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Estimation of Economic Loss of Agricultural Production and Livestock Population in Tamil Nadu due to Sago Industrial Pollution: A Case Study

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Abstract

The study focuses on the economic loss of agricultural production and livestock population in Tamil Nadu due to sago industrial pollution. Primary data was obtained from 413 households. A larger number of sago processing industries in identified villages belonging to taluks, namely Salem, Mettur and Attur, were sampled to estimate the loss of agricultural production and livestock population. The outcome of the research recommends improving the health of the ecosystem and managing sago effluents.
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Keywords

Agricultural production; Livestock population; Sago industries; Negative impact; Environmental degradation

Introduction

Tapioca or cassava (*Manihot esculenta crantz*) was introduced in India during the 17th century by the Portuguese living in Kerala, South India (Sathya and Ravichandaran, 2010; Subashini *et al*., 2011; Monisha, Rajakumar and Ayyasamy, 2013). Sago is commonly referred to "Tapioca" and is prepared from the "Tapioca root" extract. Tapioca is valued for its starch content and is primarily used by the sago industry. It contains 30 to 35 % of starch, high carbohydrates, calcium and vitamin C (Rajendran *et al.* 2011; Subha and Muthukumar, 2012). Sago manufacturing is one of the major food processing companies in Southeast Asia. It is a close alternative for wheat and rice in many areas, especially during the festival seasons in North India. The huge consuming sectors of sago products include food industries, cattle feed manufacturing, adhesive manufacturing, chemicals like dextrin manufacturing, and sizing units in the textile industry (Sathya and Ravichandaran, 2010). There are 3,226 industries in Tamil Nadu alone, of these 1,522 are small, 388 medium and 205 are of larger scale (Subha and Muthukumar, 2012). They provide job opportunities both directly and indirectly, to around 500,000 people. The estimated total area under Tamil Nadu cassava cultivation is approximately 110,000 hectares with an annual production of 7.74 million tonnes and 4,000,000 tonnes with an average output of 60 tons per hectare, which is the highest in the world. Tamil Nadu accounts for 64% of India's total area under cassava production, Kerala contributes 32%, Andhra Pradesh contributes 1.5%, Nagaland 1.2%, and Assam 0.5%. Industry meets about 80% of demand from these areas.

Sago effluents result in intangible costs that need to be accounted for and measured. Because the benefits of environmental services and the monetary values of pollution are not efficiently priced and traded, they may ignore the loss of agriculture production outcomes, livestock population and well-being. Estimating economic value calculates a person is willing to pay the maximum price for certain goods and services to receive some universal good, service or state. Therefore, the lost value from the degraded environment is the maximum amount individuals are willing to pay to have it free of contamination. It is one of the key reasons why the economic valuation of sago industrial pollution in agricultural losses and livestock population is of paramount importance, particularly in the Salem district.

Many investigators found that the wastewater from sago causes water contamination. Tapioca processing requires 30,000 to 40,000 litres of water for every tonne of sago produced. It yields an equivalent volume of highly untreated, foul-smelling, acidic wastewater (Banu *et al.*, 2006; Sathya and Ravichandaran, 2010). These units release approximately 45,000-50,000 litres of sago effluent throughout the process and take about 10 days to discharge water as effluent from the factory (Belliappa, 1991; Saravanan, Murthy and Krishnaiah, 2001; Subha and Muthukumar, 2012). During processing releases high organic load content along with the effluent results in unpleasant odours, disturbing colour, lower pH, and higher BOD and COD (Ayyasamy *et al.,* 2002; Ayyasamy *et al.,* 2008; Jenol *et al*., 2019; Monisha, Rajakumar and Ayyasamy, 2013). When the effluent is released into the common land without adequate treatment, it will change the ecosystem characteristics. Farmers use these effluents for irrigation, and they found yield increase and reduced soil health (Nandy, Kaual and Sekhar, 1994; Daud *et al*., 2010; Wan, Sadhukhan and Ng, 2016; Nash *et al*., 2020). Untreated effluent water is discharged from sago industries in the Panamarathupatti lake's overflow channel entering Ammapalyam Lake near Attur. The practice of releasing the untreated water has worsened the issue of water contamination in over 100 wells in Attuputhur, Thippampatti, Perangadu, and surrounding villages. In general, the wastewater is stored in the Power Tank. It percolates through the soil, thereby, contaminating local wells. In several wells in the region, the water's colour gradually transforms into greenish-black, depriving citizens of access to clean drinking water in many villages, and untreated waste harms the crops grown in nearby agricultural lands. If the situation continues, farming cannot be continued in this region (Ramesh, 2008).

The current study differs from previous studies with reference to the following particular aspects. Whereas other studies mostly used various treatment methods to determine water quality and focused exclusively on the causes of environmental degradation related to agricultural land and public health problems in general. However, they did not focus on monetary valuation (loss of farm income and livestock population) in the research's current issues. To understand why economic valuation might be essential to reduce industrial pollution, it is necessary first to examine the role of valuation in decisions concerning the use of environmental resources in general and water pollution in particular. This study focused on the fact that a significant reason for excessive depletion and misuse of water sources is often the failure of planning decisions to compensate for their non-market environmental values adequately. By providing a way to measure and compare the different benefits of water availability, economic valuation can be a powerful tool to support and promote the wise use and selection of global water supplies. The monetary accounting of environmental degradation is also a concept that must be taken into account in the future. In this context, the present study will be a crucial lesson on various water pollution affected economic activities.

Methodology

Theoretical Background of the Study

Environmental change has profound implications for the natural balance of the ecological system and the stability of the economic and social networks as the environment plays a crucial role in the human development process (Maxwell and Reuveny, 2000). Hence it is vital to understand the impact of the development process on the environment and the extent to which the development process is affected by the environmental change to plan for environmentally sustainable development. The negative externalities arise when an action by an individual or group produces harmful effects on other systems. Pollution is a negative externality. When a factory discharges its untreated effluents in a river, the river is polluted, and consumers of the river water bear costs in the form of health costs or/and water purification costs. In an activity generating positive externality, the social benefit is higher than private use; the social cost is higher than the private cost. Thus, in the presence of externalities, social benefits (costs) and private benefits (costs) differ. A negative externality is the uncompensated loss of welfare provoked by one economic agent (Pearce and Turner, 1990). The sago industry is considered a primary polluter of the environment and has a strong potential to cause soil and water pollution due to untreated effluent discharge (Sathya and Ravichandran, 2010).

Sampling Design and Method of Data Collection

Based on the pollution level, the sample villages were identified from Taluks[1], namely Salem, Attur and Mettur. From these sample villages, some were selected from the polluted area, and other set of villages was free from pollution. Among the 413 selected respondents, 331 respondents belonged to the pollution-affected area and 82 respondents were from non-polluted area (controlled villages). All these respondents were selected by adopting a disproportionate stratified random sampling technique. The primary data collected from households was verified with the sago industrial pollution statistics. The questionnaire was designed for collecting primary data from the sampled households, and it included the questions related to general information on the socio-economic, size of landholding, livestock population, number of death cases and loss of farm income. The data have been tabulated and analysed using statistical tools such as cross table, ‘t’ test, and multiple regression.

Results and Discussion

Impact on Agriculture Production and Livestock Population

The Salem district is primarily an agricultural area with a majority of its population involved in agriculture activities. The food grain crops cultivated are paddy (*Oryza sativa*), cholam (*Sorghum bicolor*), ragi (*Eleusine coracana*), red gram (*Cajanus cajan*), green gram (*Vigna radiata*), black gram (*Vigna mungo*) and horse gram (*Macrotyloma uniflorum*), and the primary cash crops of this district include turmeric

[1] For taxation purposes, a taluk or taluka is an administrative division in India that usually consists of a number of villages.

(*Curcuma longa*), sugarcane (*Saccharum officinarum*), tapioca (*Manihot esculenta*), mango (*Mangifera indica*), banana (*Musa acuminata*). Salem is also one of the top producers of sago (cassava) in the state of Tamil Nadu. Oilseeds that are cultivated include groundnut (*Arachis hypogaea*), coconut (*Cocos nucifera*), sunflower (*Helianthus annuus*) and ginger (*Zingiber officinale*). The irrigation water quality has degraded to the extent that crops no longer grow well when irrigated by this polluted water causing clogging of salts in the roots. As a result, the yield from agriculture has reduced, and most of the farmers drive into the viscous circle of poverty. During the field survey, farmers informed that, three decades ago, agriculture production in this basin was based on surface and subsurface irrigation, but, as the groundwater turned very salty and polluted, there is no safe irrigation-water available anymore. Farmers depend on the spartan rainfall for the cultivation of crops. Pollution of ground water has led to reduced yields and crop pattern changes that directly impact the agricultural income. Crops like paddy, sugarcane, and banana need a large volume of good quality water and are now substituted by cotton and coconut plantations. The situation put farmers in indebtedness, unemployment and poverty.

Table 1: Size of Landholding in Test Villages

Size of Land Holdings	*Name of the Area*		
	Affected Villages	*Control Village*	*Total*
Marginal Farmers (Less than 1ha)	263 (63.7%)	61 (14.8%)	324 (78.5%)
Small Farmers (1.0 to 2.0 ha)	8 (1.9%)	4 (1.0%)	12 (2.9%)
Semi-Medium Farmers (2.0 to 4.0 ha)	9 (2.2%)	0 (0.0%)	9 (2.2%)
Medium Farmers (4 to 10 ha)	51 (12.3%)	17 (4.1%)	68 (16.5%)
Total	331 (80.1%)	82 (19.9%)	413 (100.0%)

Source: Department of Economics and Statistics (2017-2018, p. 123)

According to the Ministry of Agriculture classification, the size of landholding is described in table 1, which shows the landholding pattern of households in the study area. Most of the respondents are agriculturalists in both control and affected villages. In the control villages, 61 (14.8%) are marginal farmers, 4 (1%) households have 1 to 2 hectares of land and 17 (4.1%) households have above 4 hectares of land (medium farmers). In affected villages, where sago industrial pollution has affected the agricultural land, 263 (63.7%) households are marginal landholders, and 51 (12.3%) have above 4 hectares of land (medium farmers).

Table 2: Sources of Irrigation Water in Test Villages

Sources of Irrigation	*Test Villages*		
	Affected Villages	*Control Village*	*Total*
Well Irrigation	31 (7.5%)	8 (1.9%)	39 (9.4%)
Borewell Irrigation	37 (9.0%)	13 (3.1%)	50 (12.1%)
No	263 (63.7%)	61 (14.8%)	324 (78.5%)
Total	331 (80.1%)	82 (19.9%)	413 (100.0%)

Table 2 shows the sources of irrigation methods for land cultivation in control and affected areas. In control village, 13 (3.1%) landholders have only bore well irrigation method and 8 (1.9%) have well irrigation, and

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61 (14.8%) landholders rely on seasonal rainfall. Moreover, these areas exist near Mettur dam, but the villagers are unable to use the dam water for irrigation purposes due to government restrictions. It is only availed for drinking purposes. In affected areas, 37 (9%) households have borewell irrigation, 31 (7.5%) have well irrigation and the remaining 263 (63.7%) land holders depend on seasonal rainfall.

Generally, the groundwater level in the Salem district also indicates a falling trend in a significant part of the district. Based on the factors mentioned, it is inferred that a significant part of the district can be considered vulnerable to various environmental impacts of groundwater level depletion such as drying up of shallow wells, decrease in the yield of bore wells and increased expenditure and power consumption for drawing water from progressively greater depths. Pollution of ground-water due to industrial effluents is another major problem in the district. Many industrial units, including textile units, sugar mills and sago factories, exist in the district, the effluents from which have caused local pollution of surface and ground-water resources (CGWB, 2008).

Loss of Agriculture Production

In India, the supply of freshwater is almost constant, and agriculture sector demands a larger share of around 80 to 90 percent (Kumar *et al.*, 2005; Gupta and Deshpande, 2004; Adams *et al.*, 2004; Laminou, 2015). Hence, with the growing demand/competition for water and its rising scarcity, the future demands of water for agricultural use cannot be met by freshwater resources alone but will gradually depend on marginal quality water or reuse water from domestic and industrial sectors (Bouwer, 2000; Gleick, 2000). However, domestic sewage and industrial effluents contain various water pollutants, which needs to be treated before using them for irrigation. Water quality is a critical environmental issue posed to the agricultural sector today (Barreiras and Ribeiro, 2019). Meeting the right quantity and desirable quality of water for agriculture is essential for food security and food safety.

An increase in agricultural productivity means an increase in production per unit of input, which raises the farmer's income. The family/community's increased income paves the way for augmenting savings, which can be used for further development of their agricultural land. On the other hand, a decrease in productivity leads to a lowering of production. Agriculture productivity loss was estimated to comprehend the degrees of loss caused by natural resource degradation like water and soil conditions due to industrial pollution. The details of damage functions used for estimation are presented. The results of the model are reported below:

$$Y = \alpha + \beta_1 \, TLO - \beta_2 \, TLASIP + \beta_3 \, IWASIP + \beta_4 \, YLT - \beta_5 \, YLP + \beta_6 \, YLFV + \beta_7 \, YLOS + \beta_8 \, YLM - \beta_9 \, YLC - \beta_{10} \, DIS_{sago} + \mu$$

$$Y = 289.962 + 7065.147 \, TLO - 27026.732 \, TLASIP + 34665.640 \, IWASIP + 1.160 \, YLT - .594 \, YLP + 2.068 \, YLFV + .678 \, YLOS + .828 \, YLM - 2.474 \, YLC - 88.751 \, DIS_{sago} + \mu$$

where,

Y = Dependent Variable
Y is the agriculture production
α is Constant
β_1-β_9 are coefficients to be estimated, and
μ is an error term.

The equation represents the determinants of agriculture production loss assessment as a function of

TLO	=	Total land owned
TLASIP	=	Total Land Affected by Sago Industrial Pollution
IWASIP	=	Irrigation Water Affected by Sago Industrial Pollution
YLT	=	Yield Loss Tapioca (Rs.)
YLP	=	Yield Loss Paddy (Rs.)
YLFV	=	Yield Loss Fruits & Vegetables (Rs.)
YLOS	=	Yield Loss Oil Seeds (Rs.)

YLM = Yield Loss Maize (Rs.)
YLC = Yield Loss Coconut (Rs.) and
DIS_{sago} = Distance Sago Industry to Agricultural Land (in km).

Table 3: Determinants and Loss of Agriculture Production

Sl. No.	*Independent Variables*	*B*	*SE*	*t*	*Sig.*
1	α (Constant)	289.962	1160.971	.250	0.803
2	TLO	7065.147	1614.787	4.375	0.000**
3	TLASIP	-27026.732	988.366	-27.345	0.000**
4	IWASIP	34665.640	5204.582	6.661	0.000**
5	YLT (Rs.)	1.160	0.105	11.082	0.000**
6	YLP (Rs.)	-0.594	0.175	-3.393	0.001**
7	YLFV(Rs.)	2.068	0.135	15.363	0.000**
8	YLOS (Rs.)	0.678	0.203	3.340	0.001**
9	YLM (Rs.)	0.828	0.142	5.816	0.000**
10	YLC (Rs.)	-2.474	0.217	-11.377	0.000**
11	DIS_{sago} (in km)	-88.751	347.955	-0.255	0.799
N= 413, R^2 = 0.851, F = 228.777					

Note: **1% level significant.

The value of agriculture-related damages explains the agricultural value damage function due to some of the parameters identified based on the household survey. The identified parameters of agricultural value damage function for the entire pollution radius between proximity villages are presented in this model. It is evident from the model that the farm level and village level agricultural damages were influenced significantly by the effect of pollution on farmland. It is implicit that 1 percent effect on land fertility and greater quality cause agricultural damage by 0.85 percent from the mean level. Theoretically, large number of variables influence agricultural production. The agricultural damage cost function has shown that the value of agricultural damage cost is a function of size of land owned in acre (1) Marginal farmers (less than 1 ha), (2) Small farmers (1.0 to 2.0 ha), (3) Semi-medium farmers (2.0 to 4.0 ha), (4) Medium Farmers (4 to 10 ha).[2] It was evident that once the size of land owned increases, the damage cost also increases.

Considering agricultural land affected by industrial pollution (continuous variables) and the damage cost correlation, it appears that these two variables are positively related with the independent variable. The damage function links pollution to the yield. In this model, value damage functions were developed and employed. While the agricultural damage function considered a loss in productivity of cropland and labour, crop output, change in the quality of water, damaged soil quality, etc.

Impact on Livestock Population

Cows are considered as part and parcel of agriculture. The livestock in the study area was affected by sago industrial effluents in the soil and water resources. The number of livestock is low in affected area compared to the other areas. Chloride from sago industry makes its way into air, food, and water. The most common forms of exposure are inhalation of dust or fumes and ingestion of or contact with contaminated water. Chloride waste can also go deep into the soil and contaminate groundwater systems that provide drinking water for nearby communities. Soil contaminated by chloride waste poses a health hazard, as both people

[2] Directorate of Economics & Statistics (2007). Agricultural Statistics at a Glance. Department of Agriculture & Cooperation, Government of Tamil Nadu.

and livestock can inhale toxic dust. In the field survey, households complained about the effluents discharged by the Common Effluent Treatment Plant (CETPs) contained a high level of Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) far exceeding the norms of the Tamil Nadu Pollution Control Board (TNPCB).

Table 4: Distribution of Affected Livestock in Selected Villages

Name of the village		*Total Number of Affected Livestock*						
		0	*1*	*2*	*4*	*5*	*6*	*Total*
Control Villages	Kaveripuram	59 (14.3%)	5 (1.2%)	14 (3.4%)	3 (0.7%)	1 (0.2%)	0 (0.0%)	82 (19.9%)
Affected Villages	Ammampalayam	2 (0.5%)	44 (10.7%)	25 (6.1%)	3 (0.7%)	7 (1.7%)	5 (1.2%)	86 (20.8%)
	Kattukkottai	77 (18.6%)	7 (1.7%)	27 (6.5%)	1 (0.2%)	5 (1.2%)	6 (1.5%)	123 (29.8%)
	Mallur	67 (16.2%)	17 (4.1%)	29 (7.0%)	3 (0.7%)	1 (0.2%)	5 (1.2%)	122 (29.5%)
Total		205 (49.6%)	73 (17.7%)	95 (23.0%)	10 (2.4%)	14 (3.4%)	16 (3.9%)	413 (100.0%)

Table 4 shows that 205 (49.6%) of the 413 households did not have any livestock. Out of 82 households in the control village of Kaveripuram, 59 (14.3%) reported having no livestock. Due to the fall in animal populations, the remaining households have reported cow bane, cowpox and poor livestock management. The high number of affected livestock in this area can be seen in localities like Ammampalayam is 44 (10.7%), Kattukottai is 27 (6.5%), Mallur 29 (7.0%). In this affected area, poor water quality, contaminated pasture lands, and insufficient supplies of medication, vaccinations, and equipment have all been identified as grounds for inefficiency in service delivery. Finally, the number of livestock in affected villages lower than in control village, which has an obvious explanation.

Table 5: Distribution of Livestock Death in Selected Villages

Name of the village		*Total Number of Livestock Died*					
		0	*1*	*2*	*3*	*4*	*Total*
Control Villages	Kaveripuram	71 (17.2%)	8 (1.9%)	1 (0.2%)	2 (0.5%)	0 (0.0%)	82 (19.9%)
Affected Villages	Ammampalayam	27 (6.5%)	43 (10.4%)	7 (1.7%)	7 (1.7%)	2 (0.5%)	86 (20.8%)
	Kattukkottai	96 (23.2%)	20 (4.8%)	0 (0.0%)	6 (1.5%)	1 (0.2%)	123 (29.8%)
	Mallur	89 (21.5%)	23 (5.6%)	2 (0.5%)	4 (1.0%)	4 (1.0%)	122 (29.5%)
Total		283 (68.5%)	94 (22.8%)	10 (2.4%)	19 (4.6%)	7 (1.7%)	413 (100.0%)

Table 5 shows the number of livestock died in the control and affected villages. According to the findings, 283 households (68.5%) recorded no livestock deaths. The percentages of households reporting dead livestock were 43 (10.4%), 20 (4.8%), and 23 (5.6%), respectively. According to the results, the number of livestock deaths in affected villages was higher than in control villages. It is caused by sago industrial contamination, which has poisoned common grazing land, polluted river water, and resulted in high medical costs.

Table 6: Difference in Total Number of Livestock Population between Test Villages

Total Number of Livestock's	*Levene's Test for Equality of Variances*		*t-test for Equality of Means*				
	F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*
Equal variances not assumed	11.709	0.001	-4.207	186.407	0.000*	-1.138	0.271

* Significant at 5 % level.

An independent "t" test was conducted to analyse the total livestock between control and affected villages. The test table's result indicated a significant difference in the number of livestock between test villages t (186.407) = - 4.207 p = .000. The result suggests that the number of livestock in control village (M = 1.11, SD =1.950, N = 413) is lower in number than the number in affected villages is greater in number (M = 2.25, SD = 2.979, N = 413). The analysis has concluded that the livestock population is higher in experimental villages than in control village. The unavailability of quality water is the primary reason for death of livestock in affected villages and, hence, most of the respondents are not using livestock in cultivation purposes.

The variation between control and affected villages in the number of dead livestock is significant. The 't' test shows the significant difference between control and affected villages. Since agricultural production is low in experimental village households, there are reasonable prices for meaty purposes. The other grazing land problems have been used for other purposes such as building construction and deficiency of good quality water because of pollution effluents. But in control villages the livestock is lower because of the availability of quality water and other facilities.

Table 7: Distribution of Land Holdings and Livestock in Test Villages

Total Land Owned	*Do you have livestock*		
	No	*Yes*	*Total*
Marginal Farmers (Less than 1ha)	201 (48.7%)	123 (29.8%)	324 (78.5%)
Small Farmers (1.0 to 2.0 ha)	1 (0.2%)	11 (2.7%)	12 (2.9%)
Semi-Medium Farmers (2.0 to 4.0 ha)	0 (0.0%)	9 (2.2%)	9 (2.2%)
Medium Farmers (4 to 10 ha)	3 (0.7%)	65 (15.7%)	68 (16.5%)
Total	205 (49.6%)	208 (50.4%)	413 (100.0%)

Table 7 explains the size of landholders and keeping livestock in selected villages where 205 (49.6 %) landholders have livestock and 208 (50.4%) landholders do not have livestock. The results indicate that 123 (29.8%) marginal farmers (less than 1 ha) have one or two cattle and the medium farmers (4 to 10 ha) having 65 (15.7 %) is increased in more than four numbers of cattle or buffaloes. It is concluded that marginal farmers and medium farmers depend upon agriculture and livestock earnings, but small and semi-medium farmers adopted to industrial workers and other businesses.

Table 8: Types of Livestock in Sample Villages

Name of the Village		*Types of Livestock*					
		Cow	*Buffalo*	*Goat*	*Others*	*No*	*Total*
Affected Villages	Ammampalayam	33 (8.0%)	7 (1.7%)	6 (1.5%)	38 (9.2%)	2 (0.5%)	86 (20.8%)
	Kattukkottai	46 (11.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	77 (18.6%)	123 (29.8%)
	Mallur	40 (9.7%)	2 (0.5%)	2 (0.5%)	11 (2.7%)	67 (16.2%)	122 (29.5%)
Control Village	Kaveripuram	20 (4.8%)	1 (0.2%)	2 (0.5%)	0 (0.0%)	59 (14.3%)	82 (19.9%)
Total		139 (33.7%)	10 (2.4%)	10 (2.4%)	49 (11.9%)	205 (49.6%)	413 (100.0%)

The table 8 shows the different types of livestock in selected villages. In the test villages, Kattukkottai is 46 (11.1%), Mallur is 40 (9.7%), Ammampalayam is 33 (8.0%), and Kaveripuram is 20 (4.8%) cows. Buffalos, goats, and other animals make up the remaining livestock population. In control and affected areas, 205 (49.6%) households were not having livestock. The result has clearly indicated that affected villages have a greater number of livestock as they do not migrate to other places and they depend on agriculture, local employment opportunities and livestock earnings. In control village, people migrate to outside of Tamil Nadu, i.e. Bangalore and Kerala state, for working as building construction labourers, lorry drivers etc. So, the livestock population is less in number in control village compared to affected villages.

Table 9: Determinants of Expenditure on Livestock

Sl.No.	*Independent Variables*	*Regression Coefficient*	*Std. Error*	*t*	*Sig.*
1	α (Constant)	1085.427	605.112	1.794	0.074*
2	HEDU	-156.866	132.969	-1.180	0.239*
3	FY	-0.004	0.050	-0.072	0.943
4	TNAL	1929.942	496.768	3.885	0.000**
5	TNDL	2837.152	455.253	6.232	0.000**
6	MVL	0.115	0.026	4.493	0.000**
7	RFL	0.328	0.037	8.781	0.000**
8	VHD	445.750	70.008	6.367	0.000**
N=413, R^2 = 0.846, F = 317.467					

* 5 % level significant, ** 1 % level significant.

$Y = \alpha - \beta_1 \text{ HEDU} - \beta_2 \text{ FY} + \beta_3 \text{ TNAL} + \beta_4 \text{ TNDL} + \beta_5 \text{ MVL} + \beta_6 \text{ RFL} + \beta_7 \text{ VHD} + \mu$

$Y = 1085.427 - 156.866 \text{ HEDU} - 0.004 \text{ FY} + 1929.942 \text{ TNAL} + 2837.152 \text{ TNDL} + 0.115 \text{ MVL} + 0.328 \text{ RFL} + 445.750 \text{ VHD} + \mu$

where,

Y = Dependent Variable

Y is the medical expenditure for livestock impact due to sago contamination and bad quality of grazing lands and μ is an error term, β_1-β_9 are coefficients to be estimated, α is a constant. Equation represents the determinants of livestock impact assessment as a function of

HEDU	=	Level of Education of the Head
FY	=	Family Income
TNAL	=	Total Number of Affected Livestock
TNDL	=	Total Number of died Livestock
MLV	=	Market Value of Livestock (in Rs.)
RFL	=	Returns from Livestock (in Rs.)
VHD	=	Veterinary Hospital Distance

A particular set of variables may be dominant to determine cost of livestock damage. Table 9 clearly indicates the livestock damage in the affected and control villages. The regression model was used for this analysis. Variables including the total number of livestock population died, the market value of livestock (in Rs.), returns from livestock (in Rs.), and the distance to the nearest veterinary hospital all have positively significance at 1%. The respondents in the farm and non-farm categories had several and small ruminants, respectively. Another serious problem is that some cows and buffaloes had lost their reproductive capacity and low milk productivity. Due to fear of further incapacitation or death, people have started selling their cattle on low prices. Because of the impact of pollution on livestock, there is a drastic change in the composition and livestock holding in the affected area. Hence, either the livestock has died by drinking polluted water or because the people would have sold their cattle due to fear of death.

Findings and Suggestions

Impact on Agriculture

The most important effect of sago industrial pollution was found on cropping pattern and agricultural production in the area. As the area is agrarian in nature, the loss in agricultural production leads to a very poor economic condition of the households. It was found that most of the respondents are agriculturalists in both control and affected villages. In the control village, 61 (14.8%) are marginal farmers (less than 1ha), 17 (4.1%) households have above 4 hectares of land and 4 (1.0%) are small farmers (1.0 to 2.0 ha) of land holding. In the affected villages, where sago industrial pollution affected the agricultural land, 263 (63.7%) of households are marginal farmers, 51 (12.3%) are medium farmers (4 to 10 ha), 9 (2.2%) are semi-medium farmers (2.0 to 4.0 ha) and 8 (1.9%) are small farmers (1.0 to 2.0 ha). Farmers are facing many problems of reduced agricultural production.

The farmers are using either bore well or tank and well water for the irrigation purpose. In the control village 61 households (14.8%) depend on seasonal rain, 13 (3.1%) depend on bore well irrigation and 8 depend (1.9%) on well irrigation. In the affected villages, 263 respondents (63.7%) are not actively engaged in cultivation due to water contamination leading to low production, while remaining households are using well irrigation [31 (7.5 %)] and bore well irrigation [37 (9.0%)]. The sago industrial effluents affect the crop cultivation in the affected villages. The major cultivated crops are showing decreasing trend in the total production.

The result concluded that, in the control village, the coconut cultivation is comparatively low, whereas most of the households depend on coconut cultivation in affected villages. But the yield is very low in affected villages due to sago industrial pollution in water, soil and environment. Pollution of ground water has led to reduced yields and changes in crop pattern, impacting agricultural income directly. As the other water resources are either unusable or became dry, groundwater is the major sources for irrigation. Crops like turmeric, paddy, sugarcane, fruits and vegetables, which need large volume of good quality water, are now substituted by maize, cotton and coconut plantations.

Impact on Livestock

The impact of sago industrial pollution on livestock populations in control and affected villages was investigated. There were significantly fewer households with livestock. The livestock population had decreased in both villages, according to the households. In affected villages, the gap in livestock population is more important than in control villages. In the control village, 23 people claimed that the animal population had decreased, while in the affected village, 187 people claimed that there was a significant difference in the livestock population, citing sago industrial contamination as the primary cause of the decrease in the livestock population.

Mostly, the households are not using cattle for agricultural purposes and they are now depending on the tractor more because the cost and maintenance of tractor are comparatively less. Therefore, compared to control village, number of livestock is reduced more in affected villages as a result of sago industrial pollution. In affected villages, sago industries are situated near grazing lands and agricultural lands, and waste waters are allowed to drain out into such lands. The households highlighted that the pollution affects the soil quality, and dry land and grazing land are used for dumping of industrial wastes. Thus, sago industries played major role in reducing the number of livestock in the affected villages.

Conclusion

Pollution is one of the major issues in the ecosystem. The effluents released by various industries create external costs as well as environmental degradation (Banu *et al*., 2006; Rajendran *et al*., 2011; Monisha, Rajakumar and Ayyasamy, 2013). Hence, the estimation of economic losses and environmental degradation has been a great challenge and it is a serious concern in developing countries like India. Similarly, the sago industrial effluents also a part of the impact on water and land pollution in Tamil Nadu. This is a challenge for environmental economists as well as a need for approaching processes in reuse technology. The study found that, the economic losses of agriculture production and livestock population are more prevalent in the study area. Hence the loss of agriculture production in the region should be further reinforced to meet the future demand. The study suggests new possibilities for the design of low-cost and compact onsite wastewater treatment systems with very short retention periods and the pollution control laws must be strictly enforced by the government to protect the environmental resources.

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Author's Declarations and Essential Ethical Compliances

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