part of the forest ecosystem, they become endangered species of the human genus. Through our research and analyses we suggest that the degraded land of Purnapani area should be restored back ecologically in order to bring the entire local forest ecosystem to natural or close to natural state. We also suggest that all the mine-spoiled area through out the country has to be identified and restored back ecologically. Again policy makers and planners should think seriously while giving mining lease either to government or private agencies and should ensure about maintenance of local forest ecosystem in natural or close to natural state.

9. Acknowledgment

The authors greatly acknowledge the Department of Biotechnology, Government of India for financial support to carry out this study through the project entitled, "Environmental Biotechnology Restoration Ecology" sanctioned to the Centre for Environmental Management of Degraded Ecosystem (CEMDE), University of Delhi. The authors are indebted to the logistic support provided by CEMDE for research and analysis and the logistic support provided by Purnapani Limestone and Dolomite Quarry (PL&DQ), Steel Authority of India (SAIL) to carry out the primary surveys.

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ANNEXURE

1. Mining Activity and Population Pressure

Population pressure in Purnapani area shows a rising trend since 1951. Because the mining activity attracted a large number of migrants, the population size increased, leading to an increasing trend of density of population. This trend put a lot of pressure on land and livelihood base over a period of time. Data available from the population census report shows that the total geographical area of Purnapani locality is 1552 hectares. During the pre-mining period (1951 census year) population size was 2603 and the density was very low with 168 persons per square kilometer (sq. km.). The 1991 census shows that the population size had more than three times to 8335 as compared to 1951 census figure.

Table A1: Mineral production and population pressure

Time Period	Mineral production (MP) (tones per period)	Population pressure (PP) (persons per sq. km)
Pre-mining (Before 1955)	0	168 (1951)
Transition (1955-1960)	18776	-
Mining (1961-2003)	16748174	271 (1961) 424 (1971) 500 (1981) 537 (1991) 499 (2001)
Post-mining (After 2003)	0	-

Note- years are given in the parentheses
Source: PL & DQ, Purnapani, Sundergarh District, Orissa
Various census reports of Census of India, Sundergarh District, Orissa

The density of population rose from 271 in 1961 to 424 in 1971 and further from 500 in 1981 and to 537 in 1991 per square km. The population density had increased to 499 per sq. km. during 2001 census year. The density of population of the study area has been higher than the population density of India and also the state of Orissa through out the mining period. In 1971, the density of population of India and Orissa were 177 and 142 respectively, while it was 424 per sq. km in Purnapani study area.

Similarly, in 2001, the population density of the study area was 499 as compared to population density of India being 324 and of Orissa being 236 per sq.km. This analysis shows that in Purnapani area, population pressure (in terms of density of population) increased up to a maximum of 34 percent during 2001 census year of the mining period. This population pressure was because of mining activities. Mining had attracted migrants by providing direct and indirect employment opportunities. Both mining activities and population pressure are associated with degradation of ecosystem. The detailed data on mineral production (MP) and population pressure (PP) is presented in table-A1.

2. Net Present Value

Table A2: Net Present Value

Time Period	Real Gross Economic Benefit (base year 2008) (in Rs.)	Total cost (in Rs.)	Net Economic Benefit (in Rs.)	NPV (ρ=4.3) (in Rs.)	NPV_j
Pre-mining	393676.6	123200	270476.6	270476.6	0
Transition	422440	152800	269640	50875.4717	1
Mining	312383.5	97200	215183.5	7660.50196	2
Post-mining	318571.5	113200	205371.5	1379.47097	3

3. Purnapani Limestone and Dolomite Quarry (PL&DQ)

The PL&DQ was started initially as a captive manual mine of Rourkela Steel Plant (RSP) of the Steel Authority of India (SAIL) to produce blast furnace, sintering and fertilizer grade of limestone. The mechanized mining and integrated crushing and screening plant were commissioned in 1965. The mining leasehold of 230.525 hectares of land was granted in 1960 for a period of 20 years and was renewed in 1980 for a period of 20 years. The deposit was linked to RSP as a flux source for iron making and had also been meeting requirements of other SAIL plants as per their demand from time to time. The data obtained from Mining Plan (1998) of PL & DQ focused that out of leased land of 230.525 hectares, 72 percent was being used for mining and the remaining 28 percent for non-mining purpose. The limestone deposit of this area belonged to the Birmitrapur stage of Gangapur series of middle Dharwarian age. The area was initially semi-arid land in which crops like paddy, bajra, maize, and mustard oil were cultivated.

4. Market Prices of forest product

Table A3: Market Price (at 2008 prices)

Forest Product	Price (Rs. Per Kg)
Fuel wood	2.5
Fruits	15
Nuts	100
Meat	100
Medicine	50
Gum	10
Timber	120
Mashroom	8
Sag	2
Mahula	15
Dori	10
Kendu	5
Char	15
Kushum	5