Mine over matter?
Health, wealth, and forests in a mining area of Orissa

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Abstract

Can mining serve as a pathway for economic development despite the environmental externalities? The co-occurrence of poor economic performance and natural resource abundance is an empirical regularity. The extensive literature on this 'resource curse' phenomenon at the national level generally finds that economic dependence on point resources such as minerals is associated with lower levels of economic growth and human welfare. Various explanations have been offered for this association, many related to trade, rent-seeking, and national political institutions. Our premise is that further insight can be obtained through consideration of the resource curse at the micro level, because of heterogeneity in institutions, natural resources and economic behaviors. We empirically test the resource curse at the household and village level in Orissa, India, using data from household surveys and secondary community statistics. Specifically, we examine the possibility that iron ore mining undermines welfare, as represented most fundamentally by health status, conditional on wage earnings. Clearly, mining workers could face occupational health issues from employment in the mine, but direct impacts on individuals are at least potentially compensated through wage differentials. Of greater concern are environmental health effects that occur through degradation of water quality, air quality, or forest resources that are central to the livelihoods of tribal populations in the mining belt. Identification of this environmental health effect requires controlling for the endogenous occupational health effect.

The data are from a stratified random sample of 600 households in twenty villages in the mining district of Keonjhar in Orissa. Detailed information on demography, labor allocation and employment, dependence on forest products, health, perceptions of change in local environment were elicited through the interviews. Using GIS, the household data were integrated with secondary spatial data on land cover, hydrology, and location of mines. This allowed us to construct multiple measures of exposure to iron ore mines and access to forest resources.

Bivariate analysis at the village level and econometric models at the household level demonstrate the multi-faceted nature of the relationships between mine exposure, forest resources and human welfare. While households closer to mines report higher income from wage employment and better access to infrastructure, they experience higher incidences of many illnesses, rank lower on indicators of human development and own less land and assets for agricultural production. They also derive fewer benefits from the forest, possibly an outcome of the degradation and reduced access to forest reported in villages closer to mines. Multivariate models suggest that the negative impact of mines on environmental health is robust to controls for occupational health and other socio-economic and environmental determinants.

This analysis remains timely because of on-going violent conflicts and concern over negative impacts on the welfare of rural populations in the mining areas of India, which is consistent with the notion of a resource curse. Thus, in addition to testing the resource curse at the micro scale, our analysis can inform the policy discourse over the expansion of the mining sector in Orissa.

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Introduction

Developing regions with large mineral deposits confront a challenge in striking the right balance between exploiting the mineral resources for economic prosperity and safeguarding environmental stability and social welfare. The state of Orissa in India faces this challenge as it embarks upon a major reform program with the mining sector taking center stage in the growth process. Most of Orissa's mineral deposits are in forests that are inhabited by tribal populations and harbor rich biodiversity. Mineral extraction therefore has disproportionately affected forest ecosystems and the forest dwelling population. However, the mineral sector is perceived to have failed to alleviate poverty for this population. Thus, the impact of mines upon natural ecosystems, biodiversity and tribal livelihoods has become a key concern and source of conflict in Orissa. This study profiles the forest dependent population that has been impacted by mines and evaluates the relationship between exposure to mining and available forest resources, benefits derived from the forest, and household welfare.

Mining activities around the world have been accompanied by land expropriation and environmental degradation that harm the livelihoods and health of local communities (Keenan et al 2002; Sosa 2000). Mining can acidify the soil and water, increase toxic chemical availability, and increase siltation of water and leaf surfaces. These effects in turn are known to decrease water availability, decrease plant growth, and as a result, decreased wildlife abundance and diversity (Ripley et al. 1996; Suri et al. 1996; Marchus 1997; Saxena et al. 2002; Rasmussen and Koroleva 2003). The cross-country empirical study by Sachs and Warner (1995) provides evidence of a link between natural resource abundance and poor economic growth, lending credibility to the 'resource curse' thesis (Auty 1993). However, this finding by itself does not reject the adoption of natural resource-based growth strategies. Rather, policy-makers should pursue strategies that are sensitive to issues of distribution, welfare and environment (Ross, 2001). Bulte et al. (2005) emphasize that institutional reform is necessary for resource-rich countries to escape the resource curse and achieve economic development. These issues have been recognized by the World Bank and incorporated in their model of technical and financial assistance to member countries aiming to develop the mining sector (World Bank 1998). Appropriate benefit-sharing mechanisms developed through consultation between all stakeholders are deemed indispensable for generating broad-based economic growth from mining activities (Hancock 2002).

In Orissa, the state government believes that the vast mineral reserves offer potential not only for overall economic growth, but also for creating local employment opportunities. Accordingly, plans are being developed to expand mining output threefold within the next five years.[2] The proposed plans have been criticized by environmentalists and social activists concerned about the potential loss of forests and displacement of villages as the mines increase in number and size of operation. This concern extends to private investors, as found in a recent Climate Investment Survey for Orissa. Political unrest between villagers and the state over the issue of displacement has increased recently. Insufficient attention to managing impacts on the environment and the social fabric observed in the past has reflected adversely on public support for reform and private investment needed for accelerating growth in the state.

To our knowledge, this study is the first systematic analysis of local environmental and social impacts of mines in India. The analysis combines information from household and community surveys, spatial data on land cover, location of mines and villages, and census data to examine the

[2] Presentation by Principal Secretary of Mines, Government of Orissa at the Action Planning Workshop on Growth and Environment in Orissa, Bhubaneswar, India, March 2006.

impact of iron ore mines on the forest resource and local livelihoods in Keonjhar District of Orissa. Our analysis suggests that mine location is positively correlated with local factory and industry jobs and proximity to infrastructure (e.g., bus-stops and all-weather roads). However, the location is also negatively correlated with forest benefits (e.g., major NTFP sold and forest products in diet) and various other measures of household welfare (e.g., health, education, cash income and production assets). The negative impact of mine exposure on health is robust to different measures of health, different econometric models, and to the inclusion of controls for occupational health as represented by employment in the mines. The subsequent sections of this paper describe the study area, the conceptual framework, the sampling procedure, data collection methods, the data and the detailed findings from the analyses.

Study Area

The state of Orissa lies along the eastern coast of India. Geologically, two thirds of Orissa is pre-cambrian rocks that are known to harbor many metallic and non metallic minerals. Besides large reserves of chromium, bauxite and manganese, Orissa has the largest reserve of superior quality hematite iron ore in the country (Sengupta 2005). The recorded forest area in Orissa in 2003 was 4.84 million hectares, which constituted 31.06% of the geographic area and ranked third in the country in terms of forest cover[3],[4]. However, in comparison with 1999[5], forest cover had decreased by almost a million hectares. The mining areas are in close proximity to the remnant forest. According to the Human Development Indicators for sixteen major Indian states in 2004, Orissa falls below the national average and ranks eleventh[6]. Per capita income in villages close to the forests is lower than the state average. Residents of these villages depend on forest products for consumption, medicinal use and income. Previous studies have shown that forest products provide 25 – 60% of total income in villages close to forests with large tribal populations (Mallik and Das, 2004; Bahuguna 2000).

Within the state of Orissa, Keonjhar district was selected for this study because of the concentration of iron ore mines in the Joda-Badabil mining belt (Figure 1). Mining for iron ore began in the 1950s, and some of the planned new mines fall in this district. The district had a relatively high percentage (42.7%) of forest cover in 1999 (Forest Survey of India 1999). But, in the two blocks selected for this study, analysis of the land cover data reveals that 13.4 square kilometers of vegetative cover were replaced by mining activity between 1989 and 2004. Although per capita income in the district is just above the state average, the district is ranked 24th among the thirty districts in Orissa according to the overall human development index[7].

Conceptual Framework

Mining in forested regions both directly reduces forest cover in areas of active mining and indirectly affects the quantity and quality of forests through pollution and potentially through changes in the local economy (e.g., in-migration for mining jobs, increased demand for fuelwood). This study was motivated in large part by concern over the impact of mining on the forest resource and the resulting indirect (and therefore often unrecognized and uncompensated)

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[3] Forest with canopy cover > 40% is classified as 'dense'and between 10-40 % is classified as 'open' forest. We consider all forest with > 10% canopy cover indicated by 'forest cover'.
[4] http://www.fsiorg.net/fsi2003/states/index.asp?state_code=21&state_name=Orissa accessed on October 30, 2006
[5] http://www.envfor.nic.in/fsi/sfr99/sfr.html accessed on October 30, 2006
[6] http://orissagov.nic.in/p&c/humandevelopment/index.html accessed on October 30, 2006
[7] http://orissagov.nic.in/p&c/humandevelopment/index.html accessed on October 30, 2006

impacts on forest dependent peoples. As shown in Figure 2, changes in the forest resource in turn affect the benefits that local people derive from the forest – i.e., forest use or forest dependence measured in terms of non-timber forest products (NTFPs) and watershed services (links A and D). Mining may also affect these forest benefits through other pathways, e.g., by drawing labor out of NTFP collection and into employment in the mines or by increasing incomes and thereby changing the demand for NTFPs (link B in Figure 2). On the other hand, pollution from mines could negatively affect health and therefore people's ability to collect NTFPs and their welfare. The ultimate result is a net effect on household welfare, conditioned by pre-determined characteristics of the household and its social environment (link C and E in Figure 2).

In this study, the two key explanatory factors or policy levers of interest are exposure to mining activity and extent and quality of the forest resource. The following sections describe the methodological approach to identifying the impact of these factors on the benefits that people derive from forests and their overall well-being. Information collected from household and community surveys, land cover from satellite images, GIS data on location of mines and villages, and secondary information from census data are combined to develop indicators for exposure to mines, stock and quality of forest resources, benefits derived from forest and household welfare. Measures of mine exposure and forest resources are calculated for each village, while variables reflecting forest benefits and welfare are constructed for each household. An array of bivariate tests is performed to establish how exposure to mines is linked to the forest resource, forest benefits and household welfare. Multivariate econometric models are specified and estimated to isolate the impact of mine exposure, controlling for other village and household characteristics (e.g., access to public infrastructure).

A key challenge is identifying appropriate measures of household welfare in this semi-subsistence economy. Cash income does not provide a complete picture of household welfare and is likely to overstate the benefits of mining. Full income is challenging to compute for households that produce and consume a vast array of goods, many of which are rarely traded in the market. Wealth (number and quality of assets) is a common alternative. In the context of Orissa, diversity and protein in the family diet and education of female children are potentially informative indicators. Health status is perhaps the most fundamental and least controversial measure of welfare. This could be measured as the cost of all illnesses (days unable to work, expenditures on health care, or the total cost of both of these) or as the incidence of particular illnesses with severe consequences or direct links to the mining industry (malaria, skin disease, respiratory infections). One possibility is that proximity to mines will be correlated with ill health only because both are related to employment in mines. The welfare implications and policy prescriptions for such occupational health issues are quite different from those for environmental health. Thus, it is important to separately identify these two possible impacts of iron ore mining on health and thus well-being of the local population.

Sampling Procedure and Data Collection

Two blocks were selected in Keonjhar district: Joda block, with a high concentration of mines, and Keonjhar Sadar block, which has no iron ore mines but is potentially affected by mining in neighboring blocks (Figure 1). All of the sample villages fall within the Peripheral Development Zone of 50km from the mining area. "Mine exposure" is defined as a function of distance to mines: villages closer to mines have higher exposure to mining activity. The ten sample villages in Joda are all within 4 kilometers of the closest iron ore mine, and all but two are less than 3.4 kilometers from a mine. The ten sample villages in Keonjhar Sadar are all more than 5 kilometers from the closest iron ore mine and all but two are more than 10 kilometers from a mine (Figure 3). While their exposure to mines is quite different, the villages in both blocks have access to significant forest area. For example, the time required to walk to the forest is not significantly different across the two blocks. Joda block did have somewhat more dense and open forest in 1989 (22.66% compared to 5.87% in Keonjhar Sadar).

The sample villages were selected systematically to ensure sufficient variation and representation of different social groups, especially scheduled castes and tribes. In each village, 30 households were selected at random and a detailed household questionnaire was administered. Basic information on each village was also assessed through a community survey.

The household questionnaire contains modules designed to elicit information on household access to public utilities, household perceptions of the impact of mines on the local environment, changes in dependence on forest products over a twenty year period, demography, current consumption and sale of forest products, agricultural activities, employment, asset ownership, health and participation in community activities. The community and household surveys were conducted by two teams comprising a supervisor and seven interviewers each. Key informant surveys at the community level were simultaneously conducted by field supervisors to gather information on the history of the village, history of mining around the village, prices of agricultural and forest products commonly consumed and traded by households in the village and the legal status of the forest that households collect products from.

Secondary data were collected from Census of India block level reports on village composition. Classified land cover information for the two sample blocks was obtained from Orissa Remote Sensing Application Agency for 1989 and 2004. The classification was performed on images recorded by the Indian Remote Sensing satellite (IRS). These classified images enabled identification of mining areas (including rock quarries, iron ore mines, and other mining activity), forests with varying canopy cover, agricultural land, water bodies, barren land, village settlements and urbanized areas. Additional GIS information was obtained on the locations of sample villages. Location of mining industries and hydrology information were digitized from paper maps that were obtained from the Orissa State Pollution Control Board.

Data Description

In order to evaluate the effects of mine exposure, key variables representing the different components of the conceptual framework were identified and constructed from the household surveys, community surveys, and GIS data. Tables 1, 3, 5, and 7 define the variables that represent exposure to mines, forest resource, forest benefits and household welfare.

In the absence of field-based measurements of pollution or secondary information on scale or history of mine operations, two distance-based measures of exposure of villages to mining activity are developed: (1) categorical variable indicating the location of the village in the “high” or “low” exposure blocks; and (2) Euclidean distance in kilometers from village to the nearest ion ore mine (distance to iron ore mine). The descriptive statistics for variables representing each component of the conceptual framework (Tables 2, 4, 6, 8, and 9) are designed to represent and test differences across high and low mine exposure and correlation with distance to mines. Table 2 shows that these two key indicators are correlated with other measures of mine exposure. Most of the variables in these tables are derived from the household survey, including village averages to represent forest resource conditions and indicators of forest benefits and welfares constructed from each household’s responses. Exceptions include (1) the extent of forest, constructed from GIS data on the location of villages and the land cover information, and (2) access to forest, which reflects information from the community survey.

Results

Bivariate Analyses

We first present descriptive statistics and bivariate analyses for four categories of variables indicating mine exposure, forest resource, forest benefits, and welfare. For each variable, statistics include the population-weighted mean (taking into account the different sizes of villages), the simple mean and standard deviation for the entire sample, the mean and standard deviation for the two blocks, and a correlation coefficient with distance to iron ore mines (Tables 2, 4, 6, 8, and 9). Results from two bivariate tests are also reported in these tables: a cross next to the variable name indicates that the block means are significantly different at the 5% level, and an asterix next to the correlation coefficient indicates a significant bivariate correlation with distance to iron ore mines at the 5% level. We focus on these variables that are significantly different across the two exposure categories (the two blocks) and/or significantly correlated with mine exposure.

Mine Exposure

Villages in Joda, by design, are significantly closer to mining areas (average distance being 1.99km in Joda and 12.68km for Keonjhar Sadar) and belong to the "high" mine exposure category, while villages in Keonjhar Sadar belong to the "low' mine exposure category. Other measures of mine exposure that are calculated either from the GIS information (distance to iron ore mine) or from the household survey support this exposure categorization. The count of the number of mining areas within 10km buffer zones around each village (number mines in 10k buffer) is significantly higher for Joda. 26% of households in Joda feel that mines pollute local water resources compared to 9% in Keonjhar Sadar (water pollution - mine); 80% of households in Joda blame mining for deforestation compared to 62% in Keonjhar Sadar (deforestation - mine). Mines also have benefits: 90% of Joda households report income benefits from mines compared to only 36% in Keonjhar Sadar (more employment - mine). Tables 1 and 2 also report household employment in mines. On average, 0.5 persons per household are employed as daily laborers in the mines (c.f. employment in agriculture, with 0.5 working on own and others' farms, 0.3 working as agricultural labor, and 0.3 working as sharecroppers). In Keonjhar Sadar, nearly 1 person per household is employed in the mines.

Forest Resource vs. Mine Exposure

Secondary land cover data provide measures of the stock of forest resources, i.e., the extent of forest cover in circular zones (buffers) around the villages. Indicators of forest quality are constructed based on all survey responses in a village, e.g., the number of different species collected from the forest or the number of different species observed in the past year by all respondents in a village. The average amount of forest in 2km buffers around each village (2004 percent forest around village), including 'dense' and 'open' forest with canopy cover greater than 10% from the landcover classifications for 2004, is not significantly different across the exposure levels. Villagers report that they have to walk 45 minutes on average to the nearest forest, with no statistically significant difference across the two blocks (distance to forest). These two measures suggest similar access to forest in the two blocks.

Villagers in Keonjhar Sadar report that they devote significantly more time to collecting NTFP (more time collecting NTFP) but they also collect a greater variety of forest products (percent of forest species collected). Villagers in Joda report a significantly higher number of elephant encounters (elephant encounters) but lower incidence of wildlife encounters in general (more wildlife observed). In general, there are a wide variety of patterns in wildlife observations across villages. The intermediate disturbance hypothesis offers one explanation for this variation. In undisturbed areas, wildlife are not observed because of the abundance of habitat provides cover.

In highly disturbed areas, wildlife is not observed because the scarcity of habitat causes species to exist in very low numbers or be locally extinct. At intermediate level of disturbance, species are present, but have less cover and need to move more to find suitable habitat, increasing sightings. Overall forest cover in Joda is greater than in Keonjhar Sadar, perhaps providing adequate habitat for most of the wildlife species, except elephants and other large mammals. Both forest stock and forest diversity proxied by (2004 percent forest around village) and (percent of forest species collected) are significantly correlated with distance to iron ore mines, with correlation coefficients of 0.25 and 0.68. These correlation coefficients indicate that both quantity and quality of forest increase with distance to iron ore mines. Tables 3 and 4 contain details of other variables that reflect measures or perceptions of change in forest condition.

Forest Benefits vs. Mine Exposure

Previous studies of NTFP dependence in Orissa report that collection and sale of NTFP provides 20 - 50% of household income per year (Mallik and Das 2004). In another study, Albers et al. (2004) found that NTFP contributed 15% to household cash income in Keonjhar. In our sample, 98% of the households collect some NTFP, while 32% of the households sell some NTFP. As shown in Tables 5 and 6, households on average collect 6 different NTFP and 20% of household labor is devoted to collection of forest product. While average cash income from agriculture is Rs. 663/year, average cash income from sale of forest products is Rs. 430/year. Households in Keonjhar Sadar are significantly higher collectors (forest product collection) and sellers of forest products (forest product sale). Similar pattern of dependence is observed considering only the five major NTFP (major NTFP collection) (Sal leaves, Sal seeds, Kendu leaves, Mahua flower and Tamarind) that are referred to in the literature as being most important in the livelihood of forest-dependent villages in India. They also make significantly more trips to collect forest products (collection trips). The contribution of forest products to daily diet is significantly higher for households in Keonjhar Sadar (contribution of forest product in diet). Overall, households further from mines obtain more direct benefits from forests compared to those living closer to the mines. The correlation coefficients for all these measures of forest benefits are positive and significant, indicating that benefits derived from forests are higher for villages further away from mines.

Welfare vs. Mine Exposure

Information from the household surveys is used to construct different measures of welfare, including a stated measure of changes in well-being, financial well-being (total cash income), ownership of physical assets (productive assets, land owned) and living conditions (number of rooms, construction material for house), and human capital (education, nutrition, and health). (See Tables 7 and 8.) Households in Keonjhar Sadar have higher cash income on average (total cash income). These households are significantly better off than the ones in Joda in terms of ownership of livestock assets (livestock asset), agricultural production assets (production asset) and land (dummy land owned). As mentioned before, education levels are higher for households in Keonjhar Sadar (adult education, girl child education). Separating the sources of income, wage income for households in Joda is higher than Keonjhar Sadar, most likely because of the employment benefits of nearby mines reported in Table 2. However, the difference is not statistically significant. Using size and quality of homes as indicators of living conditions, households in villages further from mines have larger homes (more rooms), though they are not always made of better construction material. The correlation coefficients for variables measuring physical assets and human capital with distance from mines are positive and significant, indicating higher asset holdings in villages further from mines.

Turning to the health variables, incidence of illness, expenditures on illness, and total cost of illness are all higher in Joda and negatively correlated with distance to mines, but none of these statistics are significant. However, households in Joda and households who live closer to mines do report significantly more days that household members are too ill to work.

Village and Household Characteristics

One potential concern with the bivariate results described above is that they may reflect factors other than mine exposure. The factors of greatest concern are village and household characteristics that are pre-determined and exogenous to mine exposure, but that are correlated with mine exposure, as defined by blocks or distance to iron ore mines. Tables 10 and 11 define and present descriptive statistics for key characteristics, including tests of difference in means across blocks and correlation with distance to iron ore mines. As expected due to their proximity to district administrative headquarters, villages in Keonjhar Sadar have better access to schools, health posts, markets and public drinking water facility. Villages in Joda have better access to all-weather roads, probably a result of road building for transport of mineral ores. Villages in Joda also report to receive more government assistance (External assistance) and have higher number of active community organizations. Education levels are significantly higher in Keonjhar Sadar, measured either using number of years of schooling of adult family members (adult education), or if adult members in the family could read newspapers (adult literacy) and maintain household accounts (adult numeracy). Villagers in Joda report higher employment in factories or as construction workers as a result of proximity to the mines. Reported cases of cough and cold are higher in Joda, while there is no significant difference in reported cases of malaria between the two blocks. No significant difference was observed across blocks in community based forest management efforts through Forest Protection Committees (FPC) or Forest User Groups (FUG) (Village level forest management organization). Tables 10 and 11 compare a much larger set of variables, including many potentially endogenous to mine exposure, across the two blocks.

Multivariate Results

Multivariate models of forest benefits and welfare outcomes are estimated to verify the impact of mine exposure suggested by the bivariate statistics presented in the previous section. Several measures of forest benefits and welfare outcomes are selected in order to best represent these multifaceted concepts. Variables representing forest benefits include indicators of income (proportion of cash income from forest), labor (collection trips), nutrition (contribution of forest product in diet) and key forest products (major NTFP collection). Variables for welfare are chosen to reflect financial, human, and physical capital: income (total cash income), production inputs (production assets), education (girl child education) and health (days ill per household member). The selected variables are uncorrelated with one another but correlated with a subset of variables in their categories that were not included in the multivariate regression. For each measure of forest benefits and household welfare, models are selected based on distribution of the dependent variable and regression diagnostics as summarized in Table 12.

For each of these models, summary of the estimation results from three specifications are presented in Table 13. All specifications include a common set of control variables, drawn from the exogenous village and household characteristics described above. The first specification (Model 1) is a reduced form estimation of the impact of mine exposure on forest benefits or welfare; this impact likely operates through mines' impact on forest as well as other pathways. The second specification (Model 2) estimates the impact of the forest resource (extent and quality) on forest benefits or welfare; the forest resource is likely to be partly but not entirely determined by mine exposure. The third specification (Model 3) tests whether mine exposure affects outcomes after controlling for the forest resource. The forest resource is represented by proxies for forest diversity (percent of forest species collected) and forest stock (2004 percent forest around village). In the results presented here, mine exposure is represented by distance to nearest iron ore mine (distance to iron ore mine). Specification checks using the categorical variable for block produce similar results in all but two models: the categorical variable is not significant in the regression on major NTFP collection and is significant in the regression on girl child education. Control variables selected for the final specification are adult education, Scheduled Tribe or Scheduled Caste, external assistance (dummy if household receives), household shock (dummy if household suffered in past year); village distances to (a) all-weather road, (b) market and (c) health post; and village level forest management organization.

Consider the model of "days ill" as an illustration of the analytical procedure. This is the total number of days that household members were not able to work due to illness, divided by household size. Conceptually, this is a very robust measure of welfare, because it is equally applicable to all households, unlike cash income (since many households are subsistence oriented), production assets (since the count may depend on the diversification of household activities), and education of female children (since not all households have girls). In contrast to those other welfare measures, this variable is a "bad": increasing levels of days ill indicate decreasing levels of welfare. Thus, the expected signs in this model are the opposite of other models. In the first specification, the mine exposure variable (distance to mine) has a negative and highly significant coefficient when combined only with the village control variables, indicating that reported days of illness increases as proximity to iron ore mines increases. In the second specification, the forest diversity variable is significantly negative, but the forest stock variable is statistically insignificant. When both the mine exposure and forest resource variables are included in the model, the exposure variable remains significantly negative but the forest diversity variable becomes insignificant. These results suggest that mine exposure impacts health partly through its impact on forest diversity and partly through other (possibly direct) pathways.

In general, the multivariate estimations are consistent with the bivariate results. Except for proportion of cash income from forest, other forest benefit variables significantly increase as distance to mines increase and the sign and significance of distance to mines remain unaffected when forest stock and diversity are controlled for. The estimated relationship between welfare and mine exposure is consistent across models, the most significant impact being that reported days of illness decrease and count of productive assets increase for households as they move further from the mines. Forest diversity has a consistent positive impact on forest benefits and on some of the welfare measures. However, in some models, the coefficient on forest stock is unexpectedly negative and significant. This may indicate that it is a poor proxy for village access to forest resource; for example, it could be that villages use forest in wider radius than 2 kilometers around the village including areas in neighboring districts and states for which landcover data are not available. Only in the case of the health indicator does the significance of forest diversity change when mine exposure is controlled for. Finally, two important measures of welfare (total cash and girl child education) appear to have little relationship to either mine exposure or forest quality, controlling for other village and household characteristics.

Among the household level control variables, adult education is an important determinant of household income. Villagers belonging to both Scheduled Tribes and Castes derive significant benefits from the forest, but the Scheduled Tribes rank low on welfare indicators. Among the village level characteristics, village level shocks are positively correlated with forest benefits, indicating a form of natural insurance that forests provide these villagers. A confounding result seems to be the negative relation between access to all-weather roads and household income. Variables for public infrastructure like access to school and health centers do not appear to have any discernible pattern.

To gain more insight from control variables, we present full model results for regressions on days ill. Table 14 reports the full models underlying Table 13. Few of the control variables are statistically significant. As expected, distance to health post has a positive correlation with days ill (except when forest cover is included, probably because of multicollinearity issues).

Scheduled tribe households report fewer days ill than other households. As noted before, exposure to mines is related to ill health, even after controlling for exogenous household and village characteristics. However, this could be because households close to mines take advantage of the employment opportunities and suffer from poor "occupational health." To control for this effect, the fourth model in Table 14 includes days worked in the mines. As expected, it is positively correlated with days ill, but the coefficient on distance to mines remains statistically significant and negative. Table 15 reports a slightly different model, with total days ill as the dependent variable and household size as a control variable. The specification also includes a dummy for whether or not anyone in the household works in the mines, rather than days employed in the mines. The results are similar and provide evidence that mines impact both occupational and environmental health.

Malaria is by far the most significant illness affecting the households in our sample, as shown in Table 9. Because mine operations alter water courses and create standing pools of water, they could be contributing to this problem. However, according to the bivariate statistics, households in Keonjhar Sadar actually lose more working days to malaria than households in Joda. The second model reported in Table 15 tests the effect of mine exposure on days ill with malaria, controlling for other household and village characteristics such as distance to surface water. Once we control for these other variables, we find that exposure to mines, either through proximity of residence or employment, increases the number of working days lost due to malaria. Among the control variables, perhaps the most surprising result is that diversity of diet is positively associated with days ill (total and malaria). Two possible explanations are that households seek to treat their illnesses with a greater diversity of diet, or that the production of a more diverse diet exposes households to more possible illnesses.

Conclusions

The cross-sectional nature of this study limits any definitive conclusions regarding the causal links between mine exposure, the forest resource, and household benefits derived from the forest and overall welfare. However, the combined bivariate and multivariate results are highly suggestive of relationships between the variables of policy interest (mine exposure and forest resource) and outcomes for the forest-dependent and mine-impacted population. Mines certainly bring some benefits, such as employment opportunities for the local population. Associated infrastructural development following establishment of mines improve village access to markets. Being located in remote areas, these villages most likely would have remained less accessible if mining operations had not been established close to them. However, the list of benefits from mines does not run long. Proximity to mines was found to reduce forest benefits, measured by collection of NTFP or contribution of forest products in the diet.

In terms of indicators of overall welfare, villages closer to mines have poorer health, education and production assets. These impacts are likely partly due to the impact of mines on forest quality. Proximity to mines is associated with reduced forest quality, as measured by the diversity of forest products available to village residents. More objective measures of pollution from mines and quality of the forest resource were not available for this study. However, our findings from available data do indicate the importance of benefit-sharing arrangements between the local communities, state and private industries. The villages closest to mines appear to bear a greater environmental cost. Thus, a compensation mechanism can and should be designed to ensure that the mining industry in Orissa becomes a sustainable engine of broad-based and equitable growth and not another example of the resource curse.

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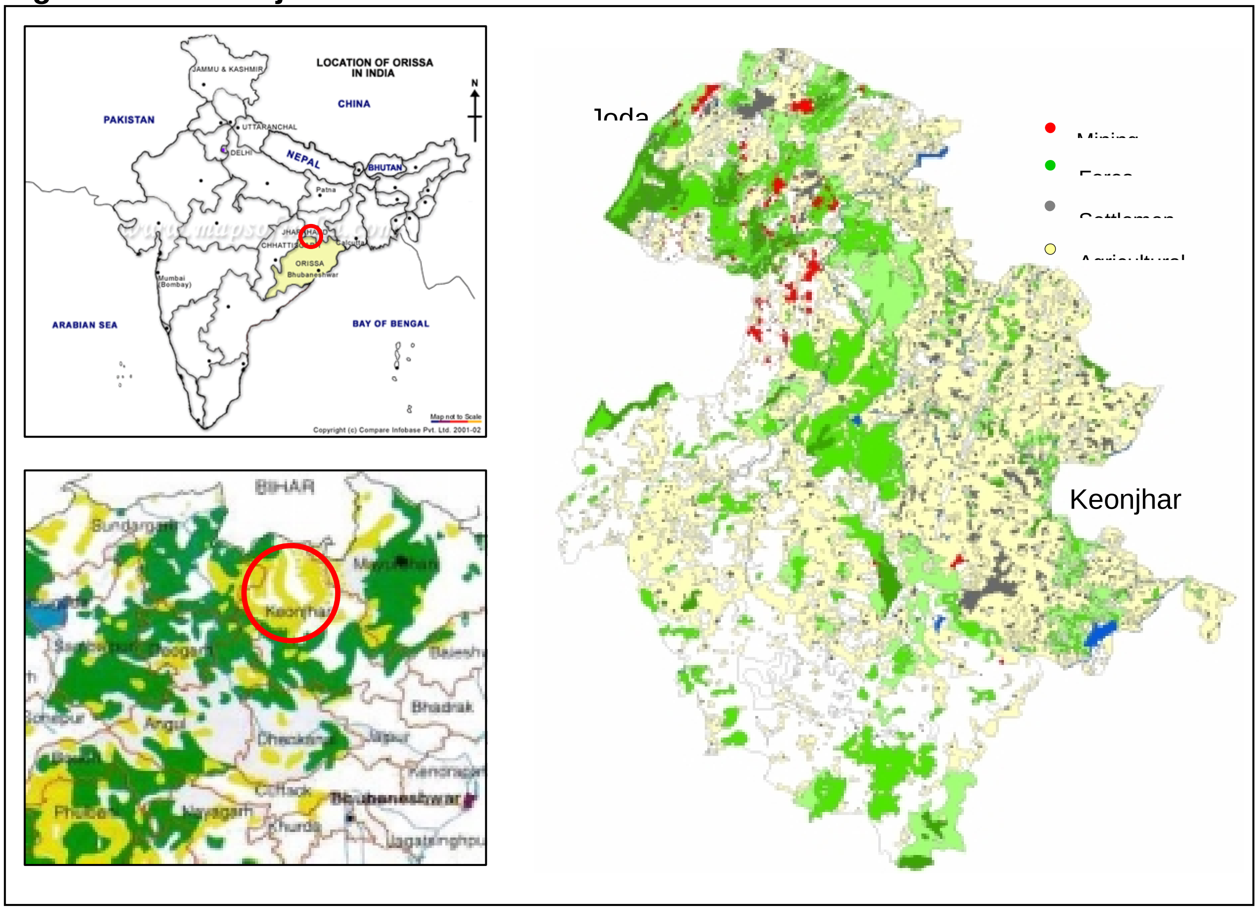
Figure 1. Keonjhar District and Location of Mines



Source: http://www.mapsofindia.com/maps/orissa/orissa-forest-map.gif (for the map of forest)

Figure 2. Conceptual Framework

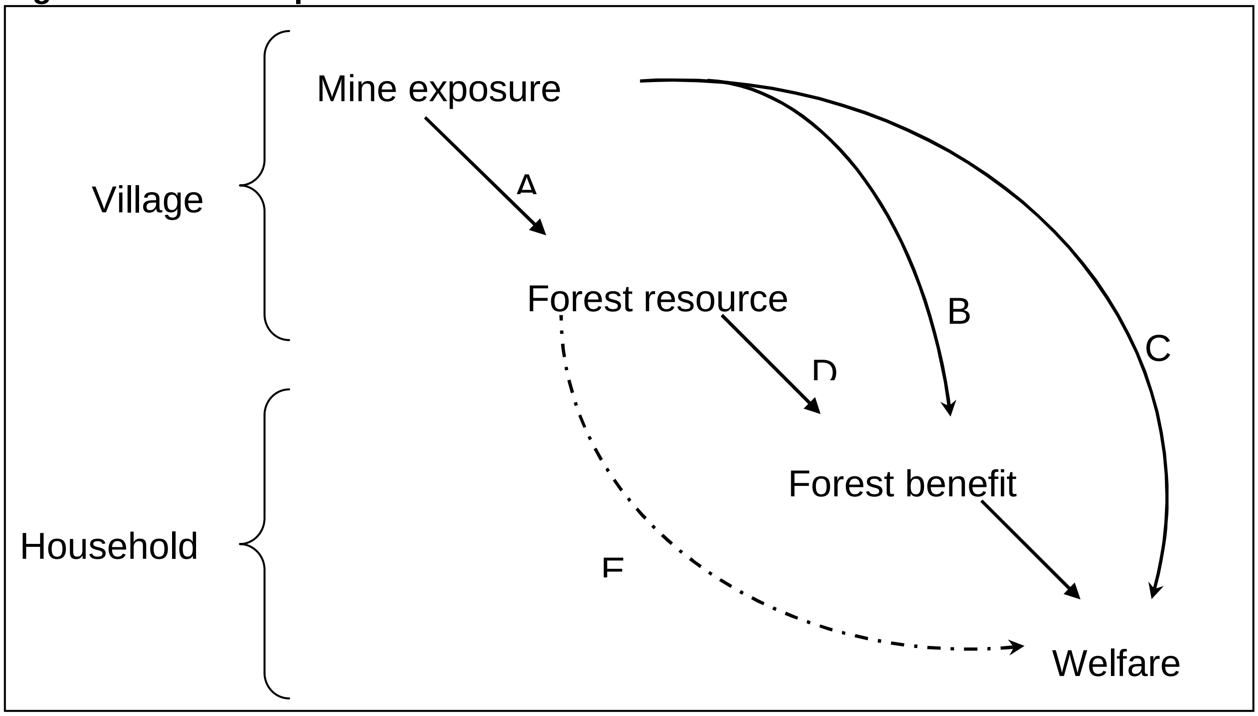


Figure 3. Sample Villages

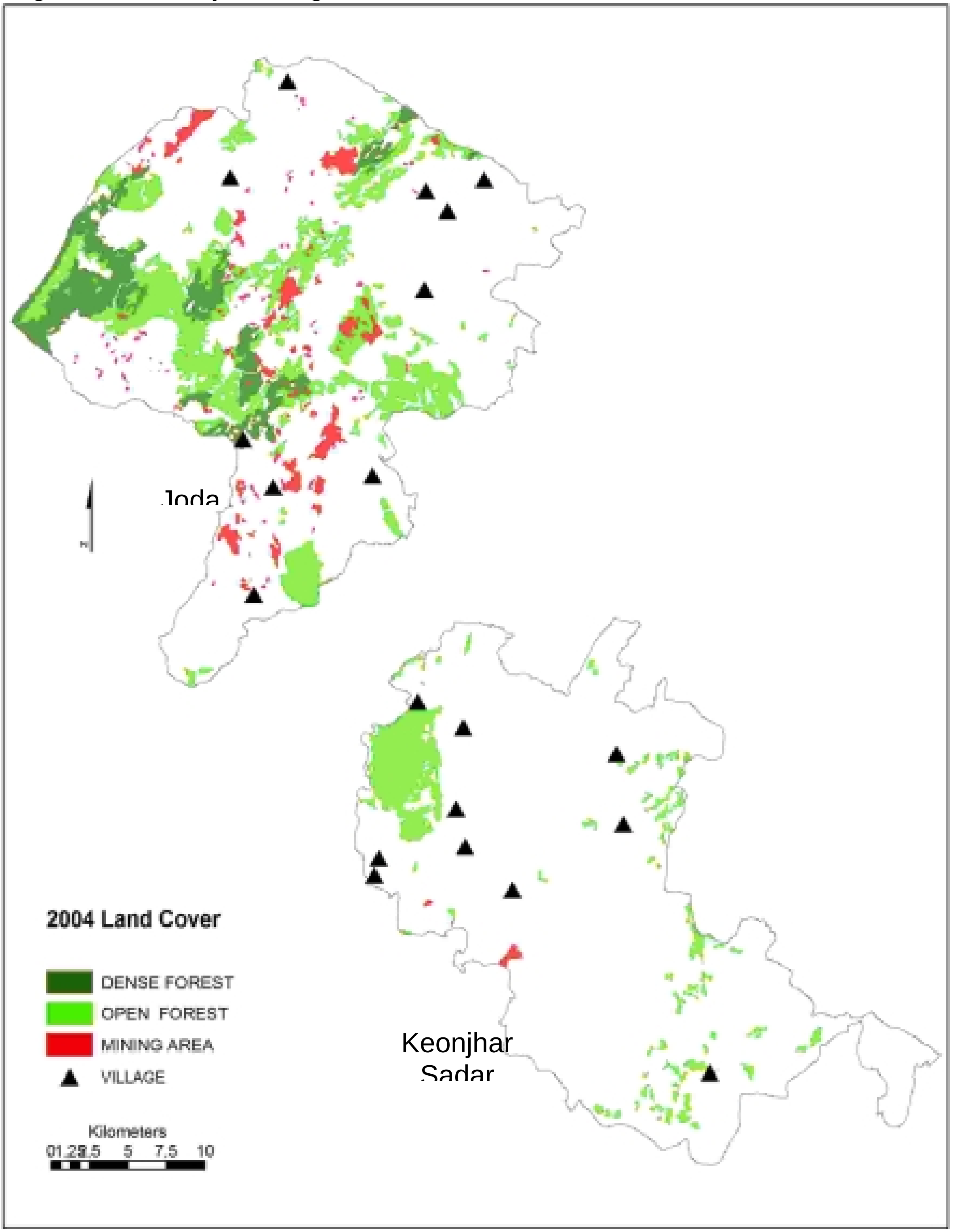


Table 1. Definitions of Mine Exposure Variables

Variable	Short Name	Description
Distance to iron ore mine	distiom	Euclidean distance from village to the nearest iron ore mine, using locations of mines as depicted in topo sheets
Downstream from mines	upstream	Indicator of villages that are located downstream from mining areas, 1 = mine is upstream from village, 0 = no mine upstream from villages
Number mines in 10k buffer	noma10k	number of distinct mining areas, including rock quarries and iron ore mines, in a 10k buffer around village
Proportionate area in mines in 2k buffer	mine042k	Percentage of land in mining areas in a 2K buffer around each village; calculated from the GIS data on village locations and landcover, as provided by Verve Consulting
Distance to mining areas	distma	Euclidean distance from village to the nearest mining area, calculated by NCSU from GIS data on village locations and landcover, as provided by Verve Consulting
Number of industries in 2k buffer	indus2k	Count of steel, sponge iron, and pig iron industries in a 2 km buffer around village, using mining industry map from Zoning Atlas
Number of industries in 5k buffer	indus5k	Count of steel, sponge iron, and pig iron industries in a 5 km buffer around village, using mining industry map from Zoning Atlas
Air pollution	airpoll	Air pollution biggest environmental problem; count of 'yes' responses by the respondents in each village
Water pollution	watpoll	Water pollution biggest environmental problem; count of 'yes' responses by the respondents in each village
Forest loss	forloss	Loss of forest biggest environmental problem; count of 'yes' responses by the respondents in each village
Aware of mines	awareMN	Aware of mining activity; count of 'yes' responses by the respondents in each village
Deforestation - mine	MNdefor	Impacts of mines on environment - caused deforestation; count of 'yes' responses by the respondents in each village
Poor water quality - mine	MNwatqly	Impacts of mines on environment - reduced quality of water in streams; count of 'yes' responses by the respondents in each village
Poor irrigation - mine	MNirrig	Impacts of mines on environment - reduced irrigation; count of 'yes' responses by the respondents in each village

Variable	Short Name	Description
More air pollution - mine	MNairpoll	Impacts of mines on environment - caused air pollution; count of 'yes' responses by the respondents in each village
More income - mine	MNhhdinc	Impacts of mines on living condition - increased household income; count of 'yes' responses by the respondents in each village
Poor health - mine	MNhealth	Impacts of mines on living condition - increased health problems; count of 'yes' responses by the respondents in each village
Forest loss - mine	MNnegfor	Impacts of mines on living condition - negatively impacted forest; count of 'yes' responses by the respondents in each village
Improved roads - mine	MNroads	Impacts of mines on living condition - improved roads; count of 'yes' responses by the respondents in each village
Employment in mines	MNemploy	Number of people among the sample households in each village having employment in factory or as construction worker
Daily worker in mines	EmployMine	Number of household members working as daily laborers in mines
Days worked in mines	Daysworkmine	Total number of days worked by household members in mines

Table 2. Descriptive Statistics of Mine Exposure Variables

Variable	Sample				Joda		Keonjhar		Correlation with distance to iron ore mines
	Mean	SD	Min	Max	Mean	SD	Mean	SD	
Distance to iron ore mines†	7.33	6.26	0.21	20.92	1.99	1.32	12.68	4.20	1
Downstream from mine	0.4	0.5	0	1	0.6	0.52	0.2	0.42	-0.49
Number mines in 10k buffer†	24.45	28.26	0.00	90.00	47.40	22.63	1.50	1.72	-0.751*
Proportionate area in mines in 2k buffer	0.01	0.03	0.00	0.15	0.02	0.05	0.00	0.00	-0.361
Distance to mining areas†	5.01	4.58	0.11	13.98	1.80	1.39	8.22	4.40	0.931*
Number of industries in 2k buffer	0.05	0.22	0.00	1.00	0.10	0.32	0.00	0.00	-0.224
Number of industries in 5k buffer	0.40	0.99	0.00	4.00	0.50	1.27	0.30	0.67	-0.128
Air pollution	12.80	4.71	5.00	21.00	13.50	4.17	12.10	5.32	-0.092
Water pollution – mine†	5.40	4.12	0.00	13.00	8.00	3.37	2.80	3.08	-0.59*
Forest loss	3.30	2.05	0.00	7.00	2.50	1.72	4.10	2.13	0.31
Aware of mines	28.25	2.97	20.00	30.00	29.50	1.58	27.00	3.56	-0.374
Deforestation – mine†	21.30	5.04	12.00	29.00	23.90	4.04	18.70	4.72	-0.527*
Poor water quality – mine	2.85	2.48	0.00	9.00	2.20	1.48	3.50	3.14	0.132
Poor irrigation – mine	3.95	2.39	0.00	8.00	4.20	2.15	3.70	2.71	0.192
More air pollution – mine	7.15	4.93	0.00	18.00	7.60	4.72	6.70	5.36	-0.065
More income – mine	16.50	4.85	8.00	25.00	18.50	4.22	14.50	4.79	-0.371
Poor health – mine†	10.55	4.95	2.00	21.00	7.80	2.78	13.30	5.21	0.479*
Forest loss – mine	1.20	1.20	0.00	3.00	1.60	1.35	0.80	0.92	0.702*
Improved roads – mine†	9.15	4.27	3.00	17.00	5.90	2.38	12.40	3.06	-0.384
Employment in mines†	18.95	11.51	0.00	40.00	27.10	8.50	10.80	7.73	-0.712*
Daily worker in mines†	0.5	0.7	0.0	5.0	0.8	0.8	0.2	0.5	-0.06
Days worked in mines†	115.5	166.5	0.0	1230	182.8	170.4	48.17	131.62	-0.335*

† Test for equality of block means is significant at the 5% level.

* Significant at the 5% level.

Table 3. Definitions of Forest Resource Variables

Name	Variable Name in Database	Variable Description
Distance to Forest	dforva	Average distance to the nearest forest in minutes, as reported by village residents.
Environmental Problem – Deforestation	eprobfor	Percent of village residents who agreed that deforestation is the biggest environmental problem.
Environmental Problem – Wildlife Loss	eprobwlf	Villager opinion that loss of wildlife is the biggest environmental problem.
Elephant Encounters	elephva	Average number of times elephants were observed in the past year by respondents in the village.
Observed Wildlife Species	wildvc	Of the twenty-five species of interest, the number of species observed by at least one household in the village in the past year, reported as a percent
Forest Species Collected	specsva	Average of the number of forest species collected by sample households in each village
Percent of Forest Species Collected	pctspecsva	Average of the number of forest species collected by sample households in each village normalized by total number of species listed in household questionnaire (48)
Count of Forest Species Collected	specsvc	Number of forest species harvested by at least one household in the village
Percent Count of Forest Species Collected	pctspecsvc	Of the 48 species harvested in this region, the percent that were harvested by at least one household in the village in the past year
Increased Distance to Forest	walkforw	Percent of village respondents who indicated that it takes longer to walk to the nearest forest now as compared to 20 years ago.
Degraded Forest Quality	forqualw	Villager opinion that the forest is lighter(degraded) compared to 20 years ago
Less Time Collecting Fuelwood	fwtimeb	Villager opinion that it takes less time for their family to collect fuelwood than 20 years ago
Less Time Collecting NTFP	ntfptb	Villager opinion that it takes less time to collect a load of NTFPs than 20 years ago
Less Wildlife Observed	wildw	Villager opinion that they encounter less wild animals than 20 years ago
Decreased Distance to Forest	walkforb	Villager opinion that it takes less time to walk to the nearest forest than 20 years ago
Improved Forest Quality	forqualb	Villager opinion that the forest is denser(better quality) compared to 20 years ago

Name	Variable Name in Database	Variable Description
More Time Collecting Fuelwood	fueltw	Villager opinion that it takes more time for their family to collect fuelwood than 20 years ago
More Time Collecting NTFP	ntfptw	Villager opinion that it takes more time to collect a load of NTFPs than 20 years ago
More Wildlife Observed	wildb	Villager opinion that they encounter more wild animals than 20 years ago
2004 Percent Forest Around Village	for042K	Percent of land classified in 2004 as open or dense forest within a 2km radius of the village
2004 Percent Wildland Around Village	wild042K	Percent of land classified in 2004 as dense forest, open forest, degraded forest, forest plantation, scrub forest, or land with scrub within a 2km radius of the village
2004 Percent Mining Area Around Village	mine042K	Percent of land classified in 2004 as mining area within a 2km radius of the village
1989 Percent Forest Around Village	mine892K	Percent of land classified in 1989 as open or dense forest within a 2km radius of the village
1989 Percent Wildland Around Village	for892K	Percent of land classified in 1989 as dense forest, open forest, degraded forest, forest plantation, scrub forest, or land with scrub within a 2km radius of the village
1989 Percent Mining Area Around Village	wild892K	Percent of land classified in 1989 as mining area within a 2km radius of the village
Have Revenue Forest	revforv	According to community survey, village has a revenue forest
Have Reserve Forest	resforv	According to community survey, village has a reserve forest
Have Village Forest	vilforv	According to community survey, village has a village forest

Table 4. Descriptive Statistics of Forest Resource Variables

Variable	Sample				Joda		Keonjhar		Population weighted mean	Correlation with distance to iron ore mines
	Mean	SD	Min	Max	Mean	SD	Mean	SD		
Distance to Forest	44.77	27.04	8	109	43.23	18.23	46.32	34.72	43.46	-0.184*
Environmental Problem – Deforestation†	3.30	2.05	0	7	2.50	1.72	4.10	2.13	3.57	0.305*
Environmental Problem – Wildlife Loss	0.15	0.49	0	2	0.30	0.67	0.00	0.00	0.20	-0.279*
Elephant Encounters†	12.29	8.02	3	36	17.22	7.41	7.36	5.17	12.42	-0.545*
Observed Wildlife Species	21.35	2.37	18	25	20.40	2.17	22.30	2.26	21.70	0.404*
Forest Species Collected†	5.43	2.63	2	11	3.76	1.16	7.09	2.65	5.68	0.673*
Percent of Forest Species Collected†	0.11	0.05	0.05	0.23	0.08	0.02	0.15	0.06	0.12	0.673*
Count of Forest Species Collected†	25.35	8.25	9	38	20.90	6.72	29.80	7.39	25.93	0.643*
Percent Count of Forest Species Collected†	0.53	0.17	0.19	0.79	0.44	0.14	0.62	0.15	0.54	0.643*
Increased Distance to Forest	27.85	2.83	22	30	27.60	2.80	28.10	3.00	27.49	-0.081*
Degraded Forest Quality	29.10	1.74	23	30	28.90	2.28	29.30	1.06	29.02	0.127*
Less Time Collecting Fuelwood	1.95	1.96	0	6	1.50	1.84	2.40	2.07	2.00	0.223*
Less Time Collecting NTFP	3.10	3.06	0	12	2.40	2.50	3.80	3.52	3.49	0.103*
Less Wildlife Observed	26.40	3.27	19	30	27.50	2.22	25.30	3.86	26.04	-0.275*
Decreased Distance to Forest	0.75	1.48	0	5	0.50	0.97	1.00	1.89	1.07	0.059
Improved Forest Quality	0.20	0.62	0	2	0.00	0.00	0.40	0.84	0.36	0.165*
More Time Collecting Fuelwood	27.25	2.61	20	30	27.20	3.29	27.30	1.89	27.24	-0.057

Variable	Sample				Joda		Keonjhar		Population weighted mean	Correlation with distance to iron ore mines
	Mean	SD	Min	Max	Mean	SD	Mean	SD		
More Time Collecting NTFP†	10.30	6.43	1	19	6.90	5.59	13.70	5.52	10.72	0.618*
More Wildlife Observed†	3.25	3.24	0	11	1.80	1.62	4.70	3.86	3.57	0.367*
2004 Percent Forest Around Village	0.06	0.13	0.00	0.50	0.06	0.16	0.06	0.10	0.06	0.149*
2004 Percent Wildland Around Village	0.39	0.24	0.01	0.86	0.44	0.21	0.34	0.27	0.42	-0.089*
2004 Percent Mining Area Around Village	0.01	0.03	0.00	0.15	0.02	0.05	0.00	0.00	0.01	-0.361*
1989 Percent Forest Around Village	0.01	0.02	0.00	0.07	0.01	0.02	0.00	0.00	0.01	-0.415*
1989 Percent Wildland Around Village	0.07	0.12	0.00	0.50	0.06	0.16	0.09	0.09	0.09	0.107*
1989 Percent Mining Area Around Village	0.41	0.26	0.02	0.86	0.48	0.21	0.34	0.29	0.45	-0.142*
Have Revenue Forest	0.10	0.31	0	1	0.10	0.32	0.10	0.32	0.11	-0.028
Have Reserve Forest	0.40	0.50	0	1	0.20	0.42	0.60	0.52	0.33	0.364*
Have Village Forest†	0.55	0.51	1	1	0.90	0.32	0.20	0.42	0.55	-0.557*

† Test for equality of block means is significant at the 5% level.

* Significant at the 5% level.

Table 5. Definitions of Forest Benefit Variables

Name	Variable Name in Database	Variable Description
Cash income from forest	forcash	Cash income from sale of forest products + sale of timber + sale of NTFP + sale of items made from forest products
Proportion of cash income from forest	fortotcash	Cash income from forest/ total cash income
NTFP collection	countntfpcol + countfpcol	number of NTFP collected
Forest product collection	countallpdtcol	Count of all forest products collected
NTFP sale	countntfpsold + countfpsold	number of NTFP sold
Forest products sale	countallpdtsold	Count of products sold
Collection trips	tottripcol	Number of trips made last year
Labor forest collection	laborforyr	Total time spent by household members in a year on forest product collection
Contribution of forest product in diet	countfpdiet	The number of instances that consumption of edible oil, meat, vegetables, fruits, spices were collected from forest
Major ntfp collection	big5ntfp	The number of major NTFP (kendu, sal seeds, sal leaves, mahua flower, and tamarind) that a household collects

Table 6. Descriptive Statistics of Forest Benefit Variables

Variable	Sample				Joda		Keonjhar		Population weighted mean	Correlation with distance to iron ore mines
	Mean	SD	Min	Max	Mean	SD	Mean	SD		
Cash income from forest†	379.33	1670.37	0.00	26980.00	138.90	1086.61	619.76	2071.92	419.72	0.155*
Proportion of cash income from forest†	0.02	0.07	0.00	0.73	0.01	0.04	0.03	0.08	0.02	0.163*
NTFP collection†	4.82	3.75	0.00	19.00	3.45	2.69	6.19	4.14	4.71	0.19*
Forest product collection†	5.49	4.38	0.00	22.00	3.76	2.90	7.21	4.90	5.32	0.401*
NTFP sale	0.08	0.53	0.00	8.00	0.06	0.57	0.10	0.49	0.09	0.02
Forest products sale†	0.52	1.19	0.00	9.00	0.20	0.78	0.85	1.41	0.61	0.19*
Collection trips†	128.77	103.21	0.00	816.00	94.97	79.05	162.58	113.13	126.05	0.337*
Labor for forest collection	0.03	0.06	0.00	0.56	0.03	0.07	0.03	0.05	0.03	0.013
Contribution of forest product in diet†	1.48	0.81	0.00	4.00	1.09	0.50	1.88	0.86	1.42	0.447*
Major ntfp collection†	1.02	1.15	0.00	5.00	0.66	0.86	1.38	1.28	1.00	0.319*

† Test for equality of block means is significant at the 5% level.

* Significant at the 5% level.

Table 7. Definitions of Welfare Variables

Variable	Short Name	Description
Better quality of life	blife	Quality of life reported to be BETTER today than 20 years ago
Number of rooms	V1635	Number of rooms used for sleeping & living
Poor quality of house	badhouse	Use 2 or more poor quality materials for floor, walls, roof
Livestock asset	lstockasset	Weighted count of livestock holding
Production asset	cprodasset	Count of the different types of productive assets owned by household
Consumption asset	cconasset	Count of the different types of consumptive assets owned by household
Land owned	landown	Number of acres of land owned by Hhd
Dummy land owned	dlandown	"1" if household owns land, "0" if household owns no land
Total cash income	totcash	Cash income from forest + income from fruit + income from livestock + income from livestock products + income from agriculture + income from wage + remittance + income from govt/ NGO assistance
Dummy savings	dsavmonth	"1" if household had any savings last month, "0" if household had no savings last month
Protein consumption	countprotein	"1" if milk and meat were consumed by household in past week
Girl child education	pctgirlschool	% of female children aged 6-18 who go to school (note 316 hhs do not have female children)
Incidence of illness	countill	Count of family members who reported malaria, skin disease and other illness
Expenditures on illness	exphealth	Expenditure incurred by the family to treat malaria, skin disease and other illness
Days ill	daysill	Number of working days that all family members lost due to all illness (and to individual illnesses) divided by household size
Cost of illness	coi	Todaysill * average wage for household plus total healthcare expenditures

Table 8. Descriptive Statistics of Welfare Variables

	Sample				Joda		Keonjhar		Population weighted mean	Correlation with distance to iron ore mines
Variable	Mean	SD	Min	Max	Mean	SD	Mean	SD		
Better quality of life[†]	0.9	0.4	0.0	1.0	0.8	0.4	0.9	0.3	0.7	0.136*
Number of rooms	2.7	1.5	1.0	11.0	2.6	1.4	2.8	1.6	2.4	0.081*
Poor quality of house	0.8	0.4	0.0	1.0	0.8	0.4	0.8	0.4	0.7	-0.016
Livestock asset[†]	2.3	2.6	0.0	16.3	1.5	2.1	3.1	2.7	2.0	0.302*
Production asset[†]	2.4	1.2	0.0	7.0	1.9	0.8	2.9	1.2	2.1	0.431*
Consumption asset	4.5	3.2	0.0	18.0	4.6	3.4	4.4	3.0	4.0	-0.006
Land owned[†]	1.3	2.7	0.0	30.0	0.9	2.3	1.6	2.9	1.1	0.134*
Dummy land owned[†]	0.6	0.5	0.0	1.0	0.3	0.5	0.8	0.4	0.4	0.35*
Total cash income[†]	23464	21632	0	221200	21623	14408	25305	26890	20047	0.110*
Dummy savings	0.1	0.4	0.0	1.0	0.1	0.3	0.2	0.4	0.1	0.021
Protein consumption	0.7	0.7	0.0	2.0	0.7	0.6	0.7	0.7	0.6	-0.017
Adult education[†]	26.5	31.6	0.0	100.0	20.0	28.7	33.1	33.0	22.6	0.193*
Girl child education	0.5	0.5	0.0	2.0	0.5	0.5	0.5	0.5	0.8	0.046
Incidence of illness	3.72	2.36	0	19.0	4.00	2.33	3.45	2.36	3.8	-0.103
Expenditures on illness[†]	1278.5	2167.5	0	20350	1306.1	1711.4	1250.9	2545.8	1285.68	-0.001
Days ill[†]	31.6	31.8	0.0	246.0	37.7	35.6	25.5	26.2	27.4	-0.159*
Cost of illness	2856.5	3192.12	0	22100	3189.4	3127.7	2523.6	3226.2	2984.7	-0.03

Test for equality of block means is significant at the 5% level.

* Significant at the 5% level.

Table 9. Descriptive Statistics of Disaggregated Health Variables

Variable	Sample				Joda		Keonjhar		Population weighted mean
	Mean	SD	Min	Max	Mean	SD	Mean	SD	
Incidence of Illness									
ARI*	1.0	1.2	0	6	1.2	1.3	0.8	1.2	1.0
Stomach problems*	0.4	0.7	0	5	0.5	0.7	0.4	0.7	0.5
Typhoid	0.1	0.4	0	3	0.1	0.4	0.1	0.3	0.1
Child birth	0.0	0.1	0	1	0.0	0.1	0.0	0.1	0.0
Blood pressure	0.0	0.2	0	2	0.0	0.2	0.0	0.2	0.0
Fever*	0.2	0.6	0	6	0.3	0.7	0.1	0.6	0.2
Tuberculosis	0.0	0.2	0	1	0.0	0.2	0.0	0.2	0.0
Malaria*	1.6	1.4	0	10	1.5	1.2	1.8	1.6	1.6
Skin disease*	0.3	0.6	0	5	0.3	0.7	0.2	0.5	0.3
Expenditure on Treatment for Illness									
ARI	143.8	450.3	0	8750	158.5	287.0	129.0	568.8	146.1
Stomach problems	70.1	244.0	0	3000	67.3	152.8	72.9	309.7	87.2
Typhoid	88.0	399.6	0	5000	81.8	275.2	94.2	494.3	80.1
Child birth	6.8	108.7	0	2500	2.0	34.6	11.7	149.8	3.9
Blood pressure	14.8	151.0	0	3000	16.0	181.0	13.6	113.7	10.4
Fever*	57.4	211.4	0	2000	87.7	240.4	27.2	172.8	62.4
Tuberculosis	29.9	224.5	0	3000	39.8	253.3	19.9	191.4	34.0
Malaria*	544.4	1110.1	0	17350	678.5	1349.0	410.2	782.9	557.2
Skin disease	42.1	232.3	0	5000	41.1	112.0	43.1	309.1	42.8
Total expense	1278.5	2167.5	0	20350	1306.1	1711.4	1250.9	2545.8	1285.68
Working Days Lost due to Illness									
ARI	4.8	9.8	0	90	5.5	9.0	4.0	10.6	5.1

Stomach problems	2.5	7.0	0	99	2.8	5.6	2.3	8.2	2.8
Typhoid	1.9	6.7	0	60	2.4	7.4	1.3	5.8	2.0
Child birth	0.0	0.5	0	10	0.0	0.1	0.1	0.8	0.0
Blood pressure	0.4	4.3	0	90	0.5	5.3	0.3	2.9	0.3
Fever*	1.9	7.5	0	100	2.7	9.2	1.0	5.3	2.1
Tuberculosis	0.7	5.3	0	60	0.9	5.9	0.5	4.6	0.9
Malaria*	16.0	17.4	0	160	19.5	19.6	12.5	13.9	17.0
Total days lost*	31.6	31.8	0	246	37.7	35.6	25.5	26.2	34.0

* indicates means of Joda and Keonjhar blocks are significantly different at 5% level.

Table 10. Definitions of General Household and Village Characteristics

Name	Variable Name in Database	Variable Description
Household is SC	sc	Household belongs to scheduled caste
Household is ST	st	Household belongs to scheduled tribe
Household is BPL	bpl	Household income is below poverty line
Adult Education	adulteduc	Percent of family members more than 18years old who have completed primary education
Adult Literacy	adultnews	Percent of family members more than 18years old who can read newspaper
Adult Numeracy	adultacc	Percent of family members more than 18years old Adult members who can keep accounts
Household Size	hhdsize	Number of household members
Percent Adult in Household	adult/hhdsize	Percent of household members who are 13 – 60 years old
Dependency Ratio	Child+old_60/hhdsize	The average dependancy ratio for the village, calculated as the number of dependents (<6, >60) divided by the number of adults
Distance to School		Distance to the nearest school in minutes
Distance to Center of Village		Distance to the center of the village in minutes
Surface water		Time taken in minutes to walk to the nearest Surface water source (river, pond, lake, tank etc.) from the dwelling
External assistance	dincassist	Dummy if household received external assistance from govt/NGO
Household shock	shock	Dummy if household received any unexpected shock in the last year
Percent Reporting External Assistance	assist	Percent of village respondents who indicated that they were receiving assistance from the government or NGOs
Count of Sources of External Assistance	numassist	Average number of NGO and government assistance programs reported by village respondents
Social Organization	active	Average number of associations/committees/groups in which households actively participate
Participation in Village Cleaning	cleanact2	Percent of village respondents who actively participate in village cleaning (more than once per year)
Public Water Available	pubtapwell	Percent of village respondents who indicated that public water was available

Name	Variable Name in Database	Variable Description
Distance to All-Weather Road	distroad	Average distance to nearest all-weather road in minutes, as reported by village residents.
Distance to Health Post	disthealth	Average distance to nearest health post in minutes, as reported by village residents.
Distance to Market	distmrkt	Average distance to the nearest market in minutes, as reported by village residents.
Suffered Shock	shockva	Percent of village respondents who indicated that the household has faced a serious burden, reported as percent that responded yes
FUG or FPC	vilorg	Active FUG or FPC in village
2004 Percent Urban Around Village	perurb04	Percent of land classified in 2004 as settlement, village, or town within a 2km radius of the village, not including areas outside of Keonjar or Joda
1989 Percent Urban Around Village	perurb89	Percent of land classified in 1989 as settlement, village, or town within a 2km radius of the village, not including areas outside of Keonjar or Joda

Table 11. Descriptive Statistics of Household and Village Characteristics

Variable	Sample		Joda		Keonjhar		Weighted mean	Correlation with distance to iron ore mines
	Mean	SD	Mean	SD	Mean	SD		
Pre-determined household characteristics								
Household is SC	0.07	0.25	0.11	0.31	0.02	0.15	0.06	-0.181*
Household is ST	0.68	0.47	0.67	0.47	0.68	0.47	0.65	-0.02
Household is BPL	0.77	0.42	0.71	0.45	0.83	0.37	0.77	0.134*
Adult Education	26.53	31.56	20.01	28.66	33.05	32.99	26.84	0.193*
Adult Literacy	33.82	35.93	27.77	34.22	39.87	36.62	34.16	0.158*
Adult Numeracy	74.79	26.67	68.87	26.71	80.71	25.32	75.51	0.213*
Household Size	4.64	1.63	4.59	1.51	4.68	1.74	4.63	0.01
Percent Adult in Household	0.71	0.21	0.71	0.20	0.72	0.21	0.69	0.05
Dependency Ratio	0.12	0.16	0.12	0.16	0.11	0.17	0.12	-0.03
Distance to School	13.65	5.04	15.59	5.11	11.70	4.37	14.37	-0.144*
Distance to Center of Village	9.38	2.92	10.70	3.24	8.06	1.91	9.47	-0.126*
Surface water	13.84	7.41	16.54	5.65	11.23	8.29	14.25	-0.314*
External assistance	0.13	0.34	0.17	0.37	0.10	0.30	0.16	-0.224*
Household shock	0.21	0.40	0.21	0.41	0.20	0.40	0.22	-0.253*
Pre-determined village characteristics								
Percent Reporting External Assistance	0.66	0.19	0.67	0.24	0.66	0.13	0.70	0.07
Count of Sources of External Assistance	1.08	0.40	1.18	0.49	0.99	0.27	1.11	-0.184*
Social Organization	46.10	20.22	49.40	22.25	42.80	18.55	49.24	-0.252*
Participation in Village Cleaning	1.80	3.49	0.90	1.60	2.70	4.62	1.43	0.107*
Public Water Available	0.54	0.27	0.45	0.29	0.64	0.22	0.53	0.386*
Distance to All-Weather Road	29.28	19.42	23.82	15.51	34.73	22.13	33.43	0.231*
Distance to Health Post	46.78	23.89	58.59	19.48	34.96	22.69	45.40	-0.440*
Distance to Market	58.33	24.21	57.13	19.06	59.52	29.51	62.67	0.177*
Suffered Shock	6.15	2.18	6.30	2.21	6.00	2.26	6.72	-0.253*
FUG or FPC	0.33	0.32	0.37	0.38	0.29	0.24	0.31	-0.109*
2004 Percent Urban Around Village	6.42	9.16	6.49	10.25	6.34	8.49	4.38	-0.09

Variable	Sample		Joda		Keonjhar		Weighted mean	Correlation with distance to iron ore mines
	Mean	SD	Mean	SD	Mean	SD		
1989 Percent Urban Around Village	3.17	3.77	3.87	4.91	2.47	2.18	2.35	-0.25

* Significant at the 5% level.

Table 12. Summary of Model Specifications

Dependent Variable	Model	Explanation of model specification
FOREST BENEFITS		
Proportion of cash income from forest	Tobit	77% of sample reports zero cash income from forest
Collection trips	OLS	Log-linear based on fit
Contribution of forest product in diet	Poisson	Number of forest products is non-negative integer count with mean similar to variance
Major NTFP collection	Poisson	Number of forest products is non-negative integer count with mean similar to variance
WELFARE		
Total cash income	OLS	Log-linear based on fit
Production assets	Poisson	Number of productive assets is non-negative integer count with mean similar to variance
Girl child education	Tobit	74% of sample report zero years education for girls
Days ill (normalized by hhd size)	OLS	Linear based on fit

Table 13. Summary of Model Estimation Results

Variable	Model 1	Model 2		Model 3		
	MINE EXPOSURE	FOREST DIVERSITY	FOREST STOCK	MINE EXPOSURE	FOREST DIVERSITY	FOREST STOCK
FOREST BENEFITS						
Proportion of cash income from forest	+ **	+ **	- **		+ **	- **
Ln (collection trips)	+ **	+ **		+ **	+ **	
Contribution of forest product in diet	+ **	+ **		+ **	+ **	
Major NTFP collection	+ **	+ **		+ *	+ **	
WELFARE						
Ln (total cash)			+ *			+ *
Girl child education			- *			- *
Production assets	+ **	+ **	- **	+ **	+ **	- **
Days ill	- **	- **	+ *	- **		+ **

+(-)** Coefficient is significant and positive (negative) at the 5% level

+(-)* Coefficient is significant and positive (negative) at the 10% level

Table 14. Regression Results for Days Ill per Household Member

	Model 1		Model 2		Model 3		Model 4	
LHS = Days Ill	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**		
Constant	10.85	0.000	10.91	0.000	11.05	0.000	9.80	0.000
Adult education	-0.003	0.748	-0.004	0.648	-0.009	0.883	-0.003	0.772
Household is SC	-1.375	0.277	-0.601	0.63	-1.138	0.369	-1.173	0.35
Household is ST	-3.468	0.000	-3.363	0.000	-3.529	0.000	-3.379	0.000
Household shock	1.508	0.03	1.568	0.024	1.507	0.030	1.418	0.039
External assistance	-0.105	0.899	-0.164	0.845	-0.327	0.70	-0.147	0.859
Distance to all-weather road	0.002	0.79	0.005	0.611	0.004	0.619	0.004	0.951
Distance to school	-0.02	0.484	-0.015	0.586	-0.022	0.44	-0.022	0.446
Distance to health post	0.003	0.75	0.006	0.434	0.005	0.573	0.003	0.715
FPC or FUG	-0.097	0.877	0.404	0.55	0.467	0.489	0.217	0.732
Percent forest species collected			-20.954	0.000	-11.108	0.148		
2004 percent forest around village			0.042	0.078	0.048	0.047		
Distance to iron ore mine	-0.18	0.000			-0.142	0.029	-0.139	0.008
Days worked in mine							0.04	0.006
Number of obs	600		600		600		600	
F statistics	F(10,589) = 5.19	0.0000	F(11,588) = 4.8	0.0000	F(12,587) = 4.83	0.0000	F(11,588) = 5.46	0.0000
Adj R^2	0.08		0.08		0.09		0.09	
Root MSE	6.759		6.759		6.738		6.726	

Table 15. OLS Model for Working Days Lost due to Illness

LHS =	Total Days Ill		Days Malaria	
	Coef.	**p-value**	**Coef.**	**p-value**
Intercept	1.141	0.92	1.004	0.881
SC	-6.271	0.247	-2.067	0.521
ST	-15.728	<0.000	-5.076	0.005
Adult education	-0.001	0.981	-0.001	0.963
Village average shock	5.92	0.051	2.203	0.222
Employment mine	5.993	0.032	2.693	0.105
2004 percent forest around village	0.171	0.123	0.044	0.506
Distance to iron ore mine	-0.691	0.006	-0.373	0.013
Distance to health post	0.049	0.174	0.011	0.606
Distance to roads	0.004	0.907	-0.028	0.238
Public tap or well	-1.864	0.763	-0.117	0.975
Surface water	-0.385	0.003	-0.185	0.015
Diversity of diet	3.549	0.002	1.502	0.027
Household size	2.984	0.001	1.962	0.001
Number of observations	600		600	
Adjusted R-square	0.169		0.109	
F-statistic	F(13,586) = 9.17		F(13.586) = 5.51	
Root MSE	29.328		17.472	