OPEN ACCESS

Volume: 8

Issue: 2

Month: March

Year: 2020

P-ISSN: 2319-961X

E-ISSN: 2582-0192

Received: 06.01.2020

Accepted: 10.02.2020

Published: 01.03.2020

Citation: Marichamy, V., Ganesan, S. and Kalirajan, R. "Influence of Stone Crusher Units' Dust Pollution on Agriculture in Virudhunagar District of Tamil Nadu." *Shanlax International Journal of Economics,* vol. 8, no. 2, 2020, pp. 41-48.

DOI:
https://doi.org/10.34293/economics.v8i2.2070

Influence of Stone Crusher Units' Dust Pollution on Agriculture in Virudhunagar District of Tamil Nadu

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Abstract
In this process, many industries are polluting the air and environment. One among them is the stone crushing industry. Air polluting industries are a proximate source of major damage to farming systems in adjacent areas, thus disrupting the main source of livelihoods of many small and marginal farmers. Scientific study shows that polluted air from industrial and urban areas usually consists of a mixture of pollutants, which can adversely affect agriculture in many complex ways. Air pollutants that are most damaging to agriculture are sulphur dioxide and the oxides of nitrogen, which are categorized as acid pollutants. Agriculture yields depend upon many factors like weather, soil fertility, irrigation, pesticides, and the like. Other things remaining the same, air pollution, particularly dust pollution, causes a significant fall in crop yields, and in turn, agriculture income reduces. Hence a modest attempt has been made here to study the influence of dust pollution by stone crushing units in the surrounding areas of Virudhunagar District. The results of the Factor Analysis show that the spread of dust from stone crushing units has affected the fertility of the soil, led to a reduction in the area of cultivation, and has a negative impact on cattle breathing and ultimatelyaffected the income levels of the farming community.
Keywords: Dust Pollution, Stone Crusher, Agricultural operation.

Introduction

Stone Crushing is an important industrial activity in the country engaged in producing stones of various sizes depending upon the requirements of the varied consumers. These serve as raw materials for various construction activities such as the construction of roads, bridges, highways, canals, and buildings, etc. It is estimated that there are over 12,000 stone crushing units in India. In India, the Stone Crushing Industrial sector is estimated to have an annual turnover of Rs.5000 crore (equivalent to over US$ 1 billion) and is, therefore, an economically important sector. This sector is estimated to be providing direct employment to over 500,000 people in various activities such as mining, crushing plant, transportation of mined stone and crushed products, etc. Most of those working in stone crushing units are from rural and economically disadvantaged areas, where employment is limited, so this is of greater importance in rural areas. It is a source of income for the uneducated, poor, and unskilled rural population.

These stone crushing, though socially and economically an important sector, gives rise to a substantial quantity of fine fugitive dust emissions, which create health hazards to not only the workers working in stone crushing units but also the people residing nearer to the crushing units. It also affects agricultural activities.

The Air polluting industries are the proximate source of major damage to farming systems in adjacent areas, thus disrupting the main source of livelihoods of many small and marginal farmers. Scientific studies show that polluted air from industrial and urban areas usually consists of a mixture of pollutants, which can adversely affect agriculture in many complex ways. Air pollutants that are most damaging to agriculture are sulphur dioxide and the oxides of nitrogen, which are categorized as acid pollutants. The sulpher dioxide can lead to visible injury, which can take the form of necrosis of plant tissue. Typically the leaves drive up from the tip of the plant to downwards.

Dust are composed of solid particles originating usually from handling, crushing, grinding, and disintegrating organic and inorganic materials like rocks, ores, metals, coal, wood, and grains. Dust comes from various sources. Factories, especially of cement, coal, and the like and vehicles on the roads are some of them. Around 40 percent of total air pollution in India is dust pollution.

Agriculture yields depend upon many factors like weather, soil fertility, irrigation, pesticides, and the like. Other things are remaining the same; air pollution, particularly dust pollution, causes a significant fall in crop yields, and in turn, agriculture income reduces. Hence, a modest attempt has been made to study the impact of dust pollution by stone crusher units on agriculture in the surrounding areas of Virudhunagar District.

Review of Literature

Ahanger, F.A., made a study on “Impact of road dust polluted mulberry leaves on the food ingestion, assimilation and conversion efficiency of Silkworms in Kashmir Valley”. Rohith, S., has conducted a study, “Vehicular pollution: the important reason for the rise in asthma case in Madurai”. Waseem, S et al., have undertaken a study on “Effects of indoor air pollution on human health: a micro-level study of Aligarh City-India”.Ilyas, M and Raheed, F., have carried out a study on “Health and environment related issues in stone crushing in Pakistan”. SaralaThambavani, D., has undertaken a scientific study on “Assessment of ambient air quality in Virudhunagar Town, Tamil Nadu”. Gamal, H.M., has conducted a study on “Respiratory problems among workers exposed to quarries dust in El - Minia Governorate”. Sinha, B.K and Choudhary, S., have undertaken a study on “Environmental Pollution and Health Hazards”. Rana, S.V.S., has carried out a study on “Environmental pollution: health and toxicology”.

Statement of the Problem

In the olden days the stones used for construction purposes are produced by using workforce. As the demand for construction material increases, nowadays people are using the same power to produce the same.

Most of the stone crushing units are located in the perimeter of the city, as it requires electricity, road facilities and labor resources. Employing modern technology, the mass production of crushed stone can create an enormous amount of dust and can spread through the air and contribute to air pollution. Breathing contaminated air with fine dust particles particularly affects the health of workers working in stone crushing units and the general public. It affects not only the health of humans but also the growth of crops, pollutes the soil, and makes the land unfit for cultivation. While stone crushing units can directly and indirectly contribute to rural and urban populations, and contribute more to job opportunities for skilled and unskilled workers, at the same time, its environmental impact cannot be forgotten. Further, the stone crushing units contribute an adequate amount to the GDP also. Hence, there is a need at this juncture to undertake a study on “Influence of stone crusher units’ dust pollution on Agricultural in Virudhunagar District of Tamil Nadu”.

Objectives of the Study

- To analyze the socio-economic profile of the farmers in the study area.

- To examine the major crops cultivated by the farmers.
- To elicit the opinions regarding the farming operations due to dust pollution by the stone crusher units.
- To offer suitable suggestions based on the finding of the study.

Sampling Design

The study was conducted in Virudhunagar District of Tamil Nadu. Totally 51 stone crushers are functioning in the study area. Out of these, 16 units have been selected by adopting a simple random sampling technique. Totally 64 farmers are interviewed, and the required information was collected from them.

Tools of Analysis

The statistical tools used to analyze the data are percentages and factor analysis.

Socio-Economic Profile of the Farmers

The researcher has analyzed the socio-economic profile of the farmers. The results are given in the table 1.

Table 1: Socio-economic Profile of the Sample Farmers

S. No	Characteristics Details	No. of Farmers	Percent
1	Age (In Years)		
	Below 30	3	4.69
	30-40	13	20.31
	40-50	19	29.69
	50-60	18	28.12
	Above 60	11	17.19
	Total	**64**	**100.00**
2	No of Family Members Engaged Cultivation		
	Below 2	37	57.81
	2-3	20	31.25
	Above 3	7	10.94
	Total	**64**	**100.00**
3	Size of Operational Holdings (in Acres)		
	Marginal Farmers	32	50.00
	Small Farmers	25	39.06
	Medium Farmers	6	9.38
	Large Farmers	1	1.56
	Total	**64**	**100.00**
4	Working Experience (in years)		
	Less than 10	14	21.88
	10-20	17	26.56
	20-30	23	35.94
	30-40	8	12.50
	Above 40	2	3.12
	Total	**64**	**100.00**
5	Cost of Cultivation (in Rs.)		
	Less than 10000	6	9.38
	10000-20000	13	20.31
	20000-30000	19	29.69
	30000-40000	14	21.87
	Above 40000	12	18.75
	Total	**64**	**100.00**
6	Income from Agricultural Operations (in Rs.)		
	Less than 20000	17	26.56
	20000-30000	27	42.19
	30000-40000	12	18.75
	40000-50000	3	4.69
	Above 50000	5	7.81
	Total	**64**	**100.00**

Source: Primary Data

The socio-economic characters of the farmers in the study area are depicted in Table 1. It can be understood from the table that nearly one - third of the total farmers in the age group of 40-50 years. It is disheartening to mention that only 4.69 percent of the farmers belong to the age group of below 30. It reveals that engaging in agriculture by young people becomes a rare phenomenon. It is also known that more than half of the total respondents engaged in agricultural activities, not with the family members. It reflects that the peasant farming system is disappearing from the economy. It can also be said that about 50 percent of the size of operational holding is small farmers. Hence it is right to mention that most of the farmers are small farmers. As far as the experience of the farmers in agricultural work is concerned, around 35 percent of the farmers engaged in agricultural business ranges from 20 to 30 years. About the cost of cultivation, 29.69 percent of the farmers incurred agricultural expenditure between Rs.20000-Rs.30000 per year. Further, as far as the income earned from the agricultural business, more than 42.19 percent of the farmers earn Rs. 20000 – Rs.30000 in a year.

Analysis of Major Crops Cultivated by the Farmers

To examine the major crops cultivated by the farmers, the researcher has collected the information and interpreted it in Table 2.

Table 2: Major Crops Cultivated by the Farmers

S. No. (in Acres)	Major Crop Cultivated	Total Acres Cultivated
1	Vegetables	93.50
2	Grain / Pulse	49.50
3	Fruits	61.50
4	Flowers	13.50
	Total	**218.00**

Source: Primary Data

It can be noted from Table 2 that the majority of the farmers in the study area are cultivating vegetables, i.e., out of 218 acres of land, 93.50 acres of land is used for cultivating vegetables. Next to this, 49.50, 61.50, and 13.50 acres of land were used for producing fruits, grains, and flowers respectively.

Factor Analysis

Factor analysis is a multivariate statistical technique in which there is no distinction between dependent and independent variables. In factor analysis, all variables under investigation are analyzed together to extract the underlined factors. Factor analysis is a data reduction method. It is a very useful method to reduce a large number of variables resulting in data complexity to a few manageable factors. These factors explain most of the original set of data. Factor analysis could be used to develop concise multiple-item scales for measuring various constructs. Factor analysis can reduce the set of statements adequately represent the critical aspects of the constructs being measured.

Extraction of Factors

The first and foremost step in factor analysis is to decide on how many factors are to be extracted from the given set of data. This could be accomplished by various methods like the centroid method, the principal component method, and the maximum likelihood method. In the present study, only the principal component method has been applied and discussed.

As we know that factors are linear combinations of the variables which are supposed to be highly correlated, the mathematical form of the same could be written as

$$F_i = w_{i1}X_1^* + w_{i2}X_2^* + w_{i3}X_3^* + \ldots + w_{ik}X_k^*$$

Where,

X_i^* = i^m Standardized variable

F_i = Estimate of ith factor

w_i = Weight or factor score coefficient for i^th standardized variable

k = Number of variables

The principal component methodology involves searching for those values of wi so that the first factor explains the largest portion of the total variance. This is called the first principal factor. This explanation is then subtracted from the original input matrix to yield a residual matrix. A second principal factor is extracted from the residual matrix in a way such that the second factor is taken care of most of the residual variance. One point that has to be kept in mind is that the second principal factor has to be statistically independent of the first principal factor.

Testing of Sampling Adequacy

To establish the strength of the factor analysis solution, it is essential to establish the reliability and validity of the obtained reduction. Bartlett's test of sphericity was used to test if the null hypothesis of the variables is index correlated in population. The test statistic for sphericity is based on a Chi-Square transformation of the determinant of the correlation matrix.

It is important to note that if the value of Kaiser – Meyar – Oklin (KMO) statistics is greater than 0.5, the factor analysis could be used for the set of data. Further, Bartlett's test of sphericity is used for testing the significance of the correlation matrix of the variables. The significance of the correlation coefficient matrix is indicated by the P-value corresponding to the Chi-Square statistic. If the P-value is 0.000, which is less than 0.05, the correlation coefficient matric will be statistically significant at the assumed level of significance. In that case, the null hypothesis that the correlation matrix of the variables is not statistically significant is rejected.

The correlation matrix is examined carefully, and the two tests viz Bartlett's test of sphericity and Kaiser – Meyar - Oklin test are undertaken, and the results are shown in Table 3.

Table 3: KMO and Bartlett's Test

Kaiser-Meyer-Oklin Measures of Sampling Adequacy	0.503
Bartlett's Test of Approx. Chi-Square Sphricity	29.296
Degrees of Freedom	21
Significance	0.107

Source: Computed Data

It has been observed from Table 3 that Bartlett's test of sphericity is significant, with .000 being less than 0.05. Sampling adequacy measured using the Kaiser – Meyar – Oklin (KMO) of 0.503 is taken as acceptable. Thus, the factor analysis may be considered as an appropriate technique for analyzing the data.

Eigen Value

It is important to know that a factor is a linear combination of the various variables. Now Eigen value for each of the factors is computed, and only those factors that have an Eigen value at least 1 are accepted under this method. If the factor having Eigen values of less than 1 are rejected. This is because each of the variables has a variance of 1, and therefore a linear combination of these variables called factor should not have an Eigen value of less than 1. The results of the Eigen values are given in each table of the factor analysis.

Total Variance Accounted by the Extracted Factors

The percentage of variance explained by each of the factors can be computed using the Eigen values. As there are seven variables, the total variance equals seven. The variance explained by each of the factors can be computed as

$$\text{Percentage of variance explained by the } i^{th} \text{ factor} = \frac{\text{Eigen Values}}{\text{Sum total of the Eigen Values}} \times 100$$

Table 4: Total Variance Explained Component

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	Percentage of Variance	Cumulative Percentage	Total	Percentage of Variance	Cumulative Percentage
1	1.690	24.140	24.140	1.354	19.347	19.347
2	1.263	18.046	42.186	1.311	18.727	38.074
3	1.056	15.082	57.269	1.200	17.150	55.223
4	1.038	14.829	72.098	1.181	16.874	72.098

Source: Computed Data

The percentage of variance explained by each of the factors can be computed using Eigen values. Table 4 clearly shows that the total variance explained by the four factors is equal to (24.140 + 18.046+15.082+14.829 =) 72.098 percent.

Communality: Explanation of Original Variable's Variance

Communality is donated byh2. It indicates how much of each variable is accounted for by the underlying factors taken together. In other words, it is a measure of the percentage of variation that is explained by the factors. As a result, relatively high communality shows that not much of the variable is left over after taking into account the effect of all potential pollutant variables. The communality for each variable is computed and is given in Table 5.

Table 5: Communalities

S. No.	Variables	Ex-traction
1	Fertility of the soil	0.797
2	Change in Nature of the Soil	0.798
3	Fall in crop yield	0.706
4	Reduction in the area of cultivation	0.818
5	Sale of land	0.643
6	Increase in cost of cultivation	0.531
7	Reduction in the agricultural income	0.753

Source: Computed Data

From Table 5, it is clear that the communality for the first variable is 0.818, which means 81.8 percent of the variance or information content of the first variable, namely reduction in the area of cultivation. The competency of farmers is explained by the four factors. Similarly, the communalities for the other variables could be computed.

Results and Interpretation

The rotated factor matrix for the variables relating to the factor, which are the most important activities and opinion regarding the farmer's operation due to dust pollution are given in Table 6. Table 6 gives the following received by the factors underF1,F2,F3and F4.

Table 6: Rotated Component Matrix

S. No.	Particulars	Rotated Factor Loadings			
		F1	F2	F3	F4
1	Change in Nature of the Soil	-.856	.058	.120	.218
2	Reduction in the agricultural income	.686	.037	.221	.483
3	Sale of land	.149	.782	-.092	.025
4	Increase in cost of cultivation	.285	-.587	.013	.325
5	Fertility of the soil	.069	-.159	.867	-.125
6	Fall in crop yield	-.191	.561	.595	.027
7	Reduction in the area of cultivation	-.079	-.102	-.152	.882
	Percentage of Variance	24.140	42.186	57.269	72.098
	Eigen Value	1.690	1.263	1.056	1.038

Source: The Principal component method is used to extract factors

Table 6 reveals that the rotated factor loadings seven statements (variables) of factors are an important opinion regarding the farmer's operation due to dust pollution. It is clear from the Table that all the seven statements have been extracted into four factors, namely F1, F2, F3, and F4. The factors are identified with new names. These are discussed in the following pages.

The Factor I- Nature of Soil and Yield

The opinions of the farmers regarding the impact of the nature of soil and yield are depicted in Table 7. The contribution made by Factor I is shown in the table.

Table 7: Factor I- Nature of Soil and Yield

S. No	Variables	Factor Loadings	Eigen Value	Percent of Variance
1	Change in Nature of the Soil	-0.856	1.690	24.140
2	Reduction in the agricultural income	-0.686		

Source: Computed Data

The values of factor loading are changing in the nature of soil (0-.856) and reduction in the agricultural income (-0.686). The factor I is characterized as "nature of soil and yield". The Eigen value for factor I is 1.690, and the percentage of variance is 24.140. Hence, it can be stated that the farmers consider these problems as the main problem due to the stone crusher units.

Factor II- Cost of Cultivation

The opinions of the farmers regarding Factor – II, the impact of the cost of cultivation are incorporated in Table 8.

Table 8: Factor II – Cost of Cultivation

S. No.	Variables	Factor Loadings	Eigen Value	Percentage of Variance
1	Sale of land	0.782	1.263	42.186
2	Increase in cost of cultivation	0-.587		

Source: Computed Data

The factor loading values are the sale of land (0.782) and an increase in the cost of cultivation (-0.577). Factor II is characterized as a "cost of cultivation". The Eigen value for factor II is 1.263, and the percentage of variance is 42.186. These are the second set of factors which significantly affected the farmers.

Factor III – Fertility and Yield

The opinions of the farmers regarding the third factor viz., impact on the fertility of the soil, and yield Table 9 are depicted in Table 9.

Table 9: Factor I – Fertility and Yield

S. No	Variables	Factor Loadings	Eigen Value	Percent of Variance
1	Fertility of the soil	-0.856	1.056	57.269
2	Fall in crop yield	-0.686		

Source: Computed Data

As could be observed from the factor loading values of the third factor in the table, the fertility of the soil was reduced due to dust pollution (-0.867) and a fall in crop yield (-0.595). Factor III is termed as "fertility and yield". The Eigen value for factor III is 1.056, and the percentage of variance is 57.269.

Factor IV– Area of Cultivation

The opinions of the farmers regarding the fourth factor, the area of cultivation, are furnished in the table 10.

Table 10: Factor IV– Area of Cultivation

S. No.	Variables	Factor Loadings	Eigen Value	Percentage of Variance
1	Reduction in the area of cultivation	-0.882	1.038	72.098

Source: Computed Data

In the fourth factor, the factor loading values are a reduction in the area of cultivation (-0.882). Factor IV is termed as "cultivation". The Eigen value for factor IV is 1.038, and the percentage of variance is 72.098. Hence, it can be said that the stone crusher units make an impact on the area of cultivation as well. The farmers who indulge in cultivation face severe troubles due to these stone crusher units.

Table 11: Opinions of the Farmers regarding the Impact of Dust Pollution on Agriculture as given by the Variables with the Highest Factor Loadings

Factor	Name of Newly Extracted Dimensions (Factor)	Selected Statements Variables	Factor Loadings
F1	Nature of soil and yield	Change in nature of the soil	0.856
F2	Cost of cultivation	Sale of land	0.782
F3	Fertility and yield	Reduction in the Fertility of the soil due to dust pollution	0.867
F4	Area of cultivation	Reduction in the area of cultivation	0.882

Source: Computed Data

It is inferred from the Table 11 that the group of variables say, dust impact on change in nature of the soil due to dust pollution with factor loading of (0.856), sale of land with factor loading of (0.782), reduction in the fertility of the soil due to dust pollution with factor loading of (0.867) and reduction in the area of cultivation with factor loading of (0.882) got limelight in making difficulties to farmers. The statements with the highest factor loading are in order, namely, nature of soil and yield (F1), cost of cultivation (F2), fertility and yield (F3), and area of cultivation (F4). Hence, these are the identified variables that make an impact on farmers.

Suggestions

- To control dust pollution, stone crushing unit owners are insisted on planting trees like CasuarinaEquisetifolia in and around crusher units.
- Trees should be planted in four layers. The tree should be planted up to 2 km radius for every 500-meter radius. The type of trees that can grow to huge height should be recommended for plantation.
- In the first 2 layers, i.e., 500 meters and 1000 meter, tree should be planted without any gap. It will make a hurdle of spreading dust from the crusher units.
- The land located 2 km radius in and around the crusher units should be purchased by the owners of crusher units by paying a reasonable value to the land owners.
- Frequent soil testing should be conducted by the land owners at a cheaper cost. According to the

condition of the soil, the agricultural department authorities should recommend the crop and fertilizer doses to get adequate yield.

Conclusion

Even though stone crushing units are very much important for the development of construction sectors and public utilities, contributing to GDP, generation of more employment opportunities both direct and indirect its impact on the environment in general and on farming activities, in particular, is to be taken care of.

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