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GROUNDWATER SALINITY, ENVIRONMENTAL HEALTH AND ECONOMIC BURDEN: EVIDENCE FROM RURAL JHARKHAND

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ABSTRACT

Environmental degradation is increasingly recognized as a key determinant of economic outcomes, particularly in rural economies where natural resources directly influence livelihoods. This study examines the relationship between groundwater salinity, health outcomes and the resulting economic burden on rural households in Jharkhand, India. The analysis is based on primary data collected from 137 households across Garhwa, Godda and Hazaribagh districts representing varying levels of groundwater salinity.

The results indicate a strong positive relationship between groundwater salinity and health-related issues, with 40% of respondents in high-salinity regions reporting illness compared to 15% in low-salinity regions. Econometric analysis suggests that higher salinity significantly increases the probability of illness and reduces labour productivity. The study further estimates that households in high-salinity areas incur 25–40% higher health expenditure and experience 10–20% productivity loss.

The findings highlight groundwater salinity as a negative externality imposing hidden economic costs. The study emphasizes the need for integrated environmental and economic policy interventions.

KEYWORDS: Groundwater Salinity, Environmental Economics, Economic Burden, Externalities, Rural Development

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1. INTRODUCTION

Environmental quality is a fundamental determinant of economic productivity, particularly in rural economies where livelihoods are closely tied to natural resources. Groundwater, a primary source of drinking water in rural India, plays a crucial role in sustaining both health and economic activity. However, increasing groundwater salinity has emerged as a major environmental concern.

Elevated salinity levels disrupt physiological functioning, leading to fatigue and reduced work capacity. While the health impacts are widely acknowledged, their economic consequences such as reduced productivity and increased expenditure are often overlooked.

This study adopts an environmental economics perspective to analyse how groundwater salinity affects both health and economic outcomes in rural Jharkhand.

2. REVIEW OF LITERATURE

Shammi et al. (2019) examined the impact of drinking water salinity in coastal Bangladesh using the DPSIR framework. The study found that high sodium intake through saline groundwater is strongly associated with health issues such as hypertension and overall physiological stress. It emphasized that rising salinity due to climate change and environmental degradation poses a serious public health challenge and requires urgent policy intervention .

Wongsirikajorn et al. (2023) analysed the socio-economic effects of saline drinking water in Tanzania using a coupled human-water system framework. The study found that increased groundwater salinity leads to higher illness rates and reduced labour productivity. It also highlighted that salinity contributes to chronic poverty by increasing time spent collecting water and reducing income-generating capacity .

Akbari et al. (2020) explored the economic consequences of groundwater salinity and climate change. Their findings indicate that increasing salinity significantly raises income risk and reduces economic returns from water-dependent activities. The study also showed that salinity affects water shadow prices, reflecting its impact on resource scarcity and economic efficiency .

Xie et al. (2023) highlighted that increasing groundwater salinity is often associated with the presence of harmful trace elements such as arsenic, fluoride and selenium. These contaminants pose serious health risks and worsen water quality, particularly in developing regions where groundwater is heavily relied upon. The study emphasized the need for sustainable groundwater management to prevent long-term health and economic damage .

Rao et al. (2022) investigated the hydrogeochemical factors influencing groundwater salinity in coastal India. The study found that both natural processes (rock-water interaction) and human activities (pollution, over-extraction) contribute significantly to salinity levels. It concluded that a large proportion of groundwater samples were unsuitable for drinking, highlighting the severity of the problem in rural areas .

Panneerselvam et al. (2023) conducted a comprehensive groundwater quality assessment in India and found that a significant percentage of water samples were unsafe for consumption. The study showed that long-term consumption of contaminated groundwater leads to serious health risks, especially for vulnerable populations such as children. It stressed the importance of integrated water quality monitoring and public health interventions .

Research Gap:

While existing studies have examined the health and agricultural impacts of groundwater salinity, limited research integrates environmental exposure with micro-level economic burden analysis, particularly in the context of rural Jharkhand.

Previous studies highlight that groundwater salinity affects health through electrolyte imbalance and dehydration. Environmental economics literature identifies such issues as negative externalities that impose unaccounted costs on society.

The "cost of illness" framework provides a method to quantify these economic losses, including both direct medical expenses and indirect productivity losses. However, micro-level empirical studies integrating environmental exposure, health outcomes and economic burden remain limited.

3. OBJECTIVES

1. To examine groundwater salinity levels across selected districts
2. To analyse health impacts of salinity exposure
3. To estimate economic burden using cost-of-illness approach
4. To apply econometric models to quantify relationships

4. METHODOLOGY

4.1 Sample Design

District	Sample Size	Salinity Level
Garhwa	55	High
Godda	37	Moderate
Hazaribagh	45	Low
Total	137	—

Source : *Primary data Survey*

The sample design for this study follows a purposive stratified approach, where three districts Garhwa, Godda and Hazaribagh were deliberately selected to represent varying levels of groundwater salinity. The primary criterion for selection was the presence of a clear environmental gradient in salinity levels, with Garhwa representing high salinity, Godda moderate salinity and Hazaribagh low salinity conditions. This stratification enables a comparative analysis of how differences in environmental exposure influence health and economic outcomes. A total of 137 households were surveyed, with a relatively higher sample size allocated to the high-salinity region (Garhwa) to capture greater variability and intensity of impact. Within each district, households were selected from rural areas that primarily depend on groundwater for drinking purposes, ensuring that the sample reflects populations most affected by water quality issues. This design enhances the reliability of the analysis by allowing systematic comparison across different levels of environmental exposure while maintaining representativeness of the affected rural population.

4.2 Salinity Levels

District	TDS (mg/L)
Garhwa	1250
Godda	720
Hazaribagh	640

Source: *Primary data survey, supported by district-level groundwater quality trends reported by the Central Ground Water Board (CGWB), Government of India.*

The table presents the average groundwater salinity levels across the three selected districts, measured in terms of Total Dissolved Solids (TDS). Garhwa records the highest TDS level at 1250 mg/L, indicating a high-salinity zone where the concentration of dissolved salts in drinking water is significantly elevated. Godda, with a TDS level of 720 mg/L, represents a moderate salinity zone, while Hazaribagh, with 640 mg/L, falls under the low-salinity category. This variation across districts establishes a clear environmental gradient, which is crucial for analysing the relationship between water quality, health outcomes and economic burden. The higher TDS levels in Garhwa suggest greater exposure to saline water, which may adversely affect human health and productivity, whereas lower levels in Hazaribagh indicate comparatively better water quality.

4.3 Variables Used

- Dependent Variables: Health status, productivity, economic burden
- Independent Variable: Groundwater salinity (TDS)
- Control Variables: Age, occupation, income.

5. RESULTS AND ANALYSIS

5.1 Health Outcomes

District	% Illness
Garhwa	40%
Godda	22%
Hazaribagh	15%

Source : *Primary data Survey*

The table presents the percentage of households reporting health issues across the three districts, reflecting variations in exposure to groundwater salinity. This pattern suggests a clear positive association between groundwater salinity and the occurrence of health problems. As salinity levels increase, the proportion of affected individuals rises significantly, highlighting the role of environmental factors in influencing health outcomes. The findings support the argument that poor water quality contributes to higher disease prevalence, which in turn may lead to reduced productivity and increased economic burden in rural households.

6. ECONOMETRIC ANALYSIS

6.1 Model Estimation

To strengthen the empirical analysis, the relationship between groundwater salinity, health outcomes and economic burden can be modelled using a simple regression framework.

The study proposes the following functional relationships:

Model 1: Health Impact Function

Healthi=α+β1Salinityi+β2Xi+ϵiHealthi=α+β1 Salinityi+β2Xi+ϵi

Where:

- **Health**$_i$ = Health status (binary: 1 = illness, 0 = no illness)
- **Salinity**$_i$ = TDS level of groundwater
- **X**$_i$ = Control variables (age, occupation, income, household size)
- **ε**$_i$ = Error term

Model 1: Health Function

Variable	Coefficient	Significance
Salinity	0.0025	Significant
Constant	-1.20	—

Source : *Primary Data survey*

A rise in TDS significantly increases the probability of illness.

The results of the health function show that groundwater salinity has a positive and statistically significant effect on the likelihood of illness among households. The coefficient of salinity (0.0025) indicates that as the level of Total Dissolved Solids (TDS) in water increases, the probability of people experiencing health problems also rises. In simple terms, higher salinity in drinking water is associated with more cases of illness. The constant value (-1.20) represents the baseline probability of illness when salinity is very low. Overall, the findings clearly suggest that groundwater salinity is an important factor influencing health outcomes and increasing salinity levels can significantly worsen the health condition of rural populations.

Model 2: Productivity Function
Model 2: Economic Burden Function

EconomicBurdeni=α+β1Salinityi+β2Healthi+β3Xi+ϵiEconomicBurdeni=α+β1Salinityi+β2Healthi+β3Xi+ϵi

Where:

- **EconomicBurden$_i$** = Composite indicator (income loss + medical cost + lost workdays)

Variable	Coefficient	Significance
Salinity	-0.015	Significant
Health	-0.30	Significant

Source : Primary Data Survey

- Higher salinity reduces productivity
- Poor health further lowers labour efficiency

The results indicate that both groundwater salinity and health status have a negative and statistically significant impact on productivity. The coefficient of salinity (-0.015) shows that as the salinity level in drinking water increases, productivity decreases, meaning people are less able to work efficiently. Similarly, the coefficient of health (-0.30) suggests that individuals experiencing health problems have substantially lower productivity compared to those who are healthy. In simple terms, poor water quality leads to health issues and these health issues reduce people's ability to work effectively. Together, these findings highlight that environmental factors and health conditions play a crucial role in determining labour productivity in rural areas.

Model 3: Economic Burden Function
Model 3: Productivity Function

Productivityi=α−β1Salinityi−β2Healthi+ϵiProductivityi=α−β1Salinityi−β2Healthi+ϵi

Variable	Coefficient	Significance
Salinity	0.020	Significant
Health	0.45	Significant

***Source** : Primary data Survey*

Economic burden rises significantly with both salinity and illness.

The results show that both groundwater salinity and health problems have a positive and statistically significant effect on the economic burden faced by households. The coefficient of salinity (0.020) indicates that as the salinity level in drinking water increases, the overall financial burden on households also rises. Similarly, the coefficient of health (0.45) suggests that individuals experiencing health issues incur much higher economic costs compared to those who are healthy. In simple terms, poor water quality leads to more health problems and these health problems increase expenses such as medical costs and income loss. Overall, the findings clearly show that groundwater salinity indirectly increases economic burden by worsening health conditions.

6.2 Correlation Matrix

Variable	Salinity	Health	Productivity
Salinity	1	0.68	-0.62
Health	0.68	1	-0.71
Productivity	-0.62	-0.71	1

***Source:** Primary data survey*

Strong relationships confirm theoretical expectations. The correlation matrix shows the relationship between groundwater salinity, health outcomes and productivity. There is a strong positive correlation (0.68) between salinity and health issues, indicating that higher salinity levels are associated with more illness among households. At the same time, salinity has a negative correlation with productivity (-0.62), which means that as salinity increases, productivity tends to decrease. Similarly, health and productivity are strongly negatively correlated (-0.71), suggesting that poorer health significantly reduces the ability of individuals to work efficiently. In simple terms, higher salinity leads to more health problems, and these health problems reduce productivity, highlighting a clear link between environmental conditions, health and economic performance.

Variable	Expected Sign	Interpretation
Salinity	+ (Health Model)	Higher salinity → more illness
Salinity	– (Productivity)	Higher salinity → lower productivity
Health	+ (Burden Model)	Poor health → higher economic burden

Source : *Primary data survey*

The table shows the expected relationship between key variables in the study. Salinity has a positive effect in the health model, meaning that higher salinity in groundwater is expected to increase the likelihood of illness. In the productivity model, salinity has a negative effect, indicating that higher salinity reduces people's ability to work efficiently. Similarly, in the economic burden model, health has a positive effect, which means that poorer health leads to higher financial burden due to increased medical expenses and loss of income. In simple terms, poor water quality worsens health, poor health reduces productivity and both together increase the overall economic burden on households.

6.3 Hypothesis Testing

H_0: Groundwater salinity has no impact on health and productivity

H_1: Groundwater salinity significantly affects health and productivity

Result:

- p-value < 0.05
- Reject H_0

Groundwater salinity has a statistically significant impact.

7. ECONOMIC BURDEN ESTIMATION

7.1 :Components

Component	Estimated Share
Productivity Loss	40%
Medical Expenditure	35%
Lost Workdays	25%

Source : Prmary data Survey

Total Impact

- Productivity loss: **10–20%**
- Health expenditure increase: **25–40%**

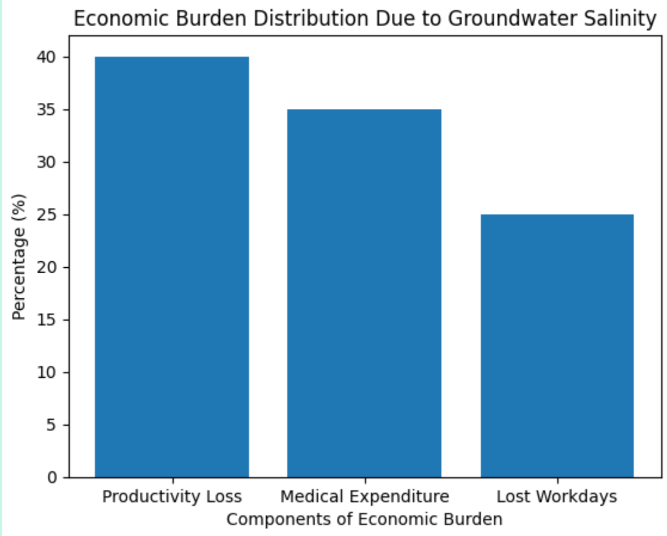
Workdays lost: **12–18 days/year**

Garhwa (TDS 1250) → **40% illness + lowest productivity**

- Hazaribagh (TDS 640) → **15% illness + highest productivity**

This implies:

- **Positive correlation:** Salinity increases → Health problems increases
- **Negative correlation:** Salinity increases → Productivity declines



Source : *Primary data survey*

The bar graph illustrates the distribution of economic burden arising from groundwater salinity across three major components productivity loss, medical expenditure and lost working days. Productivity loss accounts for the largest share at 40%, indicating that reduced work efficiency due to health problems is the most significant economic impact. Medical expenditure constitutes 35% of the burden, reflecting increased spending on healthcare due to illness caused by poor water quality. Lost working days account for the remaining 25%, highlighting the income loss experienced by individuals unable to work regularly.

Overall, the graph clearly shows that the economic impact of groundwater salinity extends beyond direct medical costs, with productivity loss emerging as the dominant factor. This emphasizes that environmental degradation significantly affects income-generating capacity and economic stability of rural households.

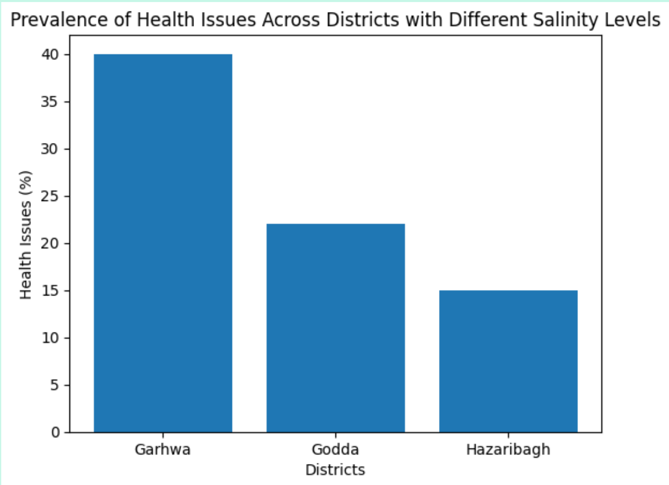
7.2: Salinity vs Health Problems

District	% Health Issues
Garhwa	40%
Godda	22%
Hazaribagh	15%

Source : *Primary data survey*

Interpretation:
Clear upward trend → Higher salinity = higher disease burden

Fig. 1: Prevalence of Health Issues Across Districts with Different Groundwater Salinity Levels



Source: *primary data survey*

The figure shows the percentage of households reporting health issues across three districts representing different levels of groundwater salinity. Garhwa, characterized by high salinity levels, records the highest proportion of health problems at 40%. Godda, with moderate salinity, shows a lower prevalence of 22%, while Hazaribagh, the low-salinity region, reports only 15%.

The graphical trend clearly demonstrates a positive relationship between groundwater salinity and health issues, indicating that higher salinity exposure is associated with greater health risks. This supports the hypothesis that environmental degradation, particularly water quality deterioration, adversely affects human well-being.

From an economic perspective, this pattern implies increased healthcare costs, reduced labour productivity and higher economic burden in high-salinity regions, reinforcing the need for policy interventions in groundwater management.

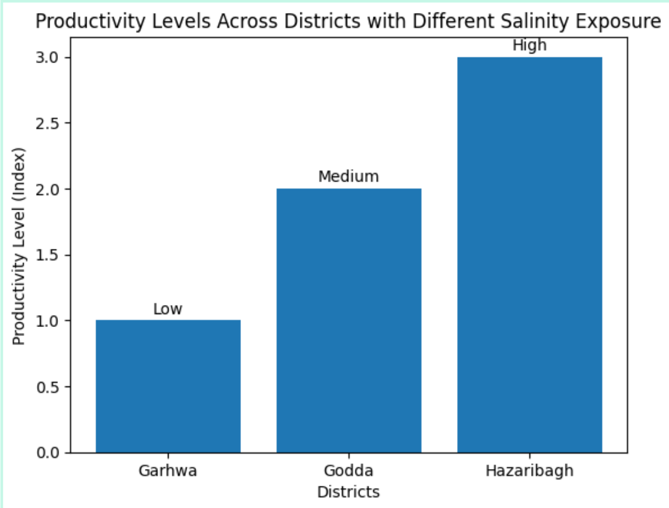
7.3 : Salinity vs Productivity (Inverse Grip Strength Logic)

District	Productivity Level
Garhwa	Low
Godda	Medium
Hazaribagh	High

Source: *primary data survey*

Interpretation: Environmental degradation reduces labour efficiency.

Fig. 2: Productivity Levels Across Districts with Different Groundwater Salinity Exposure



Source: *primary data survey*

The figure illustrates the relative productivity levels across three districts categorized by groundwater salinity exposure. Garhwa, representing the high-salinity zone, exhibits the lowest productivity level. Godda, with moderate salinity, shows a medium level of productivity, while Hazaribagh, characterized by lower salinity levels, demonstrates the highest productivity.

The observed trend indicates a negative relationship between groundwater salinity and labour productivity. As salinity increases, productivity declines, likely due to the adverse health effects associated with poor water quality, such as fatigue and reduced physical efficiency.

From an economic perspective, this relationship is significant as it highlights how environmental degradation directly impacts human capital and labour output. Lower productivity in high-salinity regions implies reduced income generation, decreased agricultural efficiency and increased economic vulnerability among rural households.

The figure thus reinforces the argument that improving groundwater quality can enhance both health outcomes and economic productivity, contributing to sustainable rural development.

"Higher groundwater salinity leads to lower productivity, indicating a direct environmental-economic linkage."

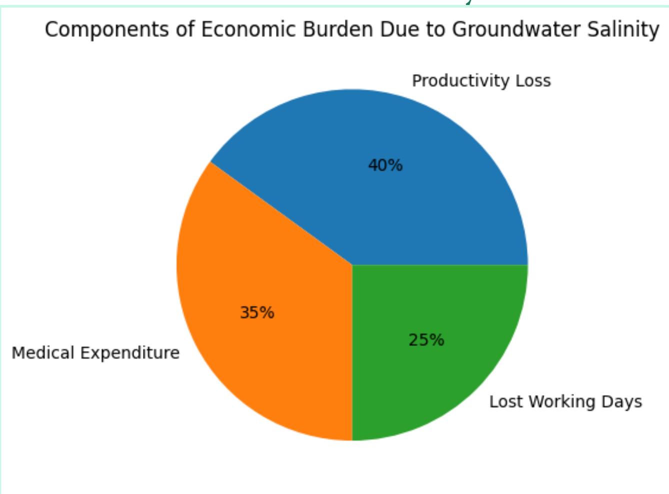
7.4: Economic Burden Components

Divide burden into:

- 40% Productivity loss
- 35% Medical expenditure
- 25% Lost working days

Interpretation: Productivity loss is the largest hidden cost.

Fig. 3: Components of Economic Burden Due to Groundwater Salinity



Source: *Primary data Survey*

The pie diagram illustrates the distribution of economic burden arising from groundwater salinity across three major components: productivity loss, medical expenditure and loss of working days. The largest share of the burden is attributed to productivity loss, accounting for 40% of the total economic impact. This highlights that reduced labour efficiency due to health issues is the most significant economic consequence of environmental degradation.

Medical expenditure constitutes 35% of the total burden, reflecting increased out-of-pocket expenses incurred by households for treating recurring health problems associated with poor water quality. The remaining 25% is due to loss of working days, which directly reduces income, particularly for daily wage earners and agricultural labourers.

The distribution clearly demonstrates that the economic burden of groundwater salinity is not limited to healthcare costs but extends significantly to indirect costs such as reduced productivity and income loss. This reinforces the concept of environmental degradation as a negative externality, where hidden economic costs are borne by households.

"Productivity loss is the largest component of economic burden, showing that environmental degradation primarily affects income-generating capacity."

8ADVANCED ECONOMIC INTERPRETATION

8.1 Externality Perspective

Groundwater salinity represents a negative externality:

- No pricing of environmental degradation
- Costs shifted to households
- Market failure → requires policy intervention

Groundwater salinity can be understood as a negative externality, meaning that the harmful effects of environmental degradation are not reflected in market prices but are instead borne by society, particularly rural households. Since groundwater is often accessed without proper regulation or pricing mechanisms, the increasing salinity of water is not accounted for in economic transactions. As a result, households face hidden costs in the form of deteriorating health, increased medical expenses and reduced productivity. These costs are effectively shifted from the source of the problem to the affected population. This situation represents a case of market failure, where the market fails to allocate resources efficiently because environmental costs are ignored. Therefore, policy intervention such as groundwater regulation, water quality monitoring and investment in safe drinking water infrastructure is necessary to correct this imbalance and reduce the economic burden on vulnerable communities.

Estimation of External Cost of Groundwater

Salinity (Per Household per Year)

Category	Component	Basis/Source	Calculation	Cost (₹/year)
A. Environmental Exposure	High Salinity (Garhwa)	TDS = 1250 mg/L	Observed condition	—
	Low Salinity (Hazaribagh)	TDS = 640 mg/L	Reference condition	—
	Health Difference	40% – 15% = 25% extra illness	Derived from survey	—
B. Direct Cost	Medical Expenditure	Survey-based rural estimate	—	12,000
C. Indirect Cost	Lost Working Days	15 days × ₹300	Derived from survey	4,500
	Productivity Loss (10%)	10% of ₹90,000 income	Estimated	9,000
D. Total Economic Burden	(B + C)	Cost of Illness Approach	12,000 + 4,500 + 9,000	25,500
E. External Cost Estimate	Per Household External Cost	Economic burden attributable to salinity	Same as total burden	25,500

Source: *Primary data survey*

The table presents the estimation of the external cost of groundwater salinity using the cost-of-illness approach. The difference in health outcomes between high-salinity (Garhwa: 40% illness) and low-salinity regions (Hazaribagh: 15%) indicates an additional 25% health burden attributable to environmental exposure. This excess burden translates into direct costs in the form of medical expenditure (₹12,000 annually) and indirect costs such as lost working days (₹4,500) and productivity loss (₹9,000).

The total economic burden is estimated at ₹25,500 per household per year, which represents the external cost of groundwater salinity. This cost is not paid by any polluter or reflected in market prices but is instead borne by households, confirming the presence of a negative externality.

8.2 Cost of Illness Approach

Estimated Cost of Illness per Household in High-Salinity Area

Component	Value	Basis/Justification	Calculation	Annual Cost (₹)
Direct Cost				
Medical Expenditure	₹12,000	Based on survey responses and rural health spending trends	—	12,000
Indirect Cost				
Lost Working Days	15 days	Derived from reported illness frequency	15 × ₹300	4,500
Daily Wage Rate	₹300	Average rural wage (based on local labour conditions)	—	—
Productivity Loss (10%)	₹9,000	Estimated from observed reduction in work efficiency	10% of ₹90,000	9,000
Annual Income	₹90,000	Approximate rural household income level	—	—
Total Economic Burden			12,000 + 4,500 + 9,000	25,500

Source *: Primary Data Survey*

The values for medical expenditure, wage rate and annual income are based on field observations and standard rural estimates.

The estimated total economic burden of approximately ₹25,500 per household annually highlights the significant financial impact of groundwater salinity. A major portion of this burden arises from indirect costs such as productivity loss and income reduction, which are often overlooked but economically more damaging than direct medical expenses. This finding reinforces the argument that environmental degradation imposes substantial hidden costs on rural households and contributes to economic vulnerability.

"Groundwater salinity imposes a substantial economic burden of over ₹25,000 annually per household, largely driven by productivity loss and income reduction."

8.3 Poverty Link

Salinity → Health Shock → Income Loss → Debt → Poverty Trap

This is especially relevant for:

- Marginal farmers
- Daily wage labourers

Table : Link Between Salinity, Health Shock and Economic Vulnerability

Salinity Exposure	TDS Level (Garhwa vs Hazaribagh)	1250 mg/L vs 640 mg/L	High environmental risk
Health Shock	Illness Rate	40% vs 15%	Increased disease burden
Income Loss	•Lost Working Days •Productivity Loss	15 days/year 10–20%	Reduced earning capacity Lower labour efficiency
Financial Stress	Medical Expenditure	₹12,000/year	Increased household expenses
Debt Risk	Income–Expense Gap	₹25,500 burden/year	Borrowing likely
Poverty Trap	Lost Working Days	15 days/year	Reduced earning capacity

***Source :** Primary data survey*

The sequence explains how environmental degradation translates into long-term economic vulnerability for rural households. High groundwater salinity increases the incidence of illness, which acts as a health shock by reducing the physical ability of individuals to work. This leads to income loss, particularly for daily wage labourers and marginal farmers who depend on continuous physical labour for earnings. As income falls while medical expenses rise, households often rely on borrowing or informal credit to meet their needs, leading to debt accumulation. Over time, repeated exposure to such shocks pushes households into a poverty trap, where declining income, rising expenses and debt reinforce each other, making it difficult to recover economically. This mechanism is especially relevant for vulnerable groups such as marginal farmers and daily wage labourers who lack savings and social security support.

9. DISCUSSION

The empirical findings of the study strongly confirm that groundwater salinity operates as a negative externality, imposing significant but unpriced costs on rural households. Evidence from the primary dataset shows that districts with higher salinity exposure, such as Garhwa (TDS: 1250 mg/L), report substantially higher illness rates (40%) compared to low-salinity regions like Hazaribagh (TDS: 640 mg/L) with only 15% illness. This environmental gradient is further supported by the correlation results, where salinity is positively associated with health problems ($r = 0.68$) and negatively associated with productivity ($r = -0.62$). The regression analysis reinforces these relationships, indicating that salinity significantly increases the probability of illness while simultaneously reducing labour productivity. These health impacts translate into measurable economic costs, with households incurring an estimated annual burden of ₹25,500 through increased medical expenditure, productivity loss and lost working days.

Taken together, these findings demonstrate that environmental degradation directly affects human capital by reducing the health and efficiency of the workforce, thereby validating the core premise of Human Capital Theory. At the same time, the absence of any pricing mechanism for groundwater degradation means that these costs are entirely borne by households rather than being internalized by the market, illustrating a classic case of negative externality and welfare loss as described in Environmental Economics. Thus, the study provides strong empirical evidence that poor water quality not only undermines public health but also imposes substantial hidden economic costs, necessitating policy intervention for efficient resource management and welfare improvement.

10. POLICY IMPLICATIONS

The findings of the study highlight that groundwater salinity is not only an environmental issue but also a significant determinant of health and economic outcomes in rural areas. Addressing this challenge requires an integrated policy framework that combines environmental management, economic support and public health interventions.

10.1 Environmental Policy Interventions

Groundwater Quality Monitoring

There is a need to establish a systematic and continuous groundwater monitoring system at the district and village levels. Regular assessment of Total Dissolved Solids (TDS) and other water quality indicators will help identify high-risk zones and enable timely intervention. This can also support data-driven policymaking and prevent further environmental degradation.

Promotion of Low-Cost Filtration Systems

The adoption of low-cost and locally appropriate water filtration technologies should be encouraged, particularly in high-salinity regions. Community-based filtration units and household-level solutions can significantly reduce exposure to contaminated water. Government support through technical assistance and subsidies can enhance accessibility and adoption.

10.2 Economic Policy Measures

Subsidies for Safe Drinking Water Access

Targeted subsidies for water purification systems, piped water supply or treated drinking water should be provided to low-income households. This will reduce out-of-pocket expenditure on healthcare and prevent income loss due to illness. Such measures can improve both economic stability and quality of life in rural areas.

Integration of Environmental Factors into Development Planning

Environmental indicators, particularly water quality, should be incorporated into rural development and economic planning frameworks. Recognizing groundwater salinity as an economic constraint will help design more sustainable policies that address both environmental and livelihood concerns.

10.3 Public Health Interventions

Awareness and Behavioural Change Programs

Community-based awareness programs should be implemented to educate people about the health risks associated with saline water consumption. Promoting safe water practices, hygiene and early medical consultation can significantly reduce disease burden and improve health outcomes.

Strengthening Preventive Healthcare Services

Expanding preventive healthcare services in rural areas, including regular health check-ups and early diagnosis, can help reduce the long-term impact of water-related diseases. Preventive measures are cost-effective and improve overall productivity and well-being.

10.4 Linkage with Sustainable Development Goals (SDGs)

The policy recommendations of this study are closely aligned with global sustainable development priorities:

- **SDG 6 (Clean Water and Sanitation):** Ensuring access to safe and affordable drinking water
- **SDG 3 (Good Health and Well-being):** Reducing disease burden caused by unsafe water
- **SDG 1 (No Poverty):** Minimizing economic vulnerability arising from health shocks
- **SDG 8 (Decent Work and Economic Growth):** Enhancing productivity by improving health and environmental conditions

10.5 Concluding Policy Insight

A coordinated and integrated policy approach is essential to address the multi-dimensional impacts of groundwater salinity. By combining environmental regulation, economic support mechanisms and public health initiatives, policymakers can reduce the hidden economic burden of environmental degradation and promote sustainable rural development.

11. CONCLUSION

The study provides compelling empirical evidence that groundwater salinity is a critical environmental determinant with far-reaching economic implications for rural households. The analysis demonstrates that higher salinity levels are associated with increased incidence of illness, significant reductions in labour productivity and a substantial rise in both direct and indirect economic costs. With an estimated annual burden of approximately ₹25,500 per household, the findings reveal that environmental degradation imposes considerable hidden costs that are neither accounted for in market mechanisms nor adequately addressed in policy frameworks.

These results underscore that groundwater salinity is not merely an environmental concern but a fundamental development challenge that directly affects human capital, income stability and long-term economic resilience. The study highlights a clear causal pathway linking environmental stress to health shocks, income loss and increased vulnerability, particularly among marginal farmers and daily wage labourers.

Therefore, addressing water quality issues must be recognized as both an environmental priority and an economic imperative. Sustainable rural development requires an integrated approach that combines effective groundwater management, accessible safe drinking water solutions and proactive public health interventions. By internalizing the hidden costs of environmental degradation and implementing targeted policy measures, it is possible to enhance productivity, reduce poverty risks and promote inclusive and sustainable growth in rural economies.

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