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# Empirical analysis of the impacts of mining dust on crop productivity in Bellary district in India

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## Abstract

**Objectives**: Iron ore mining was important economic activity in the district of Bellary, Karnataka, India. Airborne dusts from mining and ore transportation could affect agricultural productivity. It is hypothesized that dust arising into atmosphere from open pit Iron ore mining can reduce crop productivity. Objective of this study is to identify changes in agricultural productivity from environmental changes resulting due to airborne iron ore dusts in Bellary district.
**Methods:** Change in crop productivity is modeled by regressing crop productivity on fertilizer consumption, amount of rainfall, and on mining activity over the study period. Least Squares estimator with Heteroscedasticity consistent Whites estimates for covariances were calculated.
**Findings:** The results indicate predominantly significant differences in crop productivities during and after mining in case of Bajra, Jowar, Ragi, and Rice and Sunflower crops. In the case of Bajra, the productivity after cessation of mining is 1.61 times higher than during mining. Similarly, In case of rice, productivity after cessation of mining was 1.17 times that during mining. Ragi, and Sunflower also show similar trend in the changes in productivity.
**Applications:** Results from our model could be useful for improved crop protection measures and appropriate policy design. Relationships between yield and other covariates such as fertilizer levels could be utilized to optimize farmer revenues.
Keywords: Mining dusts, environmental impacts of mining, crop productivity, environmental factors.

## 1. Introduction

Iron ore mining is an important economic activity in Bellary district of Karnataka. Air borne dusts can cause negative externalities on crop production. Dust layer on leaves can reduce available light intensity for photosynthesis, affecting crop productivity. It is hypothesized that crop productivity was low during mining and improved after cessation of mining activity. Data on crop productivity is obtained from National Agricultural Insurance Scheme's crop cutting experiments spanning over six years from 2006 to 2011. The results indicate predominantly significant differences in crop productivities during and after mining in case of Bajra, Jowar, Ragi, Rice and Sunflower. Mining generated an income of ₹.2,56,903 lakh as Net District Domestic Product during 2008-09 year (2004-05 prices). Karnataka Lokayukta's report (2001) estimates that 12.58 Crore Metric Tons of iron ore was mined from 2006 to 2010 in Bellary district. Indian Bureau of mines estimates 590.11 Million Metric Tons of Iron ore reserves, with high iron content to be present in Bellary district. In Sandur and Bellary taluks, 200 mines were operational until 2008. Open pit method of mining is followed, which results in large amounts of airborne dusts. Airborne dusts can cause significant air pollution. Suspended Particulate Matter levels in air ranged between 201 and 1,195 $\mu g/m^3$ while permissible level is 200 $\mu g/m^3$.Dumping of wastes from mining and airborne dusts can cause significant damages to environment. CAG reports find that 2948 ha of land became uncultivable in Bellary, Sandur and Hospet taluks on account of mining. Mining started at a large scale from 2006 and continued till 2008. Supreme Court of India in 2008, ordered cessation of mining activity pending investigation into illicit activities by local mining companies. This gives an opportunity to study the impacts of mining dusts on agricultural productivity in the region.

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Crop productivity is affected by changes in yields due to changes in environmental conditions. Airborne dusts can settle on the leaves reducing photosynthetic efficiency and gaseous exchange in crop plants finally reducing crop yields. Mining can affect agricultural productivity by affecting air quality, land and water degradation, conversion of agricultural lands in border areas into surface mines. Apart from these factors, it can also affect available labor supply in the local area. This study assumes that marginal effect of labor on productivity is negligible. This assumption though common in agricultural economics, may be a limiting factor to this study. 2.61 lakh farmers cultivate 5.37 lakh hectares of land as per 2010-2011 agricultural census. Rainfed agriculture is predominant in the district. Only 19% of crop area is irrigated. Crops such as Bajra, Jowar, Rice, ground nut and pulses are prominently grown. Compared to the Karnataka State, Bellary district has higher productivity in crops. Data for this study is obtained from National Agricultural Insurance Scheme crop cutting data from 2006 to 2011. NAIS measures yields obtained in a unit of area in a given location. Productivity is then reported in Kilograms per Hectare. Descriptive Statistics on productivity are presented in Table 1.

*Table 1. Descriptive statistics of crop productivity, pooled across taluks of Bellary district from 2006 to 2011*

| Crop | N | Minimum | Maximum | Mean | Std Dev, |
|---|---|---|---|---|---|
| Bajra | 138 | 0 | 3162 | 775.48 | 518.96 |
| Chillies | 39 | 0 | 2993 | 1333.90 | 739.85 |
| Groundnut | 154 | 0 | 2317 | 708.77 | 446.10 |
| Jowar | 247 | 0 | 4265 | 1392.27 | 917.39 |
| Maize | 223 | 0 | 5443 | 2716.80 | 1362.24 |
| Navane | 110 | 0 | 481 | 223.05 | 119.42 |
| Onion | 32 | 0 | 15430 | 6146.75 | 3451.02 |
| Ragi | 51 | 0 | 1348 | 536.49 | 307.79 |
| Rice | 122 | 0 | 4911 | 3192.29 | 1008.20 |
| Sesamum | 47 | 0 | 743 | 292.53 | 208.23 |
| Sunflower | 358 | 0 | 1861 | 611.91 | 400.37 |
| Tur | 123 | 0 | 1233 | 448.85 | 242.26 |

Crop productivity is affected by environmental conditions such as temperature, rainfall, air quality, water quality, fertilizer levels. Air borne dusts significantly reduce chlorophyll content of leaves by as much as 76%, which is vital to photosynthesis and ultimately yields [1]. It is documented that Gold mining in Ghana reduced total factor productivity and increased rural poverty [2]. Seed weight and number of seeds per pod decreased on account of air pollution in case of Mung bean [3]. Besides dusts, pollutants such as $SO_2$, $NO_2$, and $O_3$ gas have been documented to affect seed yields and quality [4]. Pollution also adversely affected worker productivity [5]. Different Crop plants react differently to pollutants during dry and rainy periods. Tomato and Pumpkin plants were found to be more sensitive than other plants [6]. Dust particles from the road in addition to the ore particles get airborne during transportation. Agricultural impacts from vehicle generated airborne dusts can amount of 260 Million dollars per year [7-8].

## 2. Methodology and Estimation

Change in crop productivity for each crop is modeled as separate regression of crop productivity on fertilizer consumption, amount of rainfall, and on mining activity over the study period. Least Squares estimator is used. White's heteroscedasticity and autocorrelation consistent estimates were calculated. Multicollinearity was diagnosed using Variance Inflation Factors (VIFs). VIF value greater than 10 is an indicator of multicollinearity. Estimation was done in *SAS* using Base *SAS* and *SAS SQL* routines. The model is estimated as given below:

$$\ln Yield = \beta_0 + \beta_1 \ln NPK + \beta_2 mining + \epsilon$$

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A log –log model was estimated as Box Cox transformation on dependent variable. Log transformed dependent variable model performs better in terms of goodness of fit. Separate regression models were estimated for each crop, as crops differ in their responses to climatic and nutrient regimes. Data was pooled over taluks and over time from 2006 to 2011. Only crops under dry land conditions were considered, as extent of crops under irrigation is relatively less in the study area.

## 3. Results

Results from the estimated model are presented in Table 2. Parameter estimates on the mining variable are predominantly negative. The Parameter is statistically significant in case of crops such as Bajra, Jowar, Ragi, Rice, and Sunflower. In the case of Bajra, the estimated parameter value was -0.4768, indicating that productivity after mining is 1.61 times that of the value during mining. Similarly, In case of rice, the parameter estimate -0.1645 indicates that productivity after mining was 1.17 times that during mining. Ragi, and Sunflower also show similar trend in the changes in productivity. Parameter estimates on amount of fertilizer consumed are predominantly positive and significant. In case of Bajra, Maize, Onion, and Rice the estimated parameters can be interpreted as elasticities. In case of Rice, a 1% increase in Fertiliser consumed increased the productivity by 0.04%. Similarly, a 1% increase in fertilizer consumption increases Onion productivity by 0.22%, Maize productivity by 0.1%. Parameter estimates on the intercept term are all positive and significant. Parameter estimates on this term represent the productivity of the case where no mining and no fertilizers were applied. The results from the model are consistent with that of those works cited in the literature review section of this paper.

*Table 2. Parameter estimates from least squares regressions across different crops with data pooled over taluks in Bellary district*

| Variable | | Bajra | Ragi | Rice | Jowar | Maize | Navane | Ground Nut | Sesamum | Sunflower | Tur | Onion | Chilli |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | Parameter estimate | 5.8646 | 6.3781 | 7.7956 | 7.0992 | 6.93 | 6.0747 | 6.9719 | 4.8071 | 7.1213 | 6.1278 | 7.0634 | 6.634 |
| | Pr > \|t\| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| lnnpk | Parameter estimate | 0.1105 | 0.0421 | 0.0489 | 0.0169 | 0.1026 | -0.0521 | -0.0519 | 0.1137 | -0.0671 | -0.0032 | 0.2275 | 0.0257 |
| | Pr > \|t\| | 0.0059 | 0.4594 | 0.0008 | 0.6654 | 0.0033 | 0.2344 | 0.2635 | 0.1672 | 0.0278 | 0.9207 | 0.0735 | 0.7087 |
| mining | Parameter estimate | -0.4768 | -0.5544 | -0.1645 | -0.2741 | -0.092 | -0.2631 | -0.1554 | -0.2718 | -0.3617 | -0.1121 | -0.3056 | 0.3957 |
| | Pr > \|t\| | 0.0111 | 0.0085 | 0.0027 | 0.0541 | 0.6193 | 0.1827 | 0.3602 | 0.2272 | 0.0071 | 0.3654 | 0.2347 | 0.0524 |

*Dependent Variable: lnyield*

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## 4. Conclusion

Results from the estimated model indicate that crop productivity was reduced significantly during mining. The airborne dusts might have had caused this reduction. The results from the estimated model could help in quantifying the negative externalites of Mining on agriculture through reduced air quality. The results indicate predominantly significant differences in crop productivities during and after mining in case of Bajra, Jowar, Ragi, Rice, and Sunflower crops. These results are preliminary and should be interpreted with caution.

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