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STATISTICAL MODELING OF QUARRYING ACTIVITIES AND THEIR IMPACT ON RESIDENTS' SATISFACTION

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Abstract

This research aims to analyse the impact of quarrying on the health and perception of neighbouring communities. A standard questionnaire survey was conducted to collect data from quarry neighbours in a residential neighbourhood located in the city of Lavras, Minas Gerais, Brazil. Residences were distributed based on proximity to a quarrying company, resulting in three distances divided by three equally distant radii, named as Area I (closest to the quarrying company at 630 m), Area II (730 m), and Area III (farthest from the quarrying company at 830 m). Data gathered from 177 residents were analysed with logistic regression models. Results indicated significant differences between Areas I and III, and as expected, disturbances decreased as the distance from the quarrying company increased. Area III residents provided the most favourable response to quarrying activities, and the noise was the main complaint in the three areas. The number of residents who complained about noise was 91, 77, and 63% for Areas I, II, and III, respectively. The employed method can be used satisfactorily for neighbourhood impact evaluations, considering personal experiences, human perception, and seasonal effects.

Keywords: Quarrying; Logistic regression models; Quarrying impacts; Neighborhood health.

1. Introduction

Quarrying is a form of mining that is centered on the extraction of rocks or minerals through the use of manpower or machinery (Bhagyanagar et al., 2012; Vandana et al., 2020). This industrial activity is very important to human lives and influences infrastructure development, such as roads and civil construction (Arakawa & Nicholson, 2020; Darwish et al., 2011; Gunn & Bailey, 1993).

Quarrying is like other human activities that exert a significant impact on the environment and has a direct impact on environmental modifications. For example, dust generated from crushing plays a negative role in air pollution (Kobayashi et al., 2014; Macklin & Lewin, 1989; Martín-Duque et al., 2010; Parise, 2010).

The most common exposure in quarrying involves silica dust, which causes silicosis in workers. In addition, quarries can produce acidic dust depending on microclimate conditions and particle size and chemistry, directly affecting surrounding neighborhoods. Quarrying also involves the heavy blasting of hard rocks using explosives (Darwish et al., 2011; Ellis, 2011; Hancock et al., 2008; Herrera et al., 2010).

Blasting impacts can affect human health and buildings negatively, similar to earthquakes, thereby resulting in structural cracks on nearby buildings (Darwish et al., 2011). The quarrying process also generates considerable noise. Federal laws, such as the CONAMA 357 Resolution (Nartey et al., 2012) and Law 10.257 (Brazil), and state laws exist to regulate quarrying activities. However, despite regulations, quarrying activities continue to surround residents' lives in Brazil.

Similar situations can be observed in undeveloped countries. According to Castro et al. (2012), in certain cases, a population is unaware of mining activities' negative impacts, such as dust, accidents, and heavy traffic. This unawareness may be observed in 75% of the population surrounding quarries.

Apart from technical and structural evaluations on surrounding buildings and the negative impact on people's health, a few studies emphasize the effect of mining activities in Brazil. In addition, effective methodologies for analyzing a population's perception regarding the impact of quarrying activities are lacking (Baah-Ennumh et al., 2019; Goswami, 1984; Pal & Mandal, 2019; Sajinkumar et al., 2014; Vandana et al., 2020).

This study's main evaluation method is the standard NBR 9.653 (2004), which presents a methodology for analyzing quarrying activities in urban areas. The method suggests only a few steps, including implementing an information system that can inform people about detonation schedules and address complaints. Without precise data and statistical models on populations and their spatial distribution, understanding how quarrying specifically affects surrounding populations is difficult. To contribute to the understanding of the impact of quarrying on society, several publications state that survey assessments are applicable and efficient tools (ABNT, 2004; AMBIENTAL, 1992; Bhagyanagar et al., 2012; Christensen, 2019).

Simple evaluation instruments, such as survey analysis, combined with statistical postprocessing can be efficient methods for identifying not only impacts but also how uninformed societies regard the impact of industrial activities on the environment (Darwish et al., 2011). Logistic regression models are well-known (Ellis, 2011) and widely used for modeling survey data (Goswami, 1984; Gunn & Bailey, 1993; Hancock et al., 2008). In addition to providing easy-to-interpret results, this tool is available in several statistical programs. Nevertheless, such models are rarely employed in neighborhood impact studies, in which only descriptive analysis is used without any inferential procedures (Herrera et al., 2010; Instituto Brasileiro de Geografia e Estatística [IBGE], 2020; IPEA, 2018).

The objective of this research is to conduct a neighborhood impact study to analyze the effect of quarrying on a residential district in Lavras, Minas Gerais, Brazil. For this purpose, a sampling study is conducted, considering the distance between residences and a quarrying company. Distance from the quarrying company and length of residency are used as covariates in the logistic models to quantify residents' satisfaction with and the perception of quarrying activity intensity and its impact.

2. Methods

2.1. Area of investigation and survey sampling

This study's target population was residents of the Jardim Campestre II and Jardim Campestre III neighborhoods in the city of Lavras, Minas Gerais, Brazil. With an estimated population of 104,783 in 2020 (IBGE, 2020), Lavras is located in the southern physiographic zone of the State of Minas Gerais and is a part of the Upper Rio Grande microregion (Figure 1). The city is bordered in the north by the cities of Ribeirão Vermelho and Perdões, in the east by Ijaci and Itumirim, in the west by Nepomuceno, and in the south by Ingaí and Carmo da Cachoeira.

The Jardim Campestre III neighborhood is located in the northern region of Lavras and borders the Jardim Campestre II neighborhood. The region can be accessed through the Zito de Abreu Highway and Avenida Mayor Sílvio Damásio de Castro, which connects Jardim Campestre III to Jardim Campestre II and Jardim Gloria. The neighborhoods under investigation are situated within a radius of approximately 400 m from LAT coordinates—21.22705456, and LON coordinates—45.00889674.

Adjacent to these neighborhoods is a quarrying company, whose main activities include blasting rocks with explosives, transporting ores and subsequent processing, and obtaining raw materials such as rocks, fine and coarse aggregates, and stone powder for civil construction. A survey was conducted to analyze the residents' perception of the potential damage caused and the impact of quarrying activities.

Residences in the region were grouped in three areas based on proximity to the quarrying company (Figure 1). Each group was selected based on a specific radius from the quarrying company. Radii of 630 m, 730 m, and 830 m were chosen for Areas I, II, and III, respectively. The radii were stipulated to include a representative number of houses in each area.

The houses sampled for the survey were selected through probabilistic sampling. We calculated the sample size by setting the confidence level to 95%, the maximum error to 5%, and a correction for finite populations. The number of houses sampled in each area (stratum) was chosen in proportion to the area's population size, which features proportional stratified sampling. Residences in each area were selected randomly. A total of 177 houses were visited, 32 of which were in Area I, 64 were located in Area II, and 81 were located in Area III.

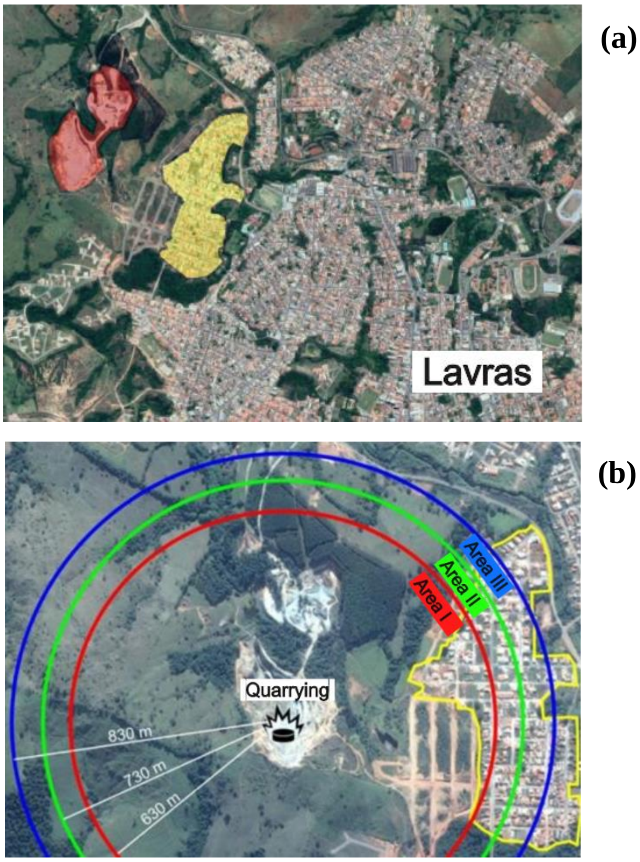

Figure 1. Area under investigation highlighting the studied radii

Source: Google Maps

2.2. Questionnaire structure

During the visits, the residents were asked to answer a survey containing brief and objective questions to assess their satisfaction with the quarrying activities and identify potential damage to buildings. The questionnaire consisted of quantitative and qualitative questions, and the latter are summarized in Table 1.

Table 1. Qualitative questions for analyzing residents' perception of quarrying activities

Variable	Question	Answers
Damage	Do you think the quarrying activities cause damages to your house?	0: No 1: Yes 99: Do not know
Nuisance	Do quarrying activities cause any kind of nuisance?	0: No 1: Yes
Type of nuisance	Type of nuisance reported	• Noise • Quakes • Dust • All • None
House affected	Do you think your house is affected by the blasting of rocks?	0: No 1: Yes 99: Do not know
Risk	Do you think your house falls within the high-risk area?	0: No 1: Sometimes 2: Yes
Satisfaction	Are you satisfied with the presence of the quarrying company?	0: No 1: Indifferent 2: Yes

The poll was based on the population's memories and experiences in the topic and the current situation at the time of the interview. The interviewers transcribed the respondents' verbal answers. The questionnaire was explained to the respondents according to IPEA recommendations (IPEA, 2018) and the literature (Oluwatofunmi et al., 2018; Shakede & Ndubisi, 2017).

2.3 Statistical modelling of residents' perception

The residents' responses to the qualitative questions presented in Table 1 were analyzed with logistic models and interpreted in terms of adjusted odds ratios. The variables "Damage," "Nuisance," and "House Affected" are treated as binary variables, and the logit of the probability of a "Yes" response ($P(Y = 1)$) is presented in Equation 1.

$$\text{logit}[P(Y = 1)] = \alpha + \beta_1 A_I + \beta_2 A_{II} + \beta_3 x, \quad (1)$$

where x denotes length of residency in years, and A_i, $i = I, II$, are dummy variables, where $A_I = 1$ if the house is in Area I, and 0 otherwise, and $A_{II} = 1$ if the house is located in Area II, and 0 otherwise.

To analyze the variables with ordinal scales (i.e., "Risk" and "Satisfaction"), cumulative logit models with proportional odds were fitted, considering the same predictor variables (length of residency and area). All statistical analyses were performed with R version 3.5.1 R Core Team (Team, 2018). The ordinal package (Christensen, 2019) was used for cumulative logit models.

3. Results and Discussion

The interview methodology for the survey questionnaire is efficient for obtaining data. The interviewers needed 12 days to complete the questionnaire survey. This difficulty was reported in the study conducted by Steele et al. (2001). The quantitative variables analyzed in this study are summarized in Table 2. The residences in the three areas are similar in terms of the number of rooms, and the mean length of residency is longer in Area III and shorter in Area I.

Table 2. Sample size in each area, mean, quartiles, and standard deviation of quantitative variables evaluated in the survey

Area	N	Variable	Mean	1Q	Median	3Q	SD
I	32	Length of residency in years	2.22	0.93	2.00	3.00	1.79
		Number of rooms	6.53	5.00	6.00	7.00	1.88

Area	N	Variable	Mean	1Q	Median	3Q	SD
II	64	Length of residency in years	4.02	2.00	3.00	5.25	3.54
		Number of rooms	6.63	6.00	7.00	7.00	1.42
III	81	Length of residency in years	5.28	1.20	3.00	9.00	5.05
		Number of rooms	6.90	6.00	7.00	8.00	1.72

Table 3 depicts the estimates of the parameters of logistic models, Wald test results, and odds ratios. In all the models, a significant increase is observed in the odds of obtaining unfavorable responses (Yes) from the Area I residents compared with those from the Area III residents (intercept). Compared with the residents from Area III, the odds of the residents believing that quarrying can cause damages to their homes are seven times higher for the residents from Area I and nearly five times higher for the residents from Area II.

Regarding nuisance, a significant effect is detected in Area I, wherein the estimated odds are more than 18 times those for Area III. In addition, regardless of the area, nuisance increases as the length of residency increases. Figure 2 presents the conditional proportions of each type of nuisance by area. Noise is the main complaint in the three areas, and as expected, disturbances decrease as the distance from the quarrying company increases. Noise pollution is one of the most negative effects of quarrying, as reported by Decardi-Nelson et al. (2015) and Bacci et al. (2006). As expected, quakes are the second most negative effects, which occur owing to intrinsic correlations with blasting noises.

Table 3. Estimates and Wald test results for logistic model parameters, odds ratio estimates, and 95% confidence intervals

Response	Parameter	Estimate	se	p-value	$\widehat{OR}$	$IC_{95\%}(OR)$
Damage	α	–0.543	0.306	0.076	-	-
	β_1	1.079	0.453	0.017	2.942	[1.232; 7.348]
	β_2	0.856	0.349	0.014	2.352	[1.197; 4.717]
	β_3	0.051	0.038	0.189	1.052	[0.977; 1.136]
Nuisance	α	0.081	0.356	0.819	-	-
	β_1	2.896	1.058	0.006	18.093	[3.419; 335.399]
	β_2	0.503	0.418	0.229	1.653	[0.735; 3.826]
	β_3	0.237	0.078	0.002	1.268	[1.109; 1.508]
House	α	–0.422	0.330	0.201	-	-

Response	Parameter	Estimate	se	p-value	$\widehat{OR}$	$IC_{95\%}(OR)$
Affected	β_1	1.303	0.508	0.010	3.681	[1.415; 10.585]
	β_2	0.860	0.387	0.026	2.362	[1.120; 5.140]
	β_3	0.191	0.058	0.001	1.210	[1.090; 1.370]
	α_{01}	0.253	0.306	-	-	-
	α_{02}	0.922	0.314	-	-	-
Risk†	β_1	1.921	0.481	<0.001	6.828	[2.755; 18.473]
	β_2	0.481	0.329	0.144	1.617	[0.851; 3.101]
	β_3	–0.061	0.037	0.102	0.941	[0.874; 1.011]
	α_{01}	–0.466	0.308	-	-	-
	α_{02}	1.103	0.337	-	-	-
Satisfaction ††	β_1	–0.978	0.447	0.029	0.376	[0.151; 0.881]
	β_2	–1.881	0.468	<0.001	0.153	[0.057; 0.363]
	β_3	0.171	0.055	0.002	1.186	[1.075; 1.334]

† In cumulative logit models, the intercepts α_{01} and α_{02} refer to "no and sometimes" and "sometimes and yes" categories, respectively.

†† In cumulative logit models, the intercepts α_{01} and α_{02} refer to "no and indifferent" and "indifferent and yes" categories, respectively.

Explosions and other quarry activities promote three types of phenomena, namely, overpressure, ground vibrations, and noise. Overpressure can be observed in window, door, wall, and object vibrations. The overpressure limit in the Brazilian Standard NBR 9653 [3] is 134 dB. The effects of this phenomenon can also be observed in cracks on houses. Several respondents reported cracking after long periods of detonation. No structural damages were found in the houses during the seismic monitoring period; however, the residents complained of discomfort during detonations and associate cracking and cracking problems caused by the quarry activities.

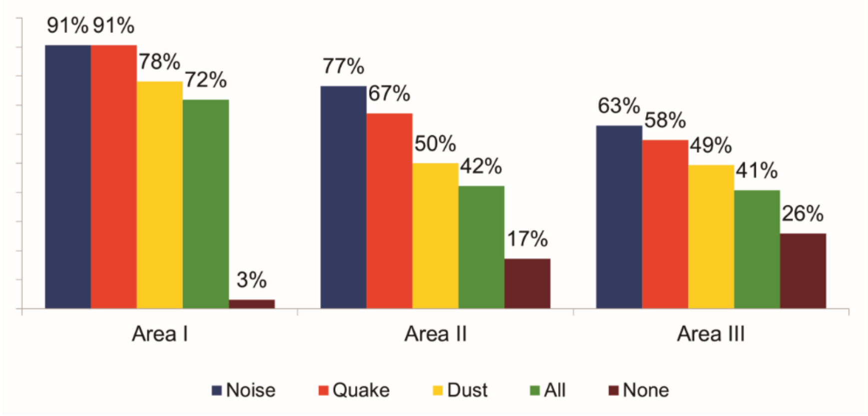

Figure 2. Conditional proportions of reported nuisance

The ground vibration limits suggested by the NBR 9653 (ABNT, 2004) are divided into three ranges according to seismic wave frequency and measured by particle velocity, that is, 15 mm/s to 20 mm/s for frequencies below 15 Hz, 20 cm/s to 5 cm/s for frequencies between 15 Hz and 40 Hz, and above 5 cm/s for frequencies above 40 Hz. In case of the State of São Paulo, CETESB (AMBIENTAL, 1992) adopts a threshold of 4.2 mm/s for the resulting component and 3.0 mm/s for the vertical component. The residents' perception of the effects of rock blasting also depends on their proximity to the quarrying company. The odds of the Area I residents believing that their home is affected by this activity may be 10 times higher than those of the Area III residents. For the residents of Area II, the odds maybe five times higher than those of the residents of more distant areas. The odds of obtaining unfavorable responses also increase as the length of residency increases.

The odds of the Area I residents believing that their home is in a high-risk area are approximately seven times higher than those of the Area III residents. In addition, regarding the perception of risk, no significant effect is detected in Area II or in length of residency. In determining the residents' satisfaction, we observe that the odds of the Area I residents being indifferent to or satisfied with the presence of the quarrying company are approximately a third of the odds of the Area III residents. Surprisingly, these odds are lower for the residents of Area II compared with those of Area III ($\hat{\theta} = 0.153$).

Finally, these odds increase significantly as the length of residency increases regardless of the area. This finding means that the residents who have lived in the area for a long time tend to be more indifferent to or satisfied with the region's quarrying activities. Despite this result, the residency length effect is also significant for "Nuisance" and "House Affected" categories. Regardless of area, the odds of obtaining unfavorable responses to these questions increase as length of residency increases.

The presented results indicate that the neighborhood residents understand the impact of the quarrying activities but still choose to live in the area. These results are similar to those obtained by Castro et al. (2012), especially for the new residents of the studied area. This finding depicts the lack of communication among the society, industry, and public administration.

A logistic regression model is most frequently used for a discrete outcome variable (Hosmer & Lemeshow, 2013). Its interpretation is simple, and it is implemented in several software, thereby increasing its popularity for survey data analysis. In this study, we illustrate how this model can be employed in a neighborhood impact study to capture residents' perception of a quarrying company's activities. Distance from the company is used as a covariate to measure impact intensity. In neighborhood impact studies, the division of a region into bands of different distances is not new. However, data analysis is often restricted to descriptive statistics and assessments of physical or structural impacts. In this study, we assess and quantify impact from residents' perspectives. The results help deduce whether the residents are aware of existing risks and how the quarrying activities impact their wellbeing. We suggest that neighborhood impact studies should incorporate surveys for the impacted population to complement technical analyses whenever possible.

The city implemented law nº156 (Prefeitura Municipal de Lavras, 2008), which indicates the need for a neighborhood impact study (EIV) in cases of new installations, construction, upscaling, and retrofitting in industrial activities that may exert a significate impact on the environment and urban spaces. When this analysis is applied properly, identifying residences constructed without consulting municipal laws is possible.

4. Conclusion

This study analyzed the application of a statistical methodology for modeling and determining residents' satisfaction about residing near quarrying activities. The following conclusions were drawn from the present research.

a. Regarding the studied variables, dissatisfaction and discomfort were substantial in the areas nearest to the quarrying company. In general, for the sampled population, the residents who have lived in the region over a long period of time tended to be indifferent to or satisfied with the quarrying activities.

b. Perception of discomfort (nuisance) seemed to be the variable most impacted by proximity to the quarrying company. The noise was the main complaint in the three areas, and disturbances decreased as distance from the quarrying company increased.
c. Highlighting the methodology used as an efficient tool for determining a population's perception of urban impacts is possible. A community survey is an efficient, fast, and low-cost methodology compared with other techniques. However, ensuring impartial judgment to mitigate errors in the answers is difficult.
d. The employed method may be utilized satisfactorily to evaluate quarry impacts on industries and other facilities surroundings in urban areas.
e. Given that quarries have an impact on air quality and residence structures, a deep technical analysis of these parameters is necessary to better quantify their status.
f. An improved examination of the relationship among quarry companies, city administrations, and society should be conducted. Educational activities and continuous evaluations should be performed to identify the possible dangers of living near such industry sites and prevent health issues and possible structural failures.

Author Contribution

Jefferson M. Domingues, Denise C. Rezende and Yara S. Lares conceived of the presented idea. Saulo R. Ferreira and Izabela R.C. de Oliveira developed the theory and performed the computations. Izabela R.C. de Oliveira and Vania F. L. Miranda verified the analytical methods. Saulo R. Ferreira and Izabela R.C. de Oliveira supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

References

ABNT. (2004). *NBR 9653* - Guia para avaliação dos efeitos provocados pelo uso de explosivos nas minerações em áreas urbanas. *Scielo*. https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0370-44672006000100007

AMBIENTAL, C. C. D. T. D. S. (1992). Norma D7.013 - Mineração por explosivo.

Arakawa, F., & Nicholson, C. (2020). Identifying new quarries as a method for expanding research: A GIS case study from the Mesa Verde region in the American Southwest. *Journal of Archaeological Science: Reports*, *33*, 102470. https://doi.org/10.1016/j.jasrep.2020.102470

Baah-Ennumh, T. Y., Yeboah, A. S., & Akularemi, A. E. J. (2019). Contextualizing the effects of stone quarrying: Insights from the Wenchi municipality in Ghana. *GeoJournal*. https://doi.org/10.1007/s10708-019-10080-8

Bacci, D. de L. C., Landim, P. M. B., & Eston, S. M. de. (2006). Aspectos e impactos ambientais de pedreira em área urbana. *Rem: Revista Escola de Minas*, *59*(1), 47–54. https://doi.org/10.1590/S0370-44672006000100007

Bhagyanagar, R., Kawal, B. M., Dwarakish, G. S., & Surathkal, S. (2012). Land use/land cover change and urban expansion during 1983–2008 in the coastal area of Dakshina Kannada district, South India. *Journal of Applied Remote Sensing*, *6*(1), 063576–1. https://doi.org/10.1117/1.JRS.6.063576

Castro, N. F., Lima, E. F., Marcon, B., Almeida, P. F. De, & Cattabriga, L. (2012). Socioeconomic impact of the local productive cluster of dimension stones of the Espírito Santo State, Brazil. *Francisco Rego Chaves Fernandes; Maria Amélia Rodrigues Da Silva Enríquez; Renata de Carvalho Jimenez Alamino. Org.). Recursos Minerais & Sustentabilidade Territorial: Arranjos Produtivos Locais*.

Christensen, R. H. B. (2019). Ordinal - Regression Models for Ordinal Data. R package version. http://www.cran.r-project.org/package=ordinal/

Darwish, T., Khater, C., Jomaa, I., Stehouwer, R., Shaban, A., & Hamzé, M. (2011). Environmental impact of quarries on natural resources in Lebanon. *Land Degradation & Development*, *22*(3), 345–358. https://doi.org/10.1002/ldr.1011

Decardi-Nelson, I., Solomon-Ayeh, B., Daniel Asenso-Gyambibi, K. T. A., & A. A. (2015). An assessment of the institutional capacity for the management of quarry industries in Ghana: The case of Buoho Stone Quarries. *Civil and Environmental Research*, *7*(5). https://www.iiste.org/Journals/index.php/CER/article/view/22188

Ellis, E. C. (2011). Anthropogenic transformation of the terrestrial biosphere. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *369*(1938), 1010–1035. https://doi.org/10.1098/rsta.2010.0331

Goswami, S. C. (1984). Quarrying of aggregates in and around gauhati: Impact on the environment. *Bulletin of the International Association of Engineering Geology*, *29*(1), 265–268. https://doi.org/10.1007/BF02594416

Gunn, J., & Bailey, D. (1993). Limestone quarrying and quarry reclamation in Britain. *Environmental Geology*, *21*(3), 167–172. https://doi.org/10.1007/BF00775301

Hancock, G. R., Lowry, J. B. C., Moliere, D. R., & Evans, K. G. (2008). An evaluation of an enhanced soil erosion and landscape evolution model: A case study assessment of the former Nabarlek uranium mine, Northern Territory, Australia. *Earth Surface Processes and Landforms*, *33*(13), 2045–2063. https://doi.org/10.1002/esp.1653

Herrera, G., Tomás, R., Vicente, F., Lopez-Sanchez, J. M., Mallorquí, J. J., & Mulas, J. (2010). Mapping ground movements in open pit mining areas using differential SAR interferometry. *International Journal of Rock Mechanics and Mining Sciences*, *47*(7), 1114–1125. https://doi.org/10.1016/j.ijrmms.2010.07.006

Hosmer, D. W., & Lemeshow, R. X. S. S. (2013). Applied Logistic Regression (3rd ed.). Wiley Series in Probability and Statistics.

Instituto Brasileiro de Geografia e Estatística - IBGE. (2020). Pesquisa Nacional por Amostra de Domicílios–2020. *Rio de Janeiro: IBGE.* https://static.poder360.com.br/2020/10/pnad-covid19-setembro.pdf

IPEA. (2018). *Questionarios: recomendacoes para formatacao*. Retrieved from http://www.ipea.gov.br/portal/images/stories/PDFs/TDs/td_1063.pdf

Kobayashi, H., Watando, H., & Kakimoto, M. (2014). A global extent site-level analysis of land cover and protected area overlap with mining activities as an indicator of biodiversity pressure. *Journal of Cleaner Production*, *84*, 459–468. https://doi.org/10.1016/j.jclepro.2014.04.049

Macklin, M. G., & Lewin, J. (1989). Sediment transfer and transformation of an alluvial valley floor: The river South Tyne, Northumbria, U.K. *Earth Surface Processes and Landforms*, *14*(3), 233–246. https://doi.org/10.1002/esp.3290140305

Martín-Duque, J. F., Sanz, M. A., Bodoque, J. M., Lucía, A., & Martín-Moreno, C. (2010). Restoring earth surface processes through landform design. A 13-year monitoring of a geomorphic reclamation model for quarries on slopes. *Earth Surface Processes and Landforms*, *35*(5), 531-548. https://doi.org/10.1002/esp.1950

Nartey, V. K., Nanor, J. N., & Klake, R. K. (2012). Effects of quarry activities on some selected communities in the lower Manya Krobo district of the eastern region of Ghana. *Atmospheric and Climate Sciences*, *02*(03), 362–372. https://doi.org/10.4236/acs.2012.23032

Oluwatofunmi, A. D., & Bibilari, I. O. (2018). Project: Outcomes of Land Policy and Good Governance in Nigeria Real Estate Market. *Locational Effect of Quarry Sites on Residents' Satisfaction and Environment of Proximate Residential Neighborhood in Akure*. *July*. https://www.researchgate.net/publication/327207295_Locational_Effect_of_Quarry_Sites_on_Residents%27_Satisfaction_and_Environment_of_Proximate_Residential_Neighborhood_in_Akure

Pal, S., & Mandal, I. (2019). Impact of aggregate quarrying and crushing on socio-ecological components of Chottanagpur plateau fringe area of India. *Environmental Earth Sciences*, *78*(23), 661. https://doi.org/10.1007/s12665-019-8678-1

Parise, M. (2010). *The Impacts of Quarrying in the Apulian Karst (Italy)* (pp. 441–447). Berlin, Germany: Springer. https://doi.org/10.1007/978-3-642-12486-0_68

Prefeitura Municipal de Lavras, M. B. (2008). *LEI COMPLEMENTAR N°156, DE 22 DE SETEMBRO DE 2.008*. http://pml.lavras.mg.gov.br/public/uploads/secretariasOrgaos/upload_acda603e51facf3223296d5c42da35d1

Sajinkumar, K. S., Sankar, G., Rani, V. R., & Sundarajan, P. (2014). Effect of quarrying on the slope stability in Banasuramala: An offshoot valley of Western Ghats, Kerala, India. *Environmental Earth Sciences*, *72*(7), 2333–2344. https://doi.org/10.1007/s12665-014-3143-7

Shakede, O. P., & Ndubisi, O. (2017). Effect of industrial pollution on residential neighbourhood: Amuwo Odofin Industrial Layout Lagos as case study. *Covenant Journal of Research in the Built Environment (CJRBE)*, *5*(1), 99–106. https://journals.covenantuniversity.edu.ng/index.php/cjrbe/article/view/496

Steele, J., Bourke, L., Luloff, A. E., Liao, P. S., Theodori, G. L., & Krannich, R. S. (2001). The drop-off/pick-up method for household survey research. *Community Development Society. Journal*, *32*(2), 238–250. https://doi.org/10.1080/15575330109489680

Team, R. C. (2018). *A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria*. *R Project*. https://www.r-project.org

Vandana, M., John, S. E., Maya, K., & Padmalal, D. (2020). Environmental impact of quarrying of building stones and laterite blocks: A comparative study of two river basins in Southern Western Ghats, India. *Environmental Earth Sciences*, *79*(14), 366. https://doi.org/10.1007/s12665-020-09104-1