Executive Summary

Social, Economic and Health Impact of Industrial Pollution in Dindigul District, Tamil Nadu

Project Director

Prof. Srinivasan Kannan PhD Professor, Achutha Menon Centre for Health Science Studies Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum

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Water is not only the lifeline to ecosystem it is also a factor of production in agriculture. Abuse of water causes scarcity, low agricultural produce and poor livelihood. The rampant industrial pollution contaminates the limited available water resources and creates water stress. In the town of Dindigul, South India, the tanneries pollute by discharging its effluents and affects the people of surrounding villages who depend on the water sources for their livelihood. The tannery pollution also adversely affect the health of the population. The water and soil pollution reduces agricultural production, contaminate drinking water, and affect the livelihood of population. The aim of the present paper is to study the use and abuse of water by the tanneries and the impacts industrial pollution on water, agriculture and livelihood of people in the villages of Dindigul district.

Methodology

Ten villages each were drawn randomly from the vicinity of and farther from the tanneries. Following explanatory design a survey using a structured interview schedule was conducted among the men and women above 18 years from the selected villages. Socio-Economic details, industrial pollution, effect of it on water, agriculture and livelihood were collected using the interview schedule. Total of 400 respondents from 20 villages were randomly selected from the affected and non-affected villages equally. Online form using Tablet supported by Kobo toolbox was used for data collection in Tamil language after obtaining consent from the respondents. Data analysed using SPSS 21. Ethical clearance was obtained.

Findings

Socio-demographic characteristics of respondents

As intended to have equal numbers of males and females both in affected and non-affected villages, there were 200 male and 200 female respondents. The mean age of the respondents was 44.83(Range21-87, SD±0.705). The mean income was INR 5160(Range 4695 – 5624, SD 4724). There was a slight difference between mean income of affected and non-affected villages (INR5449 and INR4871). In the affected villages, 47 respondents worked for the Mahatma Gandhi National Rural Employment Guarantee Scheme, 47 were agricultural/construction workers, 31 respondents were engaged in other service jobs, 30 respondents owned micro level enterprises, 21 were at home as they were housewives or retired or elderly or students. There were 18 farmers, 13 livestock breeders, and 2 were unemployed. Similarly, in the non-affected villages, more than 63 of them were agricultural/construction workers, 56 were engaged in Mahatma Gandhi National

Rural Employment Guarantee Scheme and 52 were farmers. There were 25 livestock breeders, 22 were at home as they were housewives or retired or elderly or students and 20 were engaged in other service jobs, 8 engaged owned micro level enterprises, and 4 were unemployed. It is important to note that most of them were engaged in multiple professions in different part of the year as the activities are seasonal in nature. In terms of ration card type an indicator of poverty status, 67% of the respondents were holding below poverty line (BPL) card, 30% of the respondents were holding above the poverty line (APL) card and 3% of the respondents hold Annapurna Yojana Card in the affected villages. Similarly, 68% of the respondents were holding BPL cards, 32% of them holding APL card in the non-affected villages.

Social stratification

About 62% of the respondents were from Backward Classes (BC), about 30% were Most Backward Classes (MBC), 8% were Scheduled Castes (SC) and 1% of the respondents were from general category in the affected villages. On the other hand in the non-affected villages, about 66% of them were SCs, 26.5% were BCs and 8% of them were MBCs.

The Landholdings of respondents in affected and non-affected villages.

Only 35.5% of the respondents were holding agricultural land in the affected villages compared to 51% of the respondents were holding agricultural land in non-affected villages. This gives an idea of how the affected villages had significantly lower landholding compared to that of non-affected villages.

Details of landholding

Among those who hold land (173) details of landholding are presented in Table 1. This clearly shows there is a similarity in landholding pattern in affected and non-affected villages. In fact the land holding in affected villages are higher in 1 to 2 acres and more than five acres categories. In total more people hold land (102) in non-affected villages compared to affected villages (71) out of 173. This indicates clearly there exist an imparity in terms of landholding that points to the problem of holding agricultural land.

Type of ownership on landholding

Further, a question on the kind of ownership of the land was asked among the 173 respondents in affected and non-affected villages. A total of 140 respondents cultivated on their land. Of those cultivated, 53 were from the affected villages and 87 were from the non-affected villages. In total, 26 respondents did not cultivate in their land. Of those, 15 were from the affected villages and 11

were from the non-affected villages. A total of 4 respondents have leased their land to others, of those, one respondent was from the affected village and 3 were from the non-affected villages. There was a respondent who cultivated in the leased land in the non-affected village and 2 in the affected villages had cultivated on a partnership basis.

Irrigation of land

A question on whether the agricultural land held by them was irrigated; out of 71 landholders in the affected villages 27 have irrigated their land. While in the non-affected villages, out of 102 landholders, 67 have irrigation their land.

Type of crops cultivated

To understand the type of crop cultivated among those who hold land, the following were reported (Please refer Table 2). Out of 84 cultivating farmers, 39 in affected villages and 45 in non-affected villages cultivated cereals crops such as, corn or maize, legumes, black gram. In the remaining, 19 in affected villages and 16 in non-affected villages cultivated vegetable or fruit. There were 10 in affected and 25 in non-affected villages raised trees. Seven in affected and 30 in non-affected villages cultivated flowers. There were 37 farmers in the non-affected villages cultivated paddy and 15 in affected villages engaged in cotton cultivation. There were 13 in affected and 12 in non-affected villages did not use their land for any cultivation.

Land classification

Based on the standard (wasteland, grazing land, grove land, sown land, and current barren land) land classification, the following were found in the study villages. There were no forest land, non-agricultural use land, and arable wasteland in the study villages. There was a grazing land in the non-affected village and wasteland only in the affected village. There were 54 in affected villages and 91 in non-affected villages sown their lands, and there were 6 in the affected villages and 12 in the non-affected villages had grove lands.

Duration of cultivation

In response to a question on whether they are cultivating thei agricultural land all through the year, it was found that out of 71 agricultural land holders in the affected villages only about 33% of them cultivated their land throughout the year. On the other than out of 102 agricultural land holders in the non-affected villages, about 62% have cultivated their land throughout the year. The less number of land holders cultivate in the affected villages compared to the non-affected villages is contributed to the problems associated with the pollution.

Water Pollution

Three fourth of affected village population and one third of nonaffected villages reported water pollution. In the non-affected villages there were agro-based industries that contributes to water contamination. The types of changes experienced due to water pollution are as follows. Changes in the quality of water in terms of tastelessness of water, salinity, and not fit for cooking was also reported. Overall, there are more problems found in the closer to the tanneries than the farther villages. The problems such as green deposits caused by the tannery wastes and foul smell are evident that it is unique only to the tanneries.

Pollution of water sources

The environment surrounding of villages were polluted higher in the affected villages compared to non-affected villages as they are in the affinity to the tanneries. Most of the water sources in the affected villages are polluted and the skins are floating on them.

Effect on Agriculture and Livelihood

It is found that the soil and water that are polluted in the affected villages have reduced the agricultural production. The alkalinity of the soil and the hard water made the agriculture production bare minimum. It also affected the livestock population and the people are left without any source for livelihood.

Migration

The villagers are forced to migrate out of villages as the pollution level is above the tolerance level. People started working in the spinning mills and other service sector for their survival.

Social Impact

The social impact of the pollution is many fold. The men in the villages affected by tanneries are not preferred by women for their marriage due to the mentioned problem of pollution and its impact. In terms of conflict, there were not any kind of conflict due to pollution. However, quarrels due to water was observed to be major issue.

Discussion

About 36% and 51% hold agricultural land in affected and non-affected villages respectively. Out of those hold land 53 and 87 have cultivated their land from affected and non-affected villages. Out of 71 land holders 27 have irrigated their land in the affected villages and out of 102, 67 have irrigated their land in the non-affected villages. One third of affected village and two thirds of non-affected village cultivated their land throughout the year. 72% in affected and 32% in non-affected villagers consumed polluted water. The villages around the tanneries experienced pollution problem than the farther villages. The problems reported from affected villages are, skin diseases, fever, dental problems, hair loss, looking older, skin wrinkles, rashes and itching in body, overall deterioration of health, land became uncultivable, and livelihood. Villagers felt the tanneries made their life not liveable and the livelihood was affected. There were problems in livestock, reduction in agricultural production, polluted irrigation, infertile farmland due to soil pollution and, poor quality of produce reported. Highlighting the economic benefit over environment have no merit as the problem prevail more than 30 years. Ignoring this tannery pollution by the policy makers and politicians is suggestive of a nexus between the economic gains over the livelihood of rural population.

Qualitative Findings

Findings of qualitative data clearly shows the agriculture and other activities that affect livelihood has been affected by the tannery pollution in the affected villages. The villages that were cultivating wet crops has shifted to dry crops. Also, the water and soil have been badly affected that made many to move out of villages. In the recent past some tanneries have been closed due to the resistance from the communities. Drinking water is a common problem in both affected and nonaffected villages, shows the qualitative findings.

Conclusion

A debate on environmental pollution and economic benefits did not prove its merits that are clearly evident from the findings of this study. Even after 30 years, the problem of tannery pollution still in its place and it is adding its adverse effects on the livelihood of the population in Dindigul.

Report on

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Srinivasan Kannan PhD

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Contents

I Introduction

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1. Background

Poisoning associated with pollution adversely affects both health and environment in turn affects society as a whole, this disturbs the social structure, pattern of interaction and power structure in society. Pollution of air, water and soil poisons the environment and cause diseases. The illness in a social context needs further exploration in this particular context. That also led to reduction in agricultural production, drinking water contamination, and cause illness to both human and animal. That is how it is contributing to alterations in social structure specifically the social institutions. By studying the problem of pollution, we address the impact of pollution on health, society and environment as a whole. Studies focus mainly on the social determinants of health and wellbeing but fail to see how these practices adversely affect the society as a whole.

Another important source of life is water. Due to pollution of water the water resources that are lifeline to the ecosystem and the society are contaminated and make the life difficult to live. This also creates competition and distress among the inhabitants who depend on those water sources. Clean water supply is not just one of the determinants for public heath for the harmonious life in a society. Being a factor of production in agriculture and other secondary sectors, the economic impact on that is very huge. Use and abuse of water lead to scarcity of water and will ultimately contributes to climate and social change. As the environment literature suggests, climate change increases the water demand and industrialization pollutes the existing water resources. Both generates imbalance I social and physical environment. They also create a stress on the water resource and adversely affect the health and wellbeing of the population.

2 Review of Literature

2.1 Introduction

Water resources are lifelines to the ecosystem and society. According to World Economic Forum, for sustainable development one of the concerns along with forest loss, land conversion, decline in species and climate change was water stress(Agenda, 2016). Clean water supply is one of the determinants of social wellbeing. Water is also a factor of production in agriculture. Use and abuse of water cause scarcity of water, reduction in agricultural production and affect the livelihood of the population. Excess fresh water consumption and pollution due to human activities pressurises availability of water and impact food security, environmental quality, economic development, and social wellbeing(Ercin, 2018). Scarcity of fresh water will be aggravated in future due increase in

demand for water and decrease in availability and quality(Ercin, 2018). That will also cause problems in food security and environmental sustainability(Ercin, 2018). According to World Economic Forum world risk report, 2016, India reported reduction in crop yield by around 20%(Klaus, 2016). To add to the water stress, the rampant industrial pollution contaminates the limited available water resources(Schulte and Morrison, 2014). The water stress on the water sources, adversely affects the environment and livelihood of the population. Reduction in the limited available water leads to serious economic loss(Meier, 1977). The substantial monetary burden on rural communities is caused by industrial pollution(Reddy and Behera, 2006). The livelihood of rural dwellers was greatly affected as the effluents from the industries damaged their water resources(Oluseyi et al., 2011) by adversely impact on environmental biotic and abiotic factors(Shah, SN. Manzoor, S. and Asim, 2021). Water also contributes to social capital in community-based irrigation, drinking water delivery systems(Kähkönen, 1999). The industries dump the solid waste in an open area and discharge untreated wastewater that in turn negatively affects the health of the households and environment(Mamuye Bayu, 2018). This is not only applicable to larger industries even the small rural industries pollutes rivers and make the water unsafe for human consumption(Wang et al., 2008). Larger corporations such as Cracker and Polymer industries pollute rivers that impact the health, lives and livelihood of the population who live near rivers(Mech and Hazarika, 2018). Industrial wastewater pollution along with municipal wastewater contaminates the water in the rural areas with heavy metals and that in turn affect agriculture, aquaculture, livestock drinking, and recreational activities(Mekuria et al., 2021). In addition, the river also had to deal with fertilizer use water pollution(Zhou et al., 2021). The pesticide pollution in water systems was above permitted levels affecting the health of the population(Veiga et al., 2006). People who use polluted surface water sources for drinking, cooking, bathing and clothes washing increases the risk of diarrheal diseases and stunting among children(Kulinkina et al., 2020). This makes children engage in the collection of water and that affects their education(Choudhuri and Desai, 2021). To address the problem we have to integrate social and physical science for water management(Lund, 2015). The experience of the efforts made in the budget-constrained environment was found not feasible(Shortle et al., 2012). So it is important to consider social responses in environmental and water resources planning(Walker et al., 2015). Otherwise, this will lead to conflicts during the water collection between the inhabitants

and also within the households(Mallick and Fernanda Roldan-Rojas, 2015). Water pollution should be given the same level of importance similar to that of air pollution(Fu et al., 2020).

In the town of Dindigul, Tamil Nadu in South India, Kudaganaru river was found to be polluted by 17 tanneries by discharging their effluents and affecting 15 villages who depend on the river was raised by the community initiatives demanding water rights(Trust, n.d.). There were efforts by the Legal institutions such as Supreme Court of India by establishing 'Lost of Ecology Authority' in 1996 and subsequent legal battles by the villagers on insufficient compensation and judgement by the Madras High Court were suggestive of unending problems faced by the rural population(Asha, 2002). Both the Apex court and the State Court were based their arguments emphasizing on "precautionary principle" and the "polluter pays" was to be implemented by the 'Lost of Ecology Authority' established for this purpose(Court, 2014). There were efforts by the State Pollution Control board by establishing Common Effluent Treatment Plant through an agency since 1997 and it was fully functional from March 2012. There were already 49 tanneries joined with the agency for treatment(TNSPCB, n.d.). From the above it is clear that tannery pollution adversely affects both the health of the population and the environment. The Pollution of water further, pollutes the soil and reduces agricultural production, making the drinking water contaminated, and also disturbs the livelihood of the population. The present study aims at studying the impact of industrial pollution on water, agriculture and livelihood of people in Dindigul district, South India.

The study aimed at answering the following questions:

What are the effects of tanneries pollution on water in Dindigul?

- What are the effects of industrial pollution on water, agriculture and livelihood of the population live in around the tanneries in Dindigul?
- What are the long-term consequences of industrial pollution on the rural environment and livelihood the population live in and around the tanneries compared to those villages that are located farther to the tanneries?
- What are the perception of tannery pollution on the environment and the lives of rural population in Dindigul?

What are the concerns related to safety of food, livestock and agriculture due to the pollution due to pollutants dissolved in the water and soil among the villagers who live in and around the tanneries in Dindigul?

3 Justification / Rationale for the study

Due to the industrialization in Dindigul, drinking water contamination in the surrounding villages, and migration of the population that contributes to the re-emergence of some of the infectious diseases. Use of Chromium in the tannery industry causes different problems. This affects the environment the social structure and interactions. To achieve sustainable development one need to look into all aspects of society.

The present studied social and environmental impact of industrial pollution on the population of Dindigul District, Tamil Nadu. During 1989-90, principal investigator of this study has done a study on Environmental impact of Tannery pollution on rural areas of Dindigul district for his Master's thesis.

Besides, the researcher also would like to document, the distribution and determinants of health and diseases morbidity, injuries, disability and mortality in population due to water pollution in addition of the social impacts. The researcher would also like to study the exposure of individuals to the industrial and occupational environment. The study will look into the degradation of air, water and food and study toxicity of chemicals such as Chromium and their forms as perceived by the population. Is there a reemergence of infectious diseases due to water contamination, skin and breathing disorders and their effect on social interactions, exclusion and so on?

4 Objectives of the study

The study on Social, Economic, and Health Impact of Industrial Pollution in Dindigul District, Tamil Nadu is on the impact of industrialization on the rural environment and population health. The objectives of the study are,

(1) Study water contamination caused by the tannery pollution and its effects on health, environment and society in Dindigul District.

Specifically, the study will focus on the following;

(2) Effects on livestock, agriculture, water and soil,

(3) Long-term consequences of industrial pollution on the rural environment in terms of social structure, the land owning and other economic wellbeing in the surrounding areas of tanneries.

(4) Specific consequences such as illnesses, deaths and other events in the villages.

The study will look in to degradation of air, water and food and study toxicity of chemicals such as Chromium and their forms as perceived by the pollution, Is there reemergence of infectious diseases due to water contamination, skin and breathing disorders and their effect on social interactions, exclusion and so on will also be studied.

II Methodology

2 Methodology

It is a cross-sectional study conducted using both quantitative and qualitative methods from the villages surrounding the tanneries in Dindigul 10 villages were drawn randomly. For this purpose the researcher himself select the villages based on the location by visiting the villages and the list he has already from the earlier studies. 10 villages were drawn near Chinnalapatti, which is located 15 kilometres away from the affected the villages in the town.

2.1 Study type / Design

For the mentioned objectives, the explanatory design was adapted. The study will have three components. A quantitative survey using an interview schedule conducted among the members of the selected villages of Dindigul, district. Specific questions on Social, Economic and Health impacts of industrial pollution will be administered. There will be two different locations, one closer to the Tanneries and villages located 10 Kilometres away from the Tanneries. Even the later villages there are other industries such as handlooms. This will help to understand the difference in the impact of industrial pollution with specific reference to tanneries. The Qualitative data to conducted in-depth interviews among the village leaders and Focus Group Discussions among the community members. The basic water and soil tests form the villages near tanneries will give additional pieces of evidence to understand the physical effects of pollution on the rural environment. This study has three components.

1. Primary data collection using an interview schedule
2. Qualitative data collection
3. Water and Soil testing from the samples collected from the affected and non-affected villages.

2.2 Study Setting

Dindigul District, Tamil Nadu.

2.2.1Participants and Sample Size

All men and women above 18 years in selected villages in Dindigul district will be included in the study. It is proposed to study the two sets of 10 villages, (a). Located near the tanneries and (b). Located away from the tanneries. It is proposed to collect data from each of the selected 400 households. Basic information about the respondents and all the member of the households will be

collected. Besides, the social, economic and health impacts of industrial pollution will be collected from the respondents.

2.3 Sampling

In total there will be 400 respondents for the quantitative study. Sample size calculated using OpenEpi, Version 3, open-source calculator with an assumption that the proportion of the population in the villages located near tanneries having the intention to displace themselves from those villages is 65% and the same for the villages located farther from the tanneries as 40% with the 95% confidence interval, with 90% power, with the ratio of controls to cases as 1 estimated 90 each for both the set of villages. Double the size for design effect due to multistage sampling of clusters and it was rounded to 200 each to account for refusals or ending up with incomplete interviews. This will lead to 400 respondents studied using a structured toll for a quantitative study. It is proposed to have 50% of the respondents to be women. Respondent selection for the quantitative study will be randomly drawn from the Electoral list from the selected 20 villages of Dindigul district.

For qualitative component of the study, 10 Focus Group Discussions (FGD) in affected villages and 10 FGDs in non-affected villages will be conducted to discussed on the importance of water on social and economic aspects of the population. There will also be 10 in-depth interviews among the village leaders of the affected villages and 10 in-depth interviews from the non-affected villages on the topic. There are 10 cases studies, which are based on the relevant cases, and interest to the researcher that will make the researcher understand the subject better. Besides, the investigators will be engaged in observation and documentation some of the physical characteristics of the villages. Outline of the villages will be drawn using members of the community on water and agricultural sources. For objective 3, water and soil samples will be collected from the villages located near the tanneries in Dindigul. All men and women above 18 years of age are included in the study. However, those who are not having good health and unable to participate will be excluded.

2.3.1 Sample Selection Methods

The list of affected villages was drawn from the one division out of two divisions and respective Taluks (3), Blocks (4), Panchayats (21) based on the preliminary field visit, villages (81), and Wards (76) were generated. The panchayat selected to be included 10 drawn out of 21.

Similarly, the non-affected villages were drawn from the one division out of two divisions and respective Taluks (2), Blocks (2), Panchayats (15) based on the preliminary field visit, villages (89), and Wards (80) were generated. The panchayat selected to be included 10 drawn out of 15 (village list separate sheet attached). The both areas each panchayat were selected one village for randomly, each village were selected one or two wards depends upon the situation of the village. Also, the voters list of all the voters from the 20 villages were downloaded from election commission website the team drawn samples for the purpose of collecting data. Then, separated the male and female voters list separately from the selected village and collected data from 10 male and 10 females' respondents in each selected village. (Sample selection chart Separate sheet attached). The Kobo toolboxes prepared for the purpose of data have been developed and tested the analysis.

Table 2.1 Sample Size Selection Chart

	Division	**Taluk**	**Block**	**Panchayats**	**Villages**	**Wards**
Affected	1	3	3	21	81	76
Non-Affected	1	2	2	15	89	80

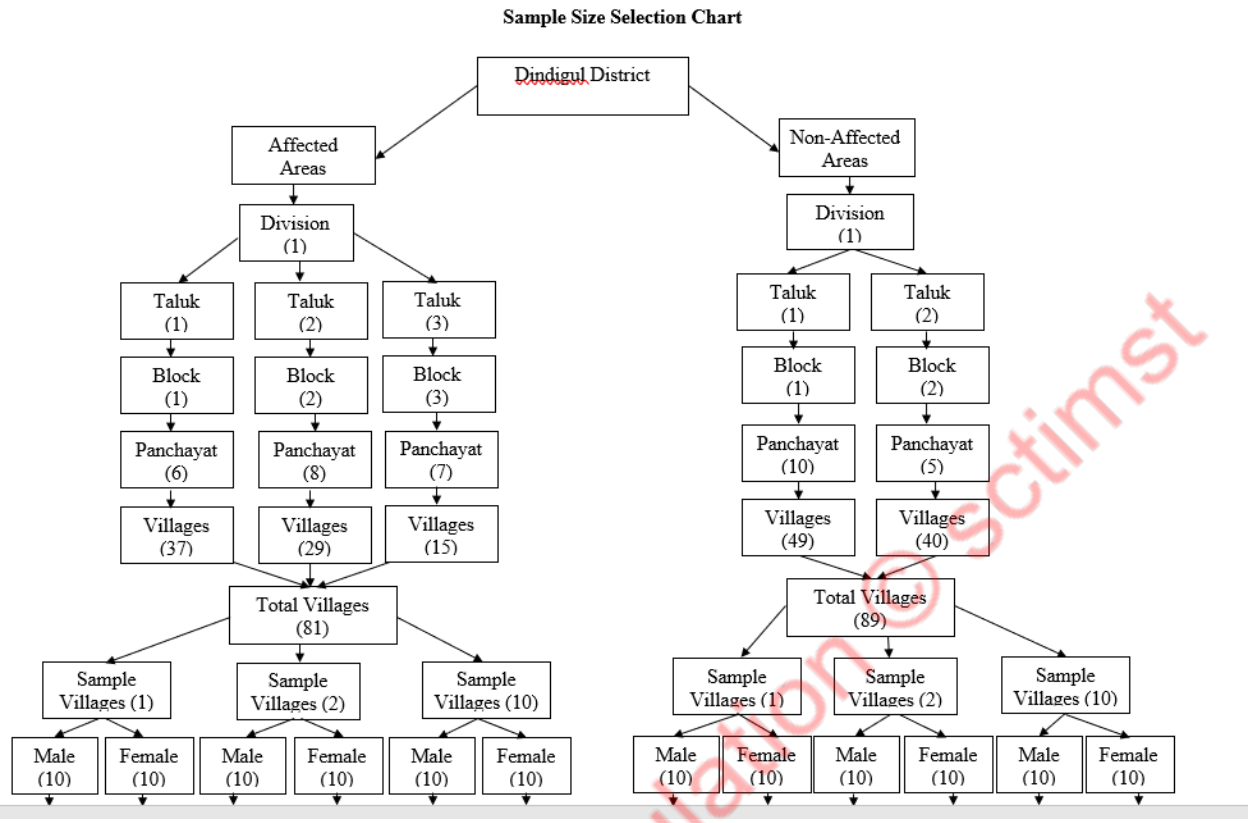

Fig 2.1 Sample Size N= 400

Table 2.2 List of Affected Sample Villages

S.No	Name of the Panchayats	Name of the Villages	Ward No.
1	Adiyanuthu	Mottanampatty	2
2	Ponmandurai	Ponmandurai	2
3	A.Vellodu	Sirunayackenpatty	4
4	Kalikkampatty	Kottaipatty	2
5	Pillaiyarnatham	Kuttiyapatty	2
6	Vakkampatty	Vakkampatty	5
7	Veerakkal	Veerakkal	2
8	Ammapatty	Ammapatty	1
9	Anumanthuraiyankottai	Susaipatty	1
10	Konur	Konur	8,9

Table 2.3 Non - Affected Sample Villages in Dindigul District

S.No	Name of the Panchayats	Name of the Villages	Ward No.
1	Jambuthuraiyankottai	Jallipatty	3
2	Kottur	Suttikaladipatty	5
3	Pachamalaiyankottai	Sedapatty	2
4	Ramarajapuram	Sadaiyampatty	1
5	Silukkuvarpatty	Kuppapalanipatty	5
6	Ambadurai	Muruganpatty	7
7	Aathoor	Aathoor	3,5
8	Ayyankottai	Ayyankottai	2,3
9	Bodikammavadi	Bodikammavadi	2,3
10	Palayankottai	Kamanpatty	1,2

2.4 Data Collection Techniques

- Interview schedule developed for this purpose will be used for quantitative study.
- Checklists for in-depth interviews and Focus Group Discussion will be used for qualitative methods.

2.5 Variables and Data Sources

The dependent variables for the study are the change in social structure, interaction and control over the resources, the opportunity cost of pollution, and illnesses associated with industrial pollution. The independent variables identified through the preliminary literature review are as follows. Household characteristics such as, gender, age, marital status, literacy, live and work outside the village, monthly income, occupation, poverty status, caste status, migration, expenditure and savings, land use and agriculture, housing and infrastructure, drinking water quality, sanitation facility, environmental factors, health and illness, perceptions and expectations on pollution, social integration and cohesion, natural increase, physical environment, and problem and suggestions on industry pollution.

2.6 Training of Field Investigators

Project Investigator and Research Associate to conducted one day training programme on "Social, Economic and Health Impact of Industrial Pollution" for participated on field investigators. The training was conducted at Dindigul Institute of Cooperative Management in Dindigul, Tamil Nadu. The project investigator had given training for first section an overviews and introduction of industrial pollutions in affected and non-affected areas: water, soil, land and air. For second section the social and economic impact of industrial pollution and health impact of industrial pollution-peoples and animal. Third section the introduction to Methodology. For fourth section the project investigator and research associate to joint deliver training for how to use tablet computers – quantitative & qualitative of data collection, information sheet and consent form. Fifth section the research associate to rapport building with villagers – sample respondents - sharing field work experience and last sixth section for discussion and clarifications. Then, finally the cooperative institute principal and project investigator distributed training certificate to field investigators and participators.

2.7 Data Collection and Analysis

Date will be analysed using SPSS for quantitative data and manual methods for qualitative data. The data will be analysed for all aspects associated with the problem of industrial pollution and its impacts on Social, Economic and Health. The impacts of social aspects will be analysed by studying how it is affecting the social structure, interaction and control over the resources. For economic impact, the opportunity cost of pollution on the livelihood will be studied. For health, the specific illnesses associated with industrial pollution will be studied.

For Water and Soil testing from the samples collected from the affected and non-affected villages, the following test will be performed.

1. Biochemical oxygen demand (BOD) will be measured.
2. Saline deposits over the soil make crop production unsuitable. Thus, the following parameters will be measured for the collected water samples at School of Chemistry, Madurai Kamaraj University, Colour, Odor, Turbidity, Electrical conductivity, pH, Total Alkalinity, Total Hardness and Softness, Metal Ions such as Ca, Mg, Fe, Mn and anions such as NO3-, C1-, F-, S042- and phosphate. The soil samples will be dried. Atomic Absorption Spectroscopy (AAS) and inductively coupled plasma mass spectrometry (ICP-MS) will be measured for metal content.

2.8 Ethical Considerations

The Principal Investigator obtained the Ethical clearance of the Institute Ethics Committee, Sree Chitra Tirunal Institute for Medical Science and Technology, Trivandrum. It is a community-based study. The study will be conducted in the Dindigul District of Tamil Nadu. The PI will directly contact the villagers for the study. For the water and soil testing, a chemistry expert from Madurai Kamaraj University will collaborate and support. Only patients voluntarily consent for the study will be included in the study. They advised about the voluntary nature of participation and their right to withdraw from the study whenever they feel so. The participant information sheet and informed consent form are prepared in lay language to make sure that each participant thoroughly comprehends the nature of the study and what is expected from them during the study. Data collection will be scheduled as convenient to the participants. Study is not directed at any particularly vulnerable population. No harms are involved in the study.

The researcher will ensure the confidentiality of participants and data security by undertaking certain measures as given below.

1. The communication details of the principal investigator are mentioned in the participant information sheet. Each participant can contact for further clarifications if needed.
2. Data will be collected at place and time convenient for the participants.
3. The researcher will ensure privacy.
4. The personal information of the participants masked during analysis.
5. The researcher will remove face sheets containing identifiers from survey instruments after the data entry.
6. Data will not be shared with anyone.
7. Principal Investigator will keep the data safely.
8. Computerized records will have codes for anonymity.

2.9 Preliminary Field Visit

In Dindigul district, the project investigator and Research associate made preliminary field visits to villages affected by tanneries waste. First, we visited the villages of Madurai South Road, Batlagundu Road and Ponmanthurai Palani Road. Namely, the most affected villages visited were Bagambur, Saveriyapalaiyam, Thomaiyarpuram, Kuttiyapatty, Pithalaipatty, Paraipatty, Muthalagupatty, Kudaiparaipatty, Kottappatty, Ponmandurai, Puthupatty, Poolamarathupatti, and Ramaiyanpatty. Similarly, leather waste stagnant ponds around the villages were also visited. That is, pools like Duraikulam, Senkulam, Ayyankulam, Alankulam, Ramaiyankulam were also found to be polluted with leather waste.

2.10 Pilot Study

The Research Associate developed online kobo tools and tested dummy data prior to the data collection. The team visited the sample villages and collected data for the pilot study. The team visited 10 affected sample villages, 22 interviews from the sample respondents and 2 In-depth interviews among the affected village leaders in Dindigul district during June - August 2020.

At the time of the pilot inspection the research associate had encountered a lot of problems. The village could not be reached easily due to Covid-19. Some people do not want to answer interview questions with us because of Covid-19. None of the villagers were able to go to work after the lockdown due to Covid-19. Then, with the government giving some relaxations in lockdown, everyone is going to work for their livelihood. The villagers are home only on Sundays. However, we could not go to the village on Sunday due to a full lockdown in the Tamil Nadu government. We were unable to recruit field investigators due to Covid-19. There has been a delay in gathering information due to lack of proper transport facilities.

2.11 Appointment of Research Associate

There were also in-depth interviews among the village leaders of the villages and on the topic. There one Research Associate appointed for the full project duration will supervise the quantitative data will do the qualitative data collection. The research associate will also do the qualitative data collection. In addition, there were two investigators engaged in data collection. The tools for reviewed by Institutional Ethics.

2.12 Appointment of Field Investigators

The project entitled "Social, Economic, and Health Impact of Industrial Pollution in Dindigul District, Tamil Nadu, # 5387, the selection of Field Investigators was held on 09.11.2020 at 10.30 am through Google meet. The selection process contacted by Prof. Sinivasan Kannan, Project Investigator, Dr Raja Alias Piranmalai, Professor and Head, Department of Rural Industries and Management, Gandhigram Rural Institute, Dindigul, Tamil Nadu, and Dr Karuppiah, Research Associate. The selected field investigators detail given below;

Table 2.4 Field Investigators

S.No	Name of the Candidates	Age	Qualifications	Marks	Google Meet Contacted Time
Selected Field Investigators					
1	MOHANALAKSHMI. R	31	M.A (Development Administration)	64%	10.35 AM
2	DIRAVIAM. P	35	M.A (Development Administration)	70%	10.40 AM
3	LOGESHWARI. A	24	M.A (Economics), MPhil	62.95%	10.30 AM
Waiting List Candidate					
1	KOWSALYA	24	MBA (Finance)	70%	10.55 AM

They are 5 candidates attended in Google meet. The needs only three field investigators. So, selected only three field investigators, one candidate for the waiting list, and rejected the one candidate based on the performance and bio-data. Then, Lokeswari automatically left before we went to collect the data.

2.13 Visited Institutions

- The Project Investigators visited Gandhigram Rural Institute during 23rd to 25th of October 2019 for the purpose of recruitment of research associate appointment.

- Project Investigator visited Madurai Kamaraj University on 14th February 2020 to discuss about water and soil testing with Dr Mayil Murugan, of Department of Chemistry.
- Research Associate met the Members of an NGO work on Tannery pollution, 'Seeds Trust' in Dindigul on 15th February 2020.
- Research Associate met the Gandhigram Rural Institute (Deemed to be University) in Social Science various departments' professors. For the purpose of recruitment of field work investigators as on 12th August 2020.
- The research associate was also involved in collection of water samples from the ponds from the affected and non-affected villages and subsequently handed over to a Dr. Mayilmurugan, Professor at Department of Chemistry, Madurai Kamaraj University, Madurai for chemical analysis.

III Results

3. Results

3.1 Social demography details

Table 3.1 Male and Female Distribution of Respondents N=400

Sex				
		Affected Villages	**Non-Affected Villages**	**Total**
Sex	Male	100	100	200
	Female	100	100	200
Total		200	200	400

As intended during the data collection by the research team purposefully selected equal number of males and females both in affected and non-affected villages as shown in table 3.1.

Table 3.2 Age of Sample Respondents N=400

		Affected Villages			**Non-Affected Villages**			**Total**		
		Male	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Grand Total**
A6: Age	< 30	26	17	43	16	25	41	42	42	84
	31-40	29	19	48	20	17	37	49	36	85
	41-50	21	31	52	20	22	42	41	53	94
	51-60	18	16	34	31	19	50	49	35	84
	> 61	6	17	23	13	17	30	19	34	53
Total Respondents		**100**	**100**	**200**	**100**	**100**	**200**	**200**	**200**	**400**
Mean		43.45			46.21			44.83		
Median		42.5			47.5			45		
Standard Deviation		13.285			14.776			14.1		
Minimum		21			22			21		
Maximum		75			87			87		

The age distribution of respondents is similar in both affected and nonaffected villages (Please refer Table 3.2). The mean age of the respondents is also more or less same. There was a small difference in the age distribution among males and females in affected and nonaffected villages.

Table 3.3 Monthly Income for Sample Respondents N=400

Respondents Monthly Incomes	Affected Villages			Non-Affected Villages			Both Villages		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Overall Total**
Salary Not Received = 0	6	13	19	4	15	19	10	28	38
< 5000	29	72	101	33	72	105	62	144	206
5001 - 10000	53	11	64	54	11	65	107	22	129
10001 - 15000	10	1	11	7	2	9	17	3	20
15001 - 20000	2	2	4	2	0	2	2	2	4
> 20000	0	1	1	4	15	19	2	1	3
Total Respondents	**100**	**100**	**200**	**100**	**100**	**200**	**200**	**200**	**400**
Mean	5449			4871			5160		
Median	5000			4250			5000		
Standard Deviation	5312.155			4044.732			4724.118		
Minimum	0			0			0		
Maximum	52000			28000			52000		

Table 3.3 shows the income distribution of respondents. The income earned in the affected in the villages are more than of the nonaffected villages. The mean income is about Rs.600 per month higher in affected villages compared to that of nonaffected villages.

Table 3.4 Types of Houses N = 400

Types of Houses			
	Affected Villages	**Non-Affected Villages**	**Total**
Built using Brick / Mud / Stone / Hollow block	146	188	334
Built using concrete	99	88	187
Asbestos sheet house	38	32	70
Thatched house	10	5	15
Tiled roof house	71	84	154
Other type of house	5	5	10

Table 3.4 Presents the types of houses of the sample respondents in affected and non-affected villages. In highest of 146 respondents and 188 respondents have resided in the built brick, mud, stone, and Hollow bricks house in both affected and non-affected villages respectively. Which was followed by 99 respondents and 88 respondents have resided built using concrete, in 71 respondents and 84 respondents have tiled rood house, in 30 respondents and 32 respondents have asbestos house, 10 respondents and 5 respondents have thatched house, and 5 respondents have other houses resided the both affected and non-affected villages respectively. Similarly, in overall total 334 respondents have resided the built brick, mud, stone, and hollow bricks house, 187 respondents have built using concrete house, 154 respondents have tiled rood house, 70 respondents have asbestos house, 15 respondents have thatched house, and 10 respondents have other house resided the sample villages respectively. While five respondents each lived in other types of houses in both affected and non-affected villages. While 38 and 32 respondents lived in houses having the asbestos sheet in both affected and nonaffected villages respectively.

Table 3.5 Types of Family N=400

Types of Family				
		Affected Villages	**Non-Affected Villages**	**Total**
Types of Family	Nuclear Family	141 70.5%	146 73%	287 71.75%
	Joint Family	56 28%	48 24%	104 26%
	Single parent Family	3 1.5%	6 3%	9 2.25%
Total		200 100%	200 100%	400 100%

Table 3.5 Presents the family types of the sample respondents in affected and non-affected villages. In 70.5% of the respondents live in nuclear family; in 28% of the respondents live in the joint family and 1.5% of the respondents in single parent family in affected villages. At the same time, in 73% of the respondents live in nuclear family, in 24% of the respondents live in joint family and 3% of the respondents live in single parent family in non-affected villages. But, in overall total 71.75% of the respondents live in nuclear family, 26% of the respondents live in joint family and 2.25% of the respondents in single parent family in overall total sample villages. The percentages of majority of the people live in nuclear family in the sample villages.

Table 3.6 Occupation of the sample respondents N = 400

Occupation of the sample respondents			
	Affected Villages	**Non-Affected Villages**	Total
Farmers	18	52	70
Mahatma Gandhi National Rural Employment Guarantee Scheme	47	56	103
Culinary work / cottage industry / business	30	8	38
Agricultural Wages / Construction Workers	47	63	110
Housewife / Retired or Elderly / Student	21	22	43
Raising livestock	13	25	38
Factory Employee / Security Employee (Security)	31	20	51
Unemployment	2	4	6
Others	36	25	61

Table 3.6 presents the occupation of the sample respondents in affected and non-affected villages. In the affected villages, 47 respondents for the Mahatma Gandhi National Rural Employment Guarantee Scheme and agricultural wages / construction workers, which was followed by 31 respondents for factory worker / security guard, 30 respondents for cooking / cottage industry / business, 21 respondents for housewife / retired or elderly / students. 18 respondents for farmers, 13 respondents of the livestock breeders and only 2 of the respondents are unemployment in the affected villages. Similarly, in non-affected villages, more than 50 of the respondents are agricultural laborers / construction workers, Mahatma Gandhi National Rural Employment Guarantee Scheme and farmers, which was followed by the between 25 to 20 respondents were raising livestock, respondents for housewife/retired or elderly students, and factory employee / security employee, 8 respondents for cooking / cottage industry / business, and 4 respondents are unemployment respectively. But, in overall more than 100 respondents are agricultural laborers / construction workers, Mahatma Gandhi National Rural Employment Guarantee Scheme, which was followed by 70 respondents for farmers, 51 respondents for factory employee / security employee, 43 respondents for housewife/retired or elderly students, 38

respondents for raising livestock, and cooking / cottage industry / business, and only 6 of the respondents are unemployment in the sample village. The most of the respondents work in multiple professions.

Table 3.7 Monthly Family Income N=400

Family Monthly Income				
		Affected Villages	**Non-Affected Villages**	**Total**
Family Income	<10000	125 62.5%	99 49.5%	224 56%
	10001 - 15000	50 25%	63 31.5%	113 28.25%
	15001 - 20000	13 6.5%	23 11.5%	36 9%
	20001 - 25000	4 2%	4 2%	8 2%
	25001 - 30000	3 1.5%	5 2.5%	8 2%
	> 30000	5 2.5%	6 3%	11 2.75
Total		200 100.0%	200 100.0%	400 100.0%

Table 3.7 presents the family monthly income distribution of respondents in affected and non-affected villages. About 62.5% of the respondents earn less than 10000 /- rupees per month. Only 2.5% of respondents earn more than 30000 /- rupees per month. When we look in to the distribution, 25% respondents earn in range of 10001-15000 followed by 6.5% respondents earn in range of 15001-20000, 2% respondents earn in range of 20001-25000 and 1.5% in the range of 25001-30000 in affected village. While, 49.5% of the respondents earn less than 10000 /- rupees per month. Only 3% of respondents earn more than 30000 /- rupees per month. When we look in to the distribution, 31.5% respondents earn in range of 10001-15000 followed by 11.5%

respondents earn in range of 15001-20000, 2.5% respondents earn in range of 25001-30000 and 2% in the range of 20001-25000 in non-affected village. Similarly, in overall total 56% of the respondents earn less than 10000 /- rupees per month. Only 2.5% of respondents earn more than 30000 /- rupees per month. When we look in to the distribution, 28.25% respondents earn in range of 10001-15000 followed by 9% respondents earn in range of 15001-20000, and 2% respondents earn in range of 25001-30000 and 20001-25000.

Table 3.8 Land holdings N=400

Land Holdings				
		Affected Villages	Non-Affected Villages	Total
Land Holdings	Yes	71 35.5%	102 51%	173 43.25%
	No	129 64.5%	98 49%	227 56.75%
Total		200 100%	200 100%	400 100%

Table 3.8 presents the Land holdings of sample respondents in affected and non-affected villages. Only 35.5% of the respondents hold agricultural land in in the affected villages compared to 51% of the respondents hold agricultural land in non-affected villages. In total 43.25% of the respondents hold agricultural land in the sample villages. This gives an idea of how the affected villages significantly lesser than non-affected villages

Table 3.9 Land Acres details of Household Members N=173

Land Acres details of Household Members				
		Affected Villages	**Non-Affected Villages**	**Total**
Land Acres details of Household Members	< 1	23 32.39%	33 32.35%	56 32.37%
	1.01 - 2	31 43.66%	26 25.49%	57 32.95%
	2.01 -3	8 11.27%	17 16.67%	25 14.45%
	3.01 - 4	6 8.45%	18 17.65%	24 13.87%
	4.01 - 5	0 0%	5 4.90%	5 2.89%
	>5	3 4.23%	3 2.94%	6 3.47%
Total		**71**	**102**	**173**

Among those hold lands(173) details of land holding are discussed in Table 3.9. In 43.66% of respondents have 1 to 2 acres in affected villages, followed by 32.39% of respondents with less than 1 acre of land, 11.27% of respondents with 2 to 3 acres of land, 8.45% of respondents, and 4.23% of respondents with 3 to 4 acres and 5 acres also have land, no one has 4 to 5 acres in the affected villages. Similarly, in that majority of 32.35% of respondents have below 1 acre in non-affected villages, which was followed by 25.49% of the respondents have 1 to 2 acres, 17.65% of the respondents have 3 to 4 acres, 16.67% of the respondents have 2 to 3 acres, and below 5% of the respondents have 4 to 5 and above 5 acres in the non-affected villages.

Table 3.10 Land Ownership Status N=173

Land Ownership Status			
	Affected villages	Non-Affected villages	Total
I own and cultivate this land	53	87	140
I own, but do not cultivate this land	16	11	27
I have leased this land from someone	1	3	4
I will lease this land	0	1	1
I have a partner	2	0	2

Further a question on the kind of ownership of the land was asked. Among the 173 respondents who hold land the following are found. Table 3.10 presents the land ownership status of respondents in affected and non-affected villages. The total of 140 respondents cultivates on their own land. Of these, 53 respondents are in the affected village and of these, 87 respondents are in the non-affected villages. In total 27 respondents do not cultivate on their own land. Of these, 16 respondents are in the affected villages and of these, 11 respondents are in the non-affected villages. The total of 4 respondents have leased land from someone, of those, one respondent was in the affected village and 3 of the respondents were in the non-affected villages. Their one respondent has leased land was found in the non-affected village and 2 respondents have a partner are in the affected village.

Table 3.11 Land under irrigation N=173

Land under irrigation				
		Affected villages(%)	Non-Affected villages(%)	Total (%)
Land under Irrigation	Yes	27	67	94
	No	44	35	79
Total		71	102	173

A question on whether their agricultural land was irrigated for those who hold land, the following were found.

. Out of 71 who hold land in the affected village only 27 have irrigation to their land. While out of 102 holds in the non-affected villages r 67 have irrigation to their land The overall total land under irrigation of 173 respondents has agricultural land. Of these, 94 respondents have irrigated land and 79 respondents have non-irrigated land.

Table 3.12 Cropping Pattern N=173

Cropping pattern			
	Affected villages	Non-Affected villages	Total
Paddy	0	27	27
Cereals (Corn, Rye, Maize, Legumes, Black Gram)	39	45	84
Vegetables / Fruits	19	16	35
Trees	10	25	35
Flowers	7	30	37
Cotton	15	0	15
Not cultivated	13	12	25

To understand the type of crop cultivated among those who hold land, the following were reported Please refer (Table 3.12). Of the total cultivable farmers, 84 respondents cultivate cereals viz., corn, rye, maize, legumes, and black gram. Of these, 39 respondents are in the affected village and 45 respondents are in the unaffected village. Similarly, in the 35 respondents, both vegetables/fruits and trees are produced equally. Of these, 19 respondents are cultivating vegetables / fruits and 10 respondents are cultivating trees in the affected villages. Of these, 16 respondents are cultivating vegetables / fruits and 25 respondents are cultivated trees in the non-affected villages. In the sample villages, the 37 respondents were cultivated flowers. Of these, 7 respondents are cultivated flowers in the affected village and 30 respondents are cultivated flowers in the non-affected villages. The 37 respondents are cultivated paddy in the non-affected village and 15 respondents are cultivated cotton in the affected village. However, 13 respondents in the affected village were not cultivated on their lands and 12 respondents were not cultivated in the non-affected village.

Table 3.13 Types of Land Classification N=173

Type of land classification			
	Affected villages	Non-Affected villages	Total
waste land	1	0	1
Grazing land	0	1	1
Grove	6	12	18
Sown land	54	91	145
Current barren	13	11	24

Based on the standard land classification, following are found the study area (Please refer Table 3.13). The land classification was collected based on standard classification types. In that forest land, non-agricultural use land and arable wasteland are not found in the study villages. The one grazing land was found in the non-affected village and waste land in only affected village. The majority of the land classification of 54 respondent's sown lands in affected villages and 91 respondents has sown lands in unaffected villages, which was followed by grove lands 6 respondents in the affected village and 12 respondents in the unaffected village (Table 3.13).

Table 3.14 Uses of Cultivated Products N=173

Uses of Cultivated Products			
	Affected Villages	Non-Affected villages	Total
For Subsistence	48	73	121
Selling at Internal Markets	42	65	107
Selling at External Markets	11	13	24
Others	3	3	6
I do not know	6	7	13

Table 3.14 presents on uses of cultivated produce from the farm lands. The majority of the uses of cultivated products of 48 respondents for subsistence in affected villages and 73 respondents for subsistence in non-affected villages, which was followed by 42 respondents selling at internal

markets, 11 respondents selling at external markets in the affected villages and 65 respondents selling at internal markets, 13 respondents selling at external markets in the non-affected villages. Similarly, in 3 respondents are uses of others in the both affected and non-affected villages. The 6 respondents do not know the uses of cultivated products in the affected village and 7 respondents in the non-affected village (Table 3.14).

Table 3.15 Cultivated in the Land throughout the Year N=173

Cultivated in the Land throughout the Year				
		Affected Villages	**Non-Affected Villages**	**Total**
Cultivated in the land throughout the year	Yes	23 32.39%	63 61.76%	86 49.71%
	No	48 67.61%	39 38.24%	87 50.29%
Total		**71** **100%**	**102** **100%**	**173** **100%**

Table 3.15 shows the response on whether the land was cultivated throughout the year.

Table 3.15 presents the land under irrigation of respondents in affected and non-affected villages. In the affected village 71 respondents have agricultural land. Of these, 32.39% of the respondents have cultivated in the land throughout the year and 67.61% of the respondents have not cultivated in the land throughout the year. Similarly, in the non-affected villages 102 respondents have agricultural land. Of these, 61.76% of the respondents have cultivated in the land throughout the year and 38.24% of the respondents have not cultivated in the land throughout the year. The overall total land under irrigation of 173 respondents has agricultural land. Of these, 49.71% of the respondents have cultivated in the land throughout the year and 50.29% of the respondents have not cultivated in the land throughout the year.

Let us discuss about the socioeconomic status from this section.

3.2 Socio Economic Status of Respondents

Table 3.16 Types of Ration Card N=400

Types of Ration Card Holding				
		Affected Villages	**Non-Affected Villages**	**Total**
Types of Ration Card	Below the Poverty line	134 67%	136 68%	270 67.5%
	Above the Poverty line	60 30%	64 32%	124 31%
	Annapurana Yojana	6 3%	0 0%	6 1.5%
Total		**200 100%**	**200 100%**	**400 100%**

Table 3.16 presents the types of ration card of the respondents in affected and non-affected villages. In 67% of the respondents is below the poverty line card, 30% of the respondents is above the poverty line card and 3% of the respondents is Annapurana yojana card in affected villages. Similarly, in 68% of the respondents is below the poverty line card, 32% of the respondents is above the poverty line card and annapurana yojana card none of the respondent in non-affected villages. At the same time, in total 67.5% of the respondents is below the poverty line card, 31% of the respondents is above the poverty line card and 2.5% of the respondents is Annapurana yojana card in the sample village.

3.3 Caste categories

Table 3.17 presents the caste types of respondents in the affected and non-affected villages. 61.5% of the respondents are backward class (BC), which was followed by 29.5% backward class (MBC), 8% are Scheduled Castes and 1% of the respondents are general categories in the affected villages. At the same time, 65.5% of the respondents were from Scheduled Castes, which was followed by 26.5% in the backward class and 8% of the respondents in the most backward class in non-affected villages.

Table 3.17 Caste Categories

Caste Categories				
		Affected Villages	**Non-Affected Villages**	**Total**
Caste Categories	General Categories	2 1%	0 0%	2 0.5%
	Backward Class (BC)	123 61.5%	53 26.5%	176 44%
	Most Backward Class (MBC)	59 29.5%	16 8%	75 18.75%
	Scheduled Caste (SC)	16 8%	131 65.5%	147 36.75%
Total		**200 100%**	**200 100%**	**400 100%**

Similarly, 44% of the respondents were Backward Class, which was followed by 36.75% in the Scheduled Case, 18.75% in the Most Backward Class and 0.5% of the respondents were general categories in overall sample respondents.

3.4 Family size

Table 3.18 Present the family members of sample respondents in the affected and non-affected villages. 33% of respondents have 4 family members living in the affected villages, which was followed by 24% of respondents have 5 family members, 18.5% of the respondents have 3 family members, 9.5% and 9% of the respondents have 2 and 6 family members, and below 4% of respondents have 1 and 7 family members living in the affected villages. Above 21% of respondents have 3 to 4 family members living in the non-affected villages, which was followed by 19.5% of respondents have 5 family members, 17.5% of respondents have 2 family members and below 5% of respondents have 1 and 7 family members living in the non-affected villages. Similarly, in more than 20% of the respondents have 3 to 5 family members living in the study villages, which was followed by 13.5% of respondents have 2 family members, 9.8% of

respondents have 6 family members, and below 5% of respondents have 1 and 7 family members living in the overall study villages.

Table 3.18 Family size of respondents N=400

Family Members of Sample Respondents				
		Affected villages	**Non-Affected villages**	**Total**
Number of Family Members	1	4 2%	7 3.5%	11 2.8%
	2	19 9.5%	35 17.5%	54 13.5%
	3	37 18.5%	43 21.5%	80 20%
	4	66 33%	46 23%	112 28%
	5	48 24%	39 19.5	87 21.8%
	6	18 9%	21 10.5%	39 9.8%
	>7	8 4%	9 4.5%	17 4.3%
Total		**200** **100**%	**200** **100**%	**400** **100**%

3.5 Gender distribution

Table 3.19 Present the gender wise household members of respondents in the affected and non-affected villages. More than 51% of respondents live in household members where men are affected and non-affected villages.

Table 3.19 Household Members Gender N=1608

Household Members Gender				
		Affected Villages	**Non-Affected Villages**	**Total**
Household Members Gender	Male	418 51.04%	408 51.71%	826 51.37%
	Female	401 48.96%	381 48.29%	782 48.63%
Total		819 100%	789 100%	1608 100%

Affected village Average : Male = 2.09, Female = 2.005, **Total= 4.095**

Non-Affected village Average : Male = 2.04, Female = 1.905, **Total = 3.945**

Total Average : Male = 4.13, Female = 3.91, **Total = 4.02**

The affected villages have an average person of 4.095 males and females. Of these, the average of 2.09 males and 2.005 were females. Similarly, the non-affected villages have an average person of 3.945 males and females. Of there, the average of 2.04 males and 1.905 were females. Overall found that have an average person of 4.02 males and females. Of these, the average of 4.13 male members and 3.91 were female members living in the study villages. The total number of household members of the sample respondents was 1608. Of these, 819 men and 789 women live in sample village houses. However, a total of 4 persons per household were found to live in the study villages.

3.6 Marital Status

Table 3.20 Present the marital status household members in the affected and non-affected villages. More than 54% of household members in affected and non-affected villages are married, which was followed by 38% and 37.6% of household members are single, and 6.3% and 5.3% of household members are widowed in the affected and non-affected villages. Similarly, less than 1% of household members were divorced in affected and non-affected villages, and the one separated was found in affected villages and no one in non-affected village.

Table 3.20 Household Members Marital Status N=1608

Household Members Marital Status				
		Affected Villages	**Non-Affected Villages**	**Total**
Household Members Marital Status	Single	311 38%	297 37.6%	608 37.8%
	Married	450 54.9%	448 56.08%	898 55.8%
	Divorced	3 0.4%	2 0.3%	5 0.3%
	Widowed	52 6.3%	42 5.3%	94 5.8%
	Separated	3 0.4%	0 0%	3 0.2%
Total		**819 100%**	**789 100%**	**1608 100%**

3.7 Literacy level of the households

Table 3.21 Family Members Literacy N=1608

Family Members Literacy				
		Affected Villages	**Non-Affected Villages**	**Total**
Family Members Literacy	Illiterate	152 18.56%	154 19.52%	306 19.03%
	Literate	667 81.44%	635 80.48%	1302 80.97%
Total		**819 100%**	**789 100%**	**1608 100%**

Table 3.21 Present the literacy of the family members in the affected and non-affected villages. More than 80% of the respondents are family members were literate in the affected and

non-affected villages. Similarly, less than 20% of the respondents are family members were illiterate in the affected and non-affected villages. Out of the total family members, 1302 family members are mostly educated and 306 were illiterate in the study villages.

3.8 Sources of water to households

Table 3.22 Source of Waters for Household Activities N=400

Source of Waters for Household Activities	Affected Villages	Non-Affected Villages	Total
Tap Water Connecting the House (Bathroom, Kitchen, Toilet)	70	21	91
Ground water using well / stream / lake Water/ bore well	13	6	19
One Tap / Hand Pump outside the House	43	100	143
Water Supply System through Multiple Taps	94	95	189
Dam water connection pipe	59	21	80
Buying water for Money	89	32	121

Table 3.22 presents the sources of waters for household activities of respondents in affected and non-affected villages. The total source of water for household activities, 189 respondents have sources of water supply system through multiple taps. Of these, 94 respondents are in the affected villages and 95 respondents in non-affected villages. This was followed by the total of 143 respondents who have a source of water on one tap/hand pump outside the house. Of these, 43 respondents and 100 respondents were in the affected and non-affected villages. Similarly, a total of 121 respondents have paid money to bought water and used it as a source of water. Of the 70 respondents in the affected villages and 21 respondents in the unaffected villages, tap water (bathroom, kitchen and toilet) connecting the house was used as water source for household activities. The 59 respondents in the affected villages and 21 respondents in the non-affected villages were used as water sources for household activities for dam water connection pipe. 89 of them are in affected villages and only 32 are in unaffected villages. Hence, a total of 19 respondents

has a source of water on Groundwater using well / stream / Lake Water/ bore well, of these, 13 respondents and 6 respondents were in the affected and non-affected villages.

3.9 Type of managing waste water

3.23 Type of wastewater system N=400

E11. Type of Wastewater System	Affected Villages	Non-Affected Villages	Total
Common Sewerage System	111	88	199
Septic Tank Disposed Regularly by Municipality	3	0	3
Septic Tank Disposed Regularly by him/herself	27	2	29
Discharged Directly to a River / Land	67	108	175
Sewage tank built by the government alone	8	3	11

Table 3.23 presents the type of wastewater system of respondents in affected and non-affected villages. In the affected villages for highest of 111 respondents have used the common sewerage system. Which was followed by 67 respondents have discharged directly to a river/land, 27 respondents have septic tank disposed regularly by him/her, and septic tank disposed regularly by the municipality. In that septic tank disposed regularly by municipality are not found in the non-affected villages. The below 3 respondents have sewage tank built by the government alone and 2 respondents have septic tank disposed regularly by him/herself. The majority of the types of wastewater system of 108 respondents have discharged directly to a river/land, which was followed by common sewerage system of 88 respondents in the non-affected villages.

3.10 Solid waste disposal details

3.24 Solid Waste Disposal Methods N=400

Solid Waste Disposal Methods	Affected Villages	Non-Affected Villages	Total
Local Administration – Village Panchyat or Municipality collects regularly	125	94	219
Disposed to a Predefined Landfill	9	14	23
Disposed to a Wild Disposal area	11	18	29

Disposed irregularly	57	81	138
Disposed to the River / Lake	15	9	24
Burning	27	17	44

Table 3.24 presents the solid waste disposal methods of respondents in affected and non-affected villages. The majority of the solid waste disposal methods of 125 respondents and 94 respondents have local administration – village panchyat or municipality collects regularly in the affected and non-affected villages. This was followed by disposed irregularly 57 respondents in the affected villages and 81 respondents in the non-affected villages. Similarly, in the affected villages' solid waste disposal methods of 27 respondents have burning, 15 respondents have disposed to the river/lake, 11 respondents have disposed to a wild disposal area, and 9 respondents have disposed to a predefined landfill. However, in the non-affected villages solid waste disposal methods of 18 respondents have disposed to a wild disposal area, 17 respondents have burning, 14 respondents have disposed to a predefined landfill, and 9 respondents have disposed to the river/lake.

3.11 Fuel usage

Table 3.25 Fuels Used for cooking N=400

Fuels Used for Heating			
	Affected Villages	**Non-Affected Villages**	**Total**
Fuel Wood	83	62	145
Cooking Gas	195	189	384
Kerosene	1	1	2

Table 3.25 presents the fuels used for cooking of respondents in affected and non-affected villages. Kerosene is used as fuel to heat only one respondent in the affected village and the unaffected village. Most of the 195 respondents in the affected villages used cooking gas as fuel for heating and 189 respondents use cooking gas in unaffected villages, followed by fuel in the affected village 83 respondents and 62 respondents use fuel in the non-affected village.

3.12 Sources of Water and Pollution

Table 3.26 presents the different sources of water used for household activities in the study villages. Out of 189 who accessed tap water through multiple sources, 94 were in the affected villages and 95 were in the non-affected villages. Out of those 143 respondents who had accessed water through one tap or hand pump, 43 were from affected villages and 100 were from non-affected villages. There were also 121 people reported to have paid for the water. Among the people who bought water, 89 were in the affected villages and 32 were in the non-affected villages. There were 70 in the affected villages and 21 in the non-affected villages had tap water connection at their home connecting to bathroom, kitchen, and toilet. There were 59 respondents in the affected villages and 21 respondents in the non-affected villages had a water connection connected to a nearby dam. Out of 19 respondents who depend on well water or stream or lake or a bore well, 13 were from affected and 6 were from non-affected villages.

Table 3.26 Source of Waters for Household Activities N=400

Source of Waters for Household Activities	Affected Villages	Non-Affected Villages	Total
Tap Water Connecting the House (Bathroom, Kitchen, Toilet)	70	21	91
Ground water using well / stream / lake Water/ bore well	13	6	19
One Tap / Hand Pump outside the House	43	100	143
Water Supply System through Multiple Taps	94	95	189
Dam water connection pipe	59	21	80
Buying water for Money	89	32	121

3.13 Pollution and water contamination

There were 72% in affected and 32% in non-affected villages reported that the water consumed by them was polluted. The types of changes experienced due to water pollution are as follows. Changes in the quality of water in terms of tastelessness of water was reported by 128 in the affected villages and 64 in the non-affected villages, while 81 in the affected villages and 18 in the non-affected villages reported salinity or deposits of salt in the water. Thirteen respondents in the affected villages and 6 in the non-affected villages experienced itching while washing the skin using water. Only in the affected villages some people (8) have reported green deposits floating on the water surface and some (11) have reported foul smell in the surroundings. Eight of the affected village respondents quoted an unexplainable water quality caused by tannery pollution. There were also 3 respondents from the non-affected villages experienced industrial pollution caused water contamination by the other non-tannery industries. Overall, there are more problems found in the closer to the tanneries than the farther villages. The problems such as green deposits caused by the tannery wastes and foul smell are evident that it is unique only to the tanneries.

3.14 Pollution of Environment

The environment surrounding of villages that were polluted higher (130) in the affected villages compared to the non-affected villages (9). While responding to the reasons, the number of reasons was reported as discussed in the following sections.

3.15 Polluted Water Sources

Among 139 who have reported their water sources were polluted, 115 of them in affected and 2 in non-affected villages have said the water storage surrounding the border areas of the villages were polluted (Table 3.27). Additionally, the table 4 clearly shows most of the water sources are polluted in the affected village compared to the non-affected village. In the non-affected villages, only 7 or less respondents have reported any of the above-mentioned type of pollution of water sources in their villages. This clearly shows how the water sources surrounding the tanneries in the affected villages were more polluting than non-affected villages.

Table 3.27 Types of Water Sources that are reported to have been Polluted N=139

Types of Water Sources that are Reported to the Polluted by the Villages	Affected Villages	Non-Affected Villages	Total
Water logging surrounding the tube wells	11	6	17
Ponds	62	0	62
Borders of the villages	115	2	117
Well	35	5	40
Agricultural land	32	7	39

3.16 Recognizable Changes in Water sources due to industrial pollution

The Recognizable Changes in Water sources due to industrial pollution in the study villages are shown in the table 5. Most of the problems are significantly higher in affected villages compared to the non-affected villages. Only the characteristics of without any attribute such as salt or colour are reported higher in the non-affected villages clearly shows the impact of tannery pollution on the water sources in the affected villages. The common characteristics reported in water sources due to industrial pollution are, salt deposits, change in colour, well water turned to black in colour, green colour particles floating on the surface, and tannery effluents mixing with the ground water. In addition, more people in affected also reported of dried-up water sources. There were 25 respondents from affected villages and 12 respondents from non-affected villages said there are unexplainable changes in their surroundings. Overall, the affected villages located in and around the tanneries experiencing larger problem of pollution than the non-affected villages. This clearly shows how the rural environment is affected due to the tannery pollution.

Table 3.28 Recognizable Changes in Water sources due to industrial pollution N=400

Recognized Changes in Water sources	Affected Villages	Non-Affected Villages	Total
Water dried up	84	18	102
Salt deposits	73	21	94
Green colour particles floating on the water	39	0	39

Changes of colour in the water	46	1	47
Well waters turned black	41	4	45
Tannery effluents mixes with the water sources	38	0	38
Without any attribute	21	175	196
Unexplainable	25	12	37

3.17 Problems faced due to industrial pollution

Table 3.29 shows the type of difficulties faced by the respondents from affected and non-affected villages. There were 167 from the affected villages and 101 from the non-affected villages reported to have faced problems in getting drinking water in their villages. While mentioning about other problems related water, 109 in affected villages and 113 in non-affected villages experienced lack of sufficient water for agriculture. While, 88 in affected villages and 22 in non-affected villages have reported that there was a non-availability of clean water in their villages. While 37 in affected villages and 2 in non-affected villages reported to have an experience of not having a clean air in their villages. Only in the affected villages, there were 105 respondents who have reported an odour caused by the tanneries during monsoon seasons. There were also people reported rashes and itching experiences mostly (29) from the affected villages. In terms of employment status, the affected villages relatively lesser (82) problem of lack of jobs compared to that of non-affected villages (107). Similarly, the transportation problem was more (156) in non-affected villages which farther from the town compared to affected villages (66) closer to the Dindigul town. There were more than 90 persons reported job losses due to Covid19 outbreak in both the villages.

Further, villagers were asked whether problems mentioned in Table 3.30 is caused by Tanneries. There were 107 of the respondents from the affected villages and 26 of the respondents from the non-affected villages mentioned that the problems mentioned in Table 3.30 are caused by tanneries. There were 62 respondents from the affected villages and 43 respondents from the non-affected villages were not sure whether the problems are caused by the tanneries.

Table 3.29 Difficulties caused by industrial pollution N=400

Difficulties experienced	Affected Villages	Non-Affected Villages	Total
Problem related drinking water	167	101	268
Lack of water for agriculture	109	113	222
Non availability of cleanly air	37	2	39
Non availability of clean water	88	22	110
Odour caused by tannery sewage during rainy season	105	0	105
Rashes and Itching experienced the body	29	2	31
Lack of job opportunities	82	107	189
No Transportation Facilities	66	156	222
Job loss caused by Corona	94	98	192

Table 3.30 Reasons for the Problems N=400

Reasons	Affected Villages	Non-Affected Villages	Total
Problems caused by tanneries	107	26	133
Not problems caused by tanneries	31	131	162
Not aware whether they are caused by Tanneries	62	43	105
Total	200	200	400

3.18 Other problems caused by industrial pollution

A question on what are other problems caused by industrial pollution, the problems such as skin diseases, fever, dental problems, hair loss, looking older, skin wrinkles, land become uncultivable, rashes and itching in body, overall deterioration of health, and livelihood been affected were reported. It is clear from the Figure 3.1 that all the reported problems were higher in the affected villages compared to the non-affected villages.

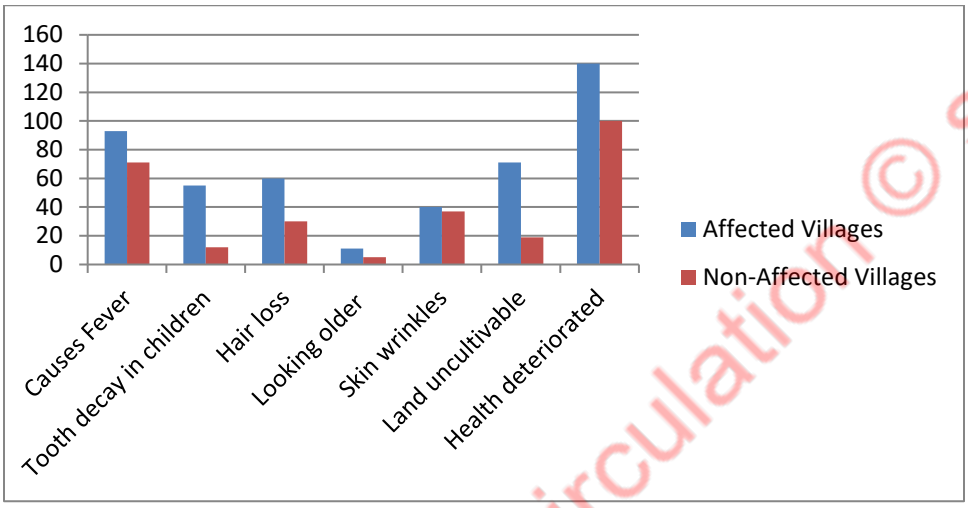

Figure 3.1 Other problems caused by industrial pollution

3.19 Impact of water pollution on livelihood

3.19.1 Water Pollution on the Households and the Community

In response to a question on whether there was an impact of water pollution on the Households and the Community, 145 from the affected villages and 9 from the non-affected villages were opined with that. Table 3.31 shows out of those 154 respondents, many (113) from the affected villages felt it is difficult even to walk in neighbourhood their villages due to tannery pollution. Other major problems reported in the affected villages are the villages are no longer liveable and their livelihood has been affected. The non-affected villages had lesser problems according to the respondents. There was also a unique problem reported by the villages near tanneries was they have not been visited by their friends and relatives due to the smell and poor environment in their villages.

Table 3.31 Effect of Pollution on livelihood N=154

Effect of Pollution on Society	Affected Villages	Non-Affected Villages	Total
Not liveable	54	1	55
Not fit to walk in the neighbourhood	113	0	113
The friends and relatives avoid visiting the villagers	9	0	9
Livelihood affected	88	9	97
Unexplainable problems	3	1	4

3.19.2 Water pollution affected the livestock and caused other problems

About 60% of the respondents in the affected villages reported that the polluted water had affected livestock and caused other problems. Only 5% of the respondents from the non-affected villages reported the same. Table 9 shows many of the problems related to livestock and other problems are higher in affected villages than the non-affected villages. The reduction in quantity of milk was reported in the affected villages more than the non-affected villages. Similarly, the problems such as increase in Mosquitoes, emergence of newer diseases were reported very in affected villages. People also feel there is a nutritional related problem due to the consumption of polluted water in the affected villages. This clearly shows how the villages surrounding the tannery pollution suffer due to various problems.

Table 3.32 Water pollution on livestock and other problems N=128

Problems	Affected Villages	Non-Affected Villages	Total
Reduction in the quantity of milk by the live stocks	54	10	64
Increase in the Mosquitoes breeding	108	5	113
Newer diseases spread in the community	110	8	118
Difficult to sell lands as they are polluted	19	0	19
People become malnourished and weakened by drinking the polluted water	42	8	50
Unexplainable problems	4	0	4

3.20 Impact of water pollution on Agriculture.

3.20.1 Impact of Water Pollution on Agriculture

When the respondents were asked whether water pollution affected the agriculture, 125 in the affected villages and 10 in the non-affected villages felt their agriculture was affected. Table 10 shows various reasons quoted on how the water pollution has affected the agriculture in the study villages. The problems such as reduction in agricultural production, irrigation sources were polluted, farmland become infertile, poor quality of produce were major problems reported. They were also finding it difficult to sell their land due to pollution. In general, the above problems were reported very low in non-affected villages.

Table 3.33 Reasons given for reporting water pollution affecting agriculture N=135

Reasons	Affected Villages	Non-Affected Villages	Total
Reduction in the Agricultural Production	101	8	109
Tannery effluents enter in to the water sources such as wells	47	9	56
Difficult to sell the Tannery Effluent Polluted farmland	4	0	4
Farmland become infertile	98	10	108
Poor quality of agricultural produce	82	5	87
Unexplainable problems	13	0	13

3.20.2 Impact of water pollution on soil

Further a question on whether the water pollution affects the soil, 148 in affected villages and 13 in non-affected villages said their soil been affected. Out of 161 respondents reported the polluted water affected their soil, more than 100 respondents in the affected villages reported that the soil quality was deteriorated and the soil was polluted due to the industrial effluents. That was followed by reasons such as 90 reported agricultural yields were reduced, 85 respondents reported soil nutrients were deteriorated, 59 respondents reported soil became saline-alkaline, 57 respondents reported the soil was unfit for cultivation, and 8 respondents reported unexplainable reasons. This was lower in the non-affected villages with only 13 respondents have reported the soil was polluted due to industrial effluents, which was followed by 12 respondents reporting deterioration in soil quality and soil nutrients, 8 respondents reported soil is unfit for cultivation, and 7 respondents reported agricultural yields reduced. In general, even the polluted soil in the affected villages due to tannery pollution is highly recognised by the respondents of the study.

IV Discussion

4 Discussion

To understand the difference in economic status authors looked in to the difference between mean income of affected and non-affected. It was found the income between the villages was significantly different and it was high among the affected villages due their vicinity to the urban centre. When analysed more in to the employment status it found that most of them were engaged in multiple professions in different part of the year as the primary activities, they were engaged in were seasonal in nature. In terms of landholding, affected villages had significantly lower landholding compared to that of non-affected villages. This is further suggestive of problems in holding agricultural land due to pollution. In terms of irrigation of their agricultural land one third of the affected villages and two thirds of the non-affected villages have irrigated their land. This is also confirming with the point that the water they have was polluted and they were not able irrigate their agricultural land. This led to a smaller number of land holders cultivate in the affected villages compared to that of non-affected villages. Study by Shah et al, 2021 too reported the Industrial pollution adversely impacts the environment(Shah, SN. Manzoor, S. and Asim, 2021). Related to the water they consumed it was found that three fourth in affected villages and one third in the non-affected villages reported that the water they consumed was polluted. In general, there were more problems reported in the villages closer to the tanneries than the farther ones. In the affected villages people further mentioned about green deposits formed on the surface of water polluted by the tannery waste and foul smell. It is clearly evident from the villagers live in and around tanneries face stringent water problems due to pollution. This also affects their surrounding environment. The water sources in general in the villages surrounding the tanneries were polluted. They further given details on the recognizable changes happened in the water sources due to the tannery pollution. The villages located in and around the tanneries experienced bigger problem of pollution compared to the non-affected villages. The comparison gives a clear distinction between the villages near tanneries and farther from tanneries. The further reiterated different problems included drinking water contamination. The problems such as non-availability of clean air, odour due to tannery effluents mixing with open drainage, and rashes and itching experienced by the population. They were undoubtedly relating these problems with the pollution due to tanneries in their vicinity. Only advantage the people live near tanneries was that of having better transportation facilities compared to the other villages. These findings are in agreement with a study from

industrial area of Panipat city, India found untreated industrial effluents can cause an environmental threat to ground water resources(Bharti et al., 2013).

There different problems that were reported high especially in the villages closer to tanneries prevalence of skin diseases, fever, and dental problems, experiencing hair loss, people feel they are looking older than their age, having wrinkled skin, experiencing rashes and itching in body, feeling the overall deterioration of their health, land was contaminated and become uncultivable, and adverse effect on livelihood of the population. Problems similar to that were reported in a study conducted in Panipat, India(Bharti et al., 2013).

The people from the affected villages reported that it was difficult for them to walk around in their neighbourhood because of tannery pollution. They further stated the villages have become unliveable and their livelihood was affected. This was less among the villagers from the non-affected villages. A unique problem stated by the respondents of the affected villages was their friends and relatives were hesitant to visit them due to the smell and poor environmental conditions caused by the tannery pollution. The effect of industrial pollution on livelihood was in agreement with a study from Nigeria that found a significant relationship between perceived effect of industrial water pollution and the livelihood activities of rural dwellers(Oluseyi et al., 2011).

Many in the affected villages reported the tannery pollution had affected livestock and caused other problems. Similar findings were reported in a study from the state of Assam in India(Mech and Hazarika, 2018). The same study found that how a Polymer company discharged the polluted effluents to the Sessa river that in turn polluted the water and that deteriorated the aquatic plants and animals that ultimately disrupted the livelihood of fishermen in that region(Mech and Hazarika, 2018).

The present study finding further went in to the details such as reduction in quantity of milk as one of the effects of tannery pollution on their livelihood. The industrial pollution adversely affect the livelihood of the population(Oluseyi et al., 2011).

Similarly, the problems such as increase in Mosquitoes, emergence of newer diseases were reported very in affected villages. People also feel there is a nutritional related problem due to the consumption of polluted water in the affected villages. This is similar to that of the findings from a study from Nigeria reported that the persistence of pollutant in the water cause long term health problems(Dan'azumi and Bichi, 2010). This clearly shows how the villages surrounding the tannery pollution suffer due to various problems. More than half in the affected villages and very

few in the non-affected villages felt their agriculture was affected by the water pollution. The reasons that were stated for the effect of water pollution on the agriculture in the study villages uncovered various problems such as reduction in agricultural production, polluted irrigation sources, farmland become infertile due to pollution, and pollution leading to poor quality of produce. Even they decide to sell their land, it is difficult for them to sell their land as they were already polluted by the tannery effluents. Very few have reported the above problems from the non-affected villages. This finding is in agreement with a study conducted in Panipat, India observing heavy metals presence in ground water used for irrigated agricultural soil that transferred them from effluent to ground water(Bharti et al., 2013). The industrial effluents cause environmental threat to ground water resources and deteriorate the soil quality and ultimately the agricultural productivity(Bharti et al., 2013). Further it is important to note about three fourth in the affected villages and a very few in non-affected villages said their soil been affected by the pollution. The soil pollution led to reduction in agricultural yields, deterioration in soil nutrients, soil became saline-alkaline, soil was unfit for cultivation. This was lower in the non-affected villages. These problems are in confirmation with the study by Bharti et al. 2013. The common people were able to recognize the polluted soil in the affected villages due to tannery pollution with their naked eye suggests the problem very obvious and not recognized by the policy makers and politicians may be due to diverse economic interests(Reddy and Behera, 2006). Even the interference of Courts that followed the polluter-pays approach to agriculture was likely to be infeasible and one should put efforts on including elements of the polluter-pays approach that is incorporated into agricultural water quality policy(Shortle et al., 2012). Even the court proceedings that is in response to the Farmers demanding for more compensation shows there need to be more efforts on resolving the issue(Court, 2014).

V Qualitative analysis Findings

5 Qualitative analysis Findings

A tool consisting on the different aspects of industrial pollution and its effects on the economic, social, and health was used for collect data on it. The following themes have evolved from the analysis. There were ten in-depth interviews and Focus Group Discussions conducted in affected and non-affected villages respectively. The discussed findings are from those transcripts analysed by first coding, then based on the codes themes that were already decided during the tool development as the present study used deductive coding. Only those themes which are relevant are included in the discussion.

5.1 Agriculture affected by the industrial pollution.

In the villages that are surrounded by the tanneries that classified as Affected Villages by the researchers found the Agricultural production had reduced during the last 15 to 20 years.

While, in the non-affected villages that were located away from the tanneries have reported their agriculture is not affected due to pollution from any industry. This clearly shows, the impact of the tanneries directly affect agriculture. To understand the problem in details water pollution was collected.

5.2 Pollution of water sources and its impact

In those villages that are surrounded by the tanneries, all water sources are polluted by the waste water discharged by the tanneries. This led to water scarcity, ground water contamination, and change in the nature of water was reported. The affected villages depend on Cauvery water for their drinking purposes and some buy water from the market.

On the other hand, those villages that were away from the tanneries reported no such problems. In general, the water in their sources is becoming saline and they are becoming hardened. The deep-water sources are now getting polluted due to unknown causes. They are about 10 kilometres away from the tanneries. The only problem the non-affected villages reported are the waste waters discharged from some agro-based industries. They do not harm much. Those villages too depend on Cauvery water for their drinking purposes along with some buy from the market.

5.3 Soil contamination due to industrial pollution

In the villages that are surrounded by the tanneries have reported that the Soil has become alkaline. They have reported a salty layer formation on the top of the soil observed around. They were mentioning none of the available seed varieties can be used for sowing in those soil conditions. On the other hand, the villages that were far from the tanneries did not experience their soil been polluted. Only due to the change in climatic conditions they were not able to continue agriculture as it was in the past.

5.4 Drinking water scarcity caused by industrial pollution

In the villages that are surrounded by the tanneries reported their water sources in general are polluted and they cannot use them not just for drinking purposes but also for other purposes as they cause some health problems. Many buys water for drinking and cooking purposes. For other purposed they depend on ground water. Even the livestock is been affected due to these. . People pay Rs. 30 per can for canned water. The Colour of water was reported as Green and black. If they use the water cooking the milk curdles and food get spoiled. Utensils also shows salt formation after cooking. The waste water from the tanneries contaminated the water pond near the road on one of the villages. In total it was mentioned by a village leader that about 10000 acres of land been affected due to tannery pollution.

Even in the non-affected villages it was found that the drinking water was a problem. The available water was saline and they were not able to use it for drinking. The villages that far from the tanneries to depend on Cauvery water and market sources. However, for other purposes they use available water. Sometime they too face problems due to the saline water available locally when used for bathing and washing. They do not have much harm effect as reported from the affected villages located closer to the tanneries.

The villages close to the tanneries have reported the following problems while using the polluted water. Use of local source is causing problems such as hair loss, itching, health issues such as breathing difficulties, headache, and other problems such tooth projection, body pain, skin problems, wrinkles in the face, early aging, fatigue, asthma, nausea and other problems. While, in the non-affected villages that are away from the tanneries have reported no problems due to water. They only reported general health problems that are commonly found in the district that were prevalent. In one of the villages that was far from the tannery has reported that they had an outbreak

of diarrheal disease before 5 years. There was also mortality due to that. Otherwise, they had no other health problems.

5.5 Change in cropping pattern due to industrial pollution

The villages surrounding the tanneries use to cultivate paddy and other wet crops in the past. Now, they only cultivate mostly dry crops such as sorghum, onion, vegetables, cotton tobacco, some places pulses such as ground nut. The shift in cultivation was due to the water and soil pollution caused by the tanneries.

On the other hand, the non-affected villages have reported different story. They all cultivate wet crops. In the recent past due to poor irrigation, they discontinued some crops such as sugarcane. Flower is cultivated more in this area. They also have a perfume factory in this region. There are also other agro-based industries in those villages. .

5.6 Change in employment pattern

The tannery pollution made a larger impact on the employment pattern. In the villages around the tanneries, the agricultural workers are depending on government employment guarantee schemes. They are also employed in construction industry, work in spinning mills, some work for local firework industry, some work in livestock and dairy product processing and rest are in service sector.

On the non-affected villages that are far from the tanneries, even though their main occupation is Agriculture, they also work in the spinning mills and other service sectors for their livelihood.

5.7 Conflicts due to pollution

There is no direct conflict due to water pollution. However, when they access the water sources, the wells that are constructed by the government located in the high caste regions are denied to those belong to lower caste population. Those villages constructed wells near the temples and they deny access to water to lower caste population. But when water is available only in the wells constructed by government located in the lower caste settlements and the higher caste population use them. This is more of a discrimination than a real conflict.

5.8 Other problems reported

In general, the villagers reported the pollution is felt more during the months of August to November every year. This may be due to the rainy season that highlights the problem.

- Due to pollution women from other villages refuse to marry groom from the villages surrounding the tanneries.
- People also reported walls of their houses are damaged due to water and soil contamination. People are now started migrating to other villages. About 20 kilo meters around the tanneries found to be affected due to pollution.
- People reported in the recent past Cattle rearing has been reduced in the affected villages. There was also a fodder shortage in those villages. They have also reported the Livestock have no water to drink.
- People also relate the infertility problem to the industrial pollution in the affected villages.

5.9 How did the people respond to the problem?

In response to the question on how did they respond or take this problem to the administration, people reported the following. This was true for both affected and non-affected villages. The non-affected villages too had drinking water problem and other cottage industries. Many had a meeting with the district collector and complained about the problem. There were also protests organised on the main roads. The affected village leaders reported the problem to the Tamil Nadu Pollution Control Board. Due to this some Tanneries have closed in the recent past. People had contacts at the higher level taken this issue to the political leaders, ministers, and the Governor.

5.10 What are things need to be addressed?

The community leaders and the people in general in the affected villages asked for immediate health facility in their villages. They also wanted a waste water treatment plant around their villages. There is a Common Effluent Treatment Plant in the locality. But the water is not treated completely hence, they wanted a treatment plant locally. They also asked for health camps for those affected. For the livestock they wanted Veterinary help.

At the non-affected villages, people sought, basic infrastructure such as transportation, school, bank, drinking water hospital facilities and employment opportunities.

VI Conclusions

6 Conclusions

This clearly shows in spite of the problem that is clearly evident from the naked eye are ignore by the policy makers and politicians due to different interests of the institutions they belong to. The first author of the study has studied the same problem in 1990 as his Master's dissertation is heartened to find the problem is still not been solved even after 30 years of his earlier study. Only the magnitude of the problem has reduced a bit but did not help the villagers who live in and around the tanneries. The efforts such as construction of Common Effluent Plant and paying compensation did not solve the problem. Even the court intervention on closing some of the units did not positively contribute to improvement in the quality of water and in turn did not improve the livelihood of the population live in those villages. A debate on environmental pollution and economic benefits did not prove its merits that are clearly evident from the findings of this study. Even after 30 years, the problem of tannery pollution still in its place and it is adding its adverse effects on the livelihood of the population in Dindigul.

Findings of qualitative data clearly shows the agriculture and other activities that affect livelihood has been affected by the tannery pollution in the affected villages. The villages that were cultivating wet crops has shifted to dry crops. Also, the water and soil have been badly affected that made many to move out of villages. In the recent past some tanneries have been closed due to the resistance from the communities. Drinking water is a common problem in both affected and nonaffected villages, shows the qualitative findings. There is no direct conflict due to the pollution, however, the well that is constructed by the government that are located in the higher caste settlements are forbidden to the lower caste people. While there is no water in the higher caste settlements the people fetch water from the lower caste settlements. The problem is indirectly caused by the pollution. The caste discrimination in Tamil Nadu is very evident from this.

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Annexure 1

Table A 1 Male and Female Distribution of Respondents N=400

		Sex		
		Affected Villages	**Non-Affected Villages**	**Total**
Sex	Male	100	100	200
	Female	100	100	200
Total		200	200	400

Table A 2 Age of Sample Respondents N=400

		Affected Villages			**Non-Affected Villages**			**Total**		
		Male (%)	**Female (%)**	**Total (%)**	**Male (%)**	**Female (%)**	**Total (%)**	**Male (%)**	**Female (%)**	**Grand Total (%)**
A6: Age	< 30	26 (26)	17 (17)	43 (21.5)	16 (16)	25 (25)	41 (20.5)	42 (21)	42 (21)	84 (21)
	31-40	29 (29)	19 (19)	48 (24)	20 (20)	17 (17)	37 (18.5)	49 (21.5)	36 (18)	85 (21.25)
	41-50	21 (21)	31 (31)	52 (26)	20 (20)	22 (22)	42 (21)	41 (20.5)	53 (26.5)	94 (23.5)
	51-60	18 (18)	16 (16)	34 (17)	31 (31)	19 (19)	50 (25)	49 (24.5)	35 (17.5)	84 (21)
	> 61	6 (6)	17 (17)	23 (11.5)	13 (13)	17 (17)	30 (15)	19 (9.5)	34 (17)	53 (13.25)
Total Respondents		**100**	**100**	**200**	**100**	**100**	**200**	**200**	**200**	**400**
Mean		43.45			46.21			44.83		
Median		42.5			47.5			45		
Standard Deviation		13.285			14.776			14.1		
Minimum		21			22			21		
Maximum		75			87			87		

Table A 3 Monthly Income for Sample Respondents N=400

Respondents Monthly Incomes	Affected Villages			Non-Affected Villages			Total		
	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Grand Total (%)
Salary Not Received = 0	6 (6)	13 (13)	19 (9.5)	4 (4)	15 (15)	19 (9.5)	10 (5)	28 (14)	38 (9.5)
< 5000	29 (29)	72 (72)	101 (50.5)	33 (33)	72 (72)	105 (52.5)	62 (31)	144 (72)	206 (51.5)
5001 - 10000	53 (53)	11 (11)	64 (32)	54 (54)	11 (11)	65 (32.5)	107 (53.5)	22 (11)	129 (32.25)
10001 - 15000	10 (10)	1 (1)	11 (5.5)	7 (7)	2 (2)	9 (4.5)	17 (8.5)	3 (1.5)	20 (5)
15001 - 20000	2 (2)	2 (2)	4 (2)	2 (2)	0 (0)	2 (1)	2 (1)	2 (1)	4 (1)
> 20000	0 (0)	1 (1)	1 (0.5)	4 (4)	15 (15)	19 (9.5)	2 (1)	1 (0.5)	3 (0.75)
Total Respondents	**100**	**100**	**200**	**100**	**100**	**200**	**200**	**200**	**400**
Mean	5449			4871			5160		
Median	5000			4250			5000		
Standard Deviation	5312.155			4044.732			4724.118		
Minimum	0			0			0		
Maximum	52000			28000			52000		

Table A 4 Types of Houses N = 400

Types of Houses			
	Affected Villages	**Non-Affected Villages**	**Total**
Built using Brick / Mud / Stone / Hollow Block	146	188	334
Built using concrete	99	88	187
Asbestos house	38	32	70
Thatched house	10	5	15

Tiled roof house	71	84	154
Other types of houses	5	5	10

Table A 5 Occupation of the sample respondents N = 400

Occupation of the sample respondents			
	Affected Villages	**Non-Affected Villages**	Total
Farmers	18	52	70
Mahatma Gandhi National Rural Employment Guarantee Scheme	47	56	103
Culinary work / cottage industry / business	30	8	38
Agricultural Wages / Construction Workers	47	63	110
Housewife / Retired or Elderly / Student	21	22	43
Raising livestock	13	25	38
Factory Employee / Security Employee (Security)	31	20	51
Unemployment	2	4	6
Others	36	25	61

Table A 6 Ration Card Holding Type N=400

Ration Card Holding Type				
		Affected Villages	**Non-Affected Villages**	**Total**
Ration Card Holding Type	Below the Poverty line	134 67%	136 68%	270 67.5%
	Above the Poverty line	60 30%	64 32%	124 31%
	Annapurana Yojana	6 3%	0 0%	6 1.5%

	Total	**200** **100%**	**200** **100%**	**400** **100%**

Table A 7 Caste Categories

Caste Categories				
		Affected Villages	**Non-Affected Villages**	**Total**
Caste Categories	General Categories	2 1%	0 0%	2 0.5%
	Backward Class (BC)	123 61.5%	53 26.5%	176 44%
	Most Backward Class (MBC)	59 29.5%	16 8%	75 18.75%
	Scheduled Caste (SC)	16 8%	131 65.5%	147 36.75%
Total		**200** **100%**	**200** **100%**	**400** **100%**

Table A 8 Land holdings N=400

Land Holdings				
		Affected Villages	Non-Affected Villages	Total
Land Holdings	Yes	71 35.5%	102 51%	173 43.25%
	No	129 64.5%	98 49%	227 56.75%
Total		200 100%	200 100%	400 100%

Table A 9 Land Acres details of Household Members N=173

Land Acres details of Household Members				
		Affected Villages	**Non-Affected Villages**	**Total**
Land Acres details of Household Members	< 1	23 32.39%	33 32.35%	56 32.37%
	1.01 - 2	31 43.66%	26 25.49%	57 32.95%
	2.01 -3	8 11.27%	17 16.67%	25 14.45%
	3.01 - 4	6 8.45%	18 17.65%	24 13.87%
	4.01 - 5	0 0%	5 4.90%	5 2.89%
	>5	3 4.23%	3 2.94%	6 3.47%
Total		**71**	**102**	**173**

Table A 10 Land under irrigation N=173

Land under irrigation				
		Affected Villages (%)	Non-Affected Villages (%)	Total (%)
Land under Irrigation	Yes	27 (38.03)	67 (65.69)	94 (54.34)
	No	44 (61.97)	35 (34.31)	79 (45.66)
Total		71 (100)	102 (100)	173 (100)

Table A 11 Types of Land Classification N=173

Type of land classification			
	Affected villages	Non-Affected villages	Total
waste land	1	0	1
Grazing land	0	1	1
Grove	6	12	18
Sown land	54	91	145
Current barren	13	11	24

Table A 12 Cultivated in the Land throughout the Year N=173

D 11. Cultivated in the Land throughout the Year				
		Affected Villages	**Non-Affected Villages**	**Total**
Cultivated in the land throughout the year	Yes	23 32.39%	63 61.76%	86 49.71%
	No	48 67.61%	39 38.24%	87 50.29%
Total		**71** **100%**	**102** **100%**	**173** **100%**

Table A 13 Changes Observed due to tannery pollution on the in the Water Quality Recognized Polluted N=208

L 1.1. Changes Observed in the Water Quality Recognized Polluted	Affected Villages	Non-Affected Villages	Total
Salt Deposited	81	18	99
Itching feeling when washing on the skin	13	6	19
Taste Less	128	64	192
Green colour particles floating on the water	8	0	8
Foul smell	11	1	12
Unexplainable Quality	8	3	11

Table A 14 Impact of water pollution on soil and Reason N=161

Reason	Affected Villages	Non-Affected Villages	Total
Deterioration in soil quality	119	12	131
Soil was polluted due to effluents	103	13	116
Soil nutrients deteriorated	85	12	97
Soil becomes saline-alkaline	59	12	71
Agricultural yields reduced	90	7	97
Unfit for cultivation	57	8	65
Unexplainable reasons	8	0	8

Annexure 2

List of Tanneries Affected Villages in Dindigul District

Division	Taluk	Block	Panchayat	S.No	Villages	Ward No.
Dindigul	Dindigul East	Dindigul	Adiyanuthu (1)	1	Adiyanuthu	
				2	Vedapatty	5
				3	Yakappanpatty	3,4
				4	Mottampatty	2
				5	Thomaiyarpuram	2
			Anaipatti (2)	6	Anaipatti	1,2
			Chettinaickanpatti (3)	7	Chettinayackenpatty	1
				8	Chennamanayackenpatty	4
				9	Mudakkurajakapatty	2
				10	Rajakkapatty	2
			Kurumbapatti (4)	11	Ramaiyanpatty	5
				12	Ayyankulam	1
				13	Meenatchinayakkanpatty	3
				14	Kurumbapatty	4
			Pallapatti (5)	15	Kottappatty	2
				16	Kanesapuram	2
				17	Paraippatty	2,4
				18	Vadakkupparaipatty	1
				19	Pallapattykanesapuram	1
				20	Murukapavanam	2
				21	Puduppatty	3
				22	Periyapallapatty	3
				23	Pallapatty	4
				24	Chinnapallapatty	5
				25	Poolamarathupatty	6
				26	Muthalakupatty	23
			A.Vellodu (6)	27	A.Vellodu	7,8

				28	Narasingapuram	3
				29	Kalluppatty	1
				30	Sirunayakkanpatty	11
				31	Thevalakarpatty	2
				32	Pappanampatty	5
				33	Ellappatty	4
				34	Poothampatty	4
				35	Karatualaganpatty	12
				36	Valaiyapatty	2
				37	Chettiyapatty	1
			Alamarathupatti (7)	38	Annamalaiyarmill colony	4
				39	Alamarathupatty	2
				40	Puthupatty	3
			Kalikkampatti (8)	41	Pommanampatty	2
				42	Kalikkampatty	2
				43	Kottaipatty	2
			Pillayarnatham (9)	44	Pillaiyarnatham	1
				45	Kuttiyapatty	2
				46	Vannanputhur	2
			Pithalaipatti (10)	47	Pithalaipatty	2
			Vakkampatti (11)	48	Kuppampatty	5
				49	Vakkampatty	1,2
			Veerakkal (12)	50	Veerakkal	1,2
				51	Kuththamppaty	2
			N.Panjampatti (13)	52	N.Panjampatty	3
	Dindigul West	Reddiyarchatram	Ammapatti (14)	53	Ammapatti	1
				54	Sokkalingapuram	2
				55	Alamarathupatti	2
				56	Thevasakayapuram	2
				57	Melapatty	2

				58	Palamrajakkapatty	3
				59	Idaiyampatti	4
				60	Kaladippatti	3
				61	Natchakonanpatti	3
			Anumanthuraiyankottai (15)	62	Dhamaraikulam	3
				63	Melappatty	1
				64	Susaippatty	1
			Kamatchipuram (16)	65	Kamatchipuram	1
			Karisalpatti (17)	66	Karisalpatti	1,2,3,4
			Kasavanampatti (18)	67	Kasavanampatty	1,3
				68	Koralampatty	3
				69	Kittampatty	3
			Konur (19)	70	Konur	8,9
			Kuttathupatti (20)	71	Aavarampatty	2
				72	Mailapoor	2
				73	Arulanantharpuram	2
				74	Kuttathupatty	1,5
				75	Kunjanampatty	1
			Ponnimanthurai (21)	76	Muthanampatty	4
				77	Chinnaponnumandurai	2
				78	Rayarpatty	4
				79	Kuttiyapatty	4
				80	Kuruvappanayackenpatty	4
				81	Periyaponnimandurai	2,3

Annexure 3

List of Non-affected Villages in Dindigul District

Division	Taluk	Block	Panchayat	S.No	Villages	Ward No.
Dindigul	Nilakottai	Nilakottai	Jambuthuraikottai	1	Uthuppatty	1,2
				2	Sakkaiyanayackanoor	2,4,5
				3	Poothipuram	2
				4	Mottananpatty	2
				5	Kamalapuram	4
				6	Jallipatty	3
				7	Mettur	3
			Kottur	8	Maikkelpalaiyam	2,3
				9	Avaiyampatty	3
				10	Santhanamathapuram	3
				11	Sangalpatty	1
				12	Kalliyasaripatty	4
				13	K.Puthur	4
				14	Nagamanayackanpatty	4
				15	Kottur	4
				16	Dhathakapatty	4
				17	Senkottai	5
				18	Rayappanpatty	5
				19	Semapuram	5
				20	Suttikaladipatty	5
			Pachamalaiyankottai	21	Patchamalaiyankottai	1
				22	Kethaiyagavundanpatty	2
				23	Thirumayanagoundanpatty	2
				24	Sedeaptty	2
				25	S.Pudukottai	4
				26	Sellayipuram	4

				27	Thimminayackanpatty	3
				28	Vettaipatty	3
				29	Sukkulapuram	4
				30	Puduchatram	4
				31	Pathukkamanpatty	4
				32	Ottupatty	5
				33	Kuththampatty	5
			Ramarajapuram	34	Sadaiyampatty	1
				35	Ramarajapuram	2,3,4,5
				36	Meenatchipuram	1
				37	Thangaiyapuram	5
			Silukkuvarpatti	38	Silukkuvarpatty	1,2,3,4,5
				39	Kuppapalanipatty	5
				40	Sennanchettiyapatty	5
	Athoor	Athoor	Akkaraipatti	41	Akkaaraipatty	12,1
				42	Mallaiyapuram	2,3
			Ambathurai	43	Kollapatty	3
				44	Perumalkovilpatty	4,5,6
				45	Muruganpatty	7
				46	Kurumbapatty	10
				47	Natuppatty	11
				48	Velampatty	13
				49	Ramanathapuram	12
				50	Kathirippatty	9
			Athoor	51	Aathoor	1,2,3,4 5,6,7
			Ayyankottai	52	Ayyankottai	1,2,3
			Bodikamanvadi	53	Bodikammanvai	2,3
				54	Sonkkalingapuram	1,2
				55	Veerachikkanam	1

			Devarappanpatti	56	Devarappanpatty	
				57	Chinnagoundanpatty	4
				58	Meenatchipuram	3,4
			Sitharevu	59	Kottaipatty	7
				60	Kathirnayackenpatty	8
				61	Nellur	9
				62	Kuppinayackenpatty	10
				63	Kondamanayackenpatty	10
				64	Salaiputhur	11
				65	Udaiyakaraiyanputhur	13
				66	Singakarakottai	12,13
				67	Chellampatty	13
				68	Ottupatty	13
				69	Sangarettikottai	14
			Jivalsaragu	70	Jivalsaragu	1
				71	Pommanampatty	1
				72	Aathilakshmipuram	2
				73	Velagoundanpatty	2
				74	Aathuppatty	1,2
				75	Kodangipatty	2
				76	J. Puthukottai	3
				77	Kenditchampatty	3
			Palayankottai	78	Palaiyankottai	1
				79	Koolampatty	2
				80	Kamanpatty	1,2,3
				81	Piravanpatty	3
			Thoppampatti	82	Thoppampatty	1
				83	Ernayakampatty	1
				84	Jathikkagoundanpatty	2
				85	Sirangampatty	1

				86	Kavirayapuram	1
				87	Mannavarathi	1
				88	Kariyampatty	2,3
				89	Vellaithathanpatty	3