

# Evaluating the Impact of UGPL on Agricultural Landholding Patterns and Land Value in Surendranagar

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## 1. Abstract:

This study evaluates the impact of the Underground Pipeline (UGPL) irrigation system on agricultural landholding patterns and land values in Surendranagar, Gujarat. Operating within a rapid context of urbanization and agricultural land conversion in India, the research utilizes a multi-stage sampling framework encompassing 744 respondents evenly divided between beneficiaries and non-beneficiaries. Quantitative data collected via personal interviews was analyzed using Excel 2013 and SPSS. The descriptive and non-parametric statistical results (Wilcoxon Signed Rank Test) show a statistically significant expansion of total cultivated land and a sharp conversion of non-irrigated to irrigated land among beneficiaries post-implementation. Furthermore, a positive shift in land value appreciation was observed. Though the Mann–Whitney U Test revealed no significant discrepancy in total cultivated land distribution between beneficiaries and non-beneficiaries, beneficiaries displayed optimized resource management by drastically decreasing fallow and rain-fed holdings.

## 2. Introduction:

Urbanization represents a key demographic trend in an increasingly globalized and interconnected world. According to the United Nations' *World Urbanization Prospects* report (2014), 54% of the global population lived in urban areas at that time, with this proportion expected to increase to 66% by 2050. India is projected to be one of the leading contributors to this growth, with an estimated addition of approximately 404 million urban residents by 2050. (United Nations, 2015).

India, despite being home to the world's second-largest population, faces significant constraints in terms of available land resources. As of 2011, the country's population had risen to 1.21 billion—accounting for approximately 17% of the global population—yet the net sown area remained around 140 million hectares in 2012–13. This translates to merely 0.12 hectares of cultivable land per person, which is significantly below the global average of 0.23 hectares (Government of India [GoI], 2015). The pressure on land has been further intensified by continuous population growth, urbanization, and the diversion of fertile agricultural land to non-agricultural uses. Over the past two decades, while the population expanded by roughly 184 million, the area under agriculture declined by about 3.2 million hectares. According to Land Use Statistics from the Ministry of Agriculture (GoI, 2015), nearly 3.16 million hectares of agricultural land—averaging a loss of 150,000 hectares annually—was diverted to other sectors between the Triennium Ending (TE) 1991–92 and TE 2012–13 (GoI, 2015). In contrast, land under non-agricultural purposes grew by more than five million hectares during the same period, increasing from 21.3 million to 26.4 million hectares. Even after accounting for gains

from the reclamation and rehabilitation of approximately 2.4 million hectares of culturable wasteland, the country experienced a net loss of around four million hectares of sown area—equating to 180,000 hectares per year. This decline is primarily attributed to factors such as industrial and economic development, infrastructure expansion, demographic pressures, urban growth, and environmental degradation.

Urbanization also contributes to an increase in land surface temperatures, leading to the formation of urban heat island (UHI) effects in cities. Moreover, land use change, landscape patterns, and urbanization are closely interconnected and influence one another (Dadashpoor et al., 2019).

Therefore, accurate data on land use change is essential for the effective management of natural resources and for establishing policy priorities that promote balanced and equitable urban and rural development (United Nations, 2015; Kafy et al., 2021).

While land use analysis offers a means to observe and compare historical and current patterns of land use change and growth trends, Land Use and Land Cover Change (LULCC) models aim to generate insights into potential future scenarios and developments (Eastman, 2016; Halmy et al., 2015; Veldkamp & Lambin, 2001).

### **3. Importance of the Research paper:**

This research holds major agro-economic significance as India faces immense pressure on land resources from sweeping urbanization, population growth, and steady conversion of fertile fields to non-agricultural uses. With cultivable land dropping significantly below the global average, preserving agricultural productivity through infrastructural modernization is a paramount national priority. Examining the impact of UGPL systems provides vital empirical evidence regarding how underground irrigation pipelines can prevent land degradation, enhance moisture retention, and boost water-use efficiency. By assessing changes in land utilization categories and structural land values, this study provides actionable insights for resource managers. Ultimately, the data guides future state agricultural investments, aids sustainable land management policies, and outlines balanced structural priorities crucial for promoting equitable urban-rural development across changing geographical and administrative units.

### **4. Research Objectives:**

1. To assess and compare the changes in agricultural landholding patterns (cultivated, irrigated, non-irrigated, and fallow land) among beneficiary farmers before and after the implementation of the UGPL system.

2. To compare the efficiency of land utilization and structural distributions of landholding categories between UGPL beneficiaries and non-beneficiaries.
3. To evaluate the impact of UGPL infrastructure on per-acre land valuation before and after implementation, as well as against non-beneficiary market baselines.

### **5. Research Hypothesis:**

1.  $H_0$  (Null Hypothesis): There is no median difference in cultivated area before and after UGPL implementation.

$H_1$  (Alternative Hypothesis): There is a median difference in cultivated area before and after UGPL implementation.

2.  $H_0$  (Null Hypothesis): The distribution of total cultivated area is the same for beneficiaries and non-beneficiaries.

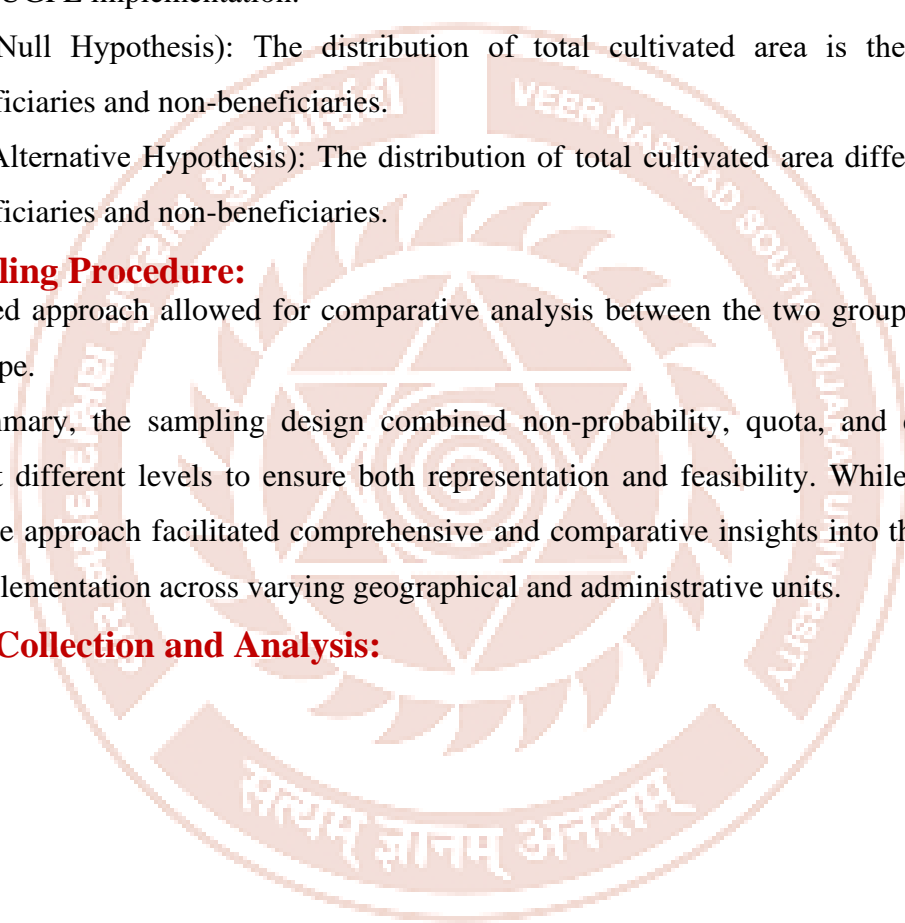
$H_1$  (Alternative Hypothesis): The distribution of total cultivated area differs between beneficiaries and non-beneficiaries.

### **6. Sampling Procedure:**

balanced approach allowed for comparative analysis between the two groups within the study's scope.

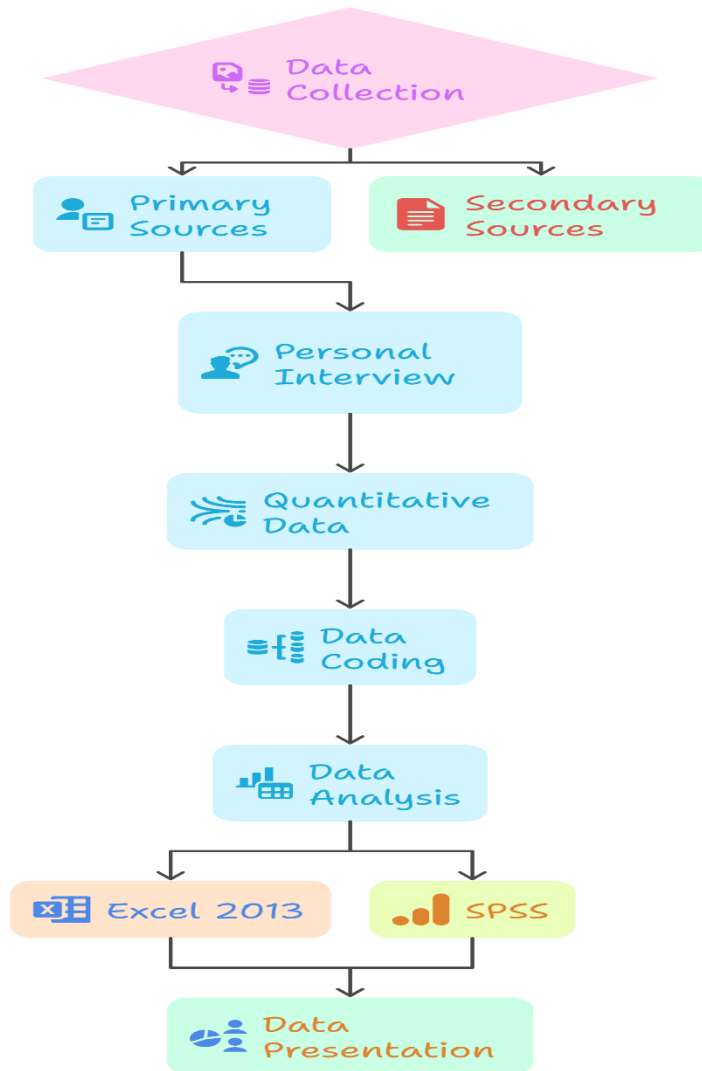
In summary, the sampling design combined non-probability, quota, and convenience methods at different levels to ensure both representation and feasibility. While not strictly random, the approach facilitated comprehensive and comparative insights into the impact of UGPL implementation across varying geographical and administrative units.

### **7. Data Collection and Analysis:**



The data collection and analysis process employed in the study was methodical and systematic, beginning with the collection of both primary and secondary sources. Primary data was gathered through personal interviews, targeting selected respondents, while secondary data was sourced from relevant official documents and literature. The information collected from personal interviews was primarily quantitative, enabling statistical analysis. This quantitative data underwent a phase of data coding, where responses were organized into analyzable formats. The coded data was then subjected to data analysis using two main tools—Excel 2013 and SPSS—to ensure comprehensive and accurate evaluation. Finally, the analyzed results were synthesized and visually structured in the data presentation phase, facilitating clear interpretation and drawing of conclusions. This stepwise approach ensured reliability, consistency, and clarity throughout the research process.

### Data Collection and Analysis Process



## 8. Impact of UGPL on Landholding

Information regarding the impact of UGPL (Underground Pipeline) on landholding patterns of respondents is critically important for assessing agricultural productivity potential, soil quality, and long-term agricultural management. Such data enables the evaluation of effects on land consolidation, moisture retention, and irrigation efficiency, which in turn supports sustainable and efficient land use practices.

As per the Agricultural Census conducted by the Ministry of Agriculture and Farmers' Welfare, Government of India, operational landholdings are classified into the following five categories:

Classification of Landholding Categories		
Category	Size Class	Definition
Marginal	Below 1 hectare	Farmers possessing less than 1 hectare of land are classified as marginal farmers.
Small	1.1 – 1.99 hectares	Farmers possessing between 1 and less than 2 hectares of land are classified as small farmers.
Semi-Medium	2.0 – 3.99 hectares	Farmers possessing between 2 and less than 4 hectares of land are classified as semi-medium farmers.
Medium	4.0 – 9.99 hectares	Farmers possessing between 4 and less than 10 hectares of land are classified as medium farmers.
Large	10.00 hectares and above	Farmers possessing 10 or more hectares of land are classified as large farmers.
<i>Source: Government of India. (2021). Agricultural Statistics at a Glance 2021. Ministry of Agriculture &amp; Farmers Welfare.</i>		

In the present study, data on landholding patterns before and after the implementation of UGPL has been collected from a total of 372 beneficiaries. A descriptive analysis has been carried out to assess the extent of land utilization during the pre- and post-UGPL periods. The analysis specifically focuses on the proportions of irrigated and non-irrigated land, cultivated area, and fallow land. The comparative findings of these variables before and after the implementation of UGPL are presented below.

Comparative Data on Landholding of Beneficiaries Before and After UGPL Implementation									
Particulars	Before UGPL				After UGPL				Average Difference
	N	Min	Max	Average	N	Min	Max	Average	
Total Land	372	0.49	8.9	3.762	372	0.49	12.95	3.962	0.2003
Irrigated Land	372	0.49	8.9	3.545	372	0.49	12.95	3.687	0.1418

Non-Irrigated Land	70	0.49	4.05	1.153	45	0.49	6.47	0.276	0.877
Cultivated Area	37 2	0.49	8.9	3.747	37 2	0.49	11.33	3.921	0.1742
Fallow Land	17	0.49	2.43	0.821	16	0.16	2.43	0.627	0.194
<b>Source:</b> Based on Field Survey									
<b>Source:</b> Based on Field Survey									

The table presents a comparative analysis of landholding patterns among beneficiaries before and after the implementation of the Underground Pipeline (UGPL) irrigation system, based on primary data collected through field surveys. The key landholding indicators considered include total land, irrigated land, non-irrigated land, cultivated area, and fallow land. For each variable, the table reports the number of observations (N), minimum and maximum landholding values (in hectares), the average landholding, and the average difference between pre- and post-UGPL scenarios.

Total landholding increased slightly after UGPL implementation, with the average rising from 3.762 hectares to 3.962 hectares an improvement of 0.2003 hectares. This suggests a marginal expansion in overall land access or improved land recording post-intervention.

Irrigated land also witnessed a modest increase, with the average moving from 3.545 hectares before UGPL to 3.687 hectares afterward. The average difference of 0.1418 hectares indicates that the UGPL system has enhanced irrigation coverage, potentially contributing to more reliable agricultural production.

In contrast, non-irrigated land experienced a significant decline, from an average of 1.153 hectares to 0.276 hectares. The reduction of 0.877 hectares implies a substantial shift of land from non-irrigated to irrigated status, underscoring the effectiveness of the UGPL in reducing reliance on rain-fed agriculture.

The cultivated area expanded marginally from an average of 3.747 hectares to 3.921 hectares (a difference of 0.1742 hectares), which aligns with the increase in irrigated land and reflects improved land utilization.

Finally, the average fallow land decreased from 0.821 to 0.627 hectares, marking a reduction of 0.194 hectares. This suggests that land previously left uncultivated is now being brought under productive use, likely due to improved irrigation access.

Overall, the data highlights the positive impact of the UGPL system in enhancing irrigation facilities, reducing fallow and non-irrigated land, and marginally increasing the area under cultivation. These outcomes are indicative of improved agricultural efficiency and land utilization following the intervention.

Based on the above analysis, it can be inferred that there has been a quantitative increase in the total cultivated area after the implementation of UGPL, rising from 3.747 hectares to 3.921 hectares. To determine whether this difference between the two related groups is statistically significant, it is essential to conduct a statistical test. For this purpose, a normality test was conducted to examine the distribution pattern of the data.

The results indicated that the data does not follow a normal distribution, i.e., it is non-normally distributed. Hence, instead of parametric tests, a non-parametric test is considered appropriate for further analysis.

In this study, to test the hypothesis that the median difference in total cultivated area before and after UGPL implementation is zero, the Related-Samples Wilcoxon Signed Rank Test was employed.

$H_0$  (Null Hypothesis): There is no median difference in cultivated area before and after UGPL implementation.

$H_1$  (Alternative Hypothesis): There is a median difference in cultivated area before and after UGPL implementation.

<b>Related-Samples Wilcoxon Signed Rank Test Summary</b>			
Null Hypothesis	Test	Sig.	Decision
The median of differences between Total Cultivated Area Before UGPL and Total Cultivated Area After UGPL equals 0.	Related-Samples Wilcoxon Signed Rank Test	0.000	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.			
<b>Source:</b> Based on Field Survey			

The results of the Related-Samples Wilcoxon Signed Rank Test provide statistical evidence regarding changes in the total cultivated area before and after the implementation of the Underground Pipeline (UGPL) system. The null hypothesis tested whether the median difference between the two time points is equal to zero, implying no significant change in cultivated area due to the intervention.

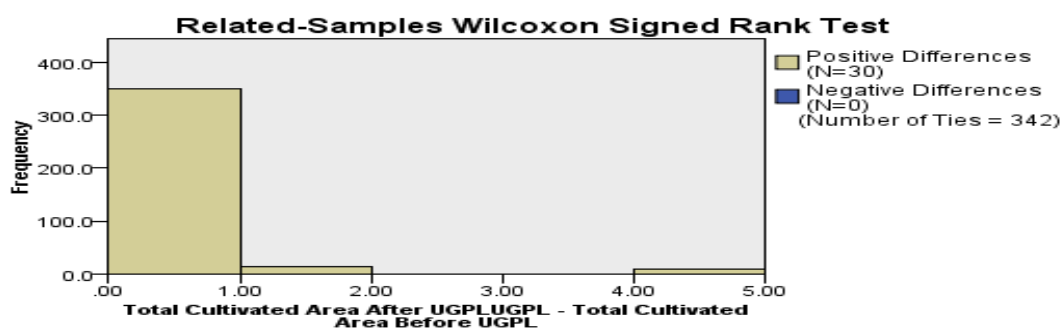
The test yielded a significance (p-value) of 0.000, which is well below the conventional threshold of 0.05. Consequently, the null hypothesis is rejected, indicating that there is a

statistically significant difference in the total cultivated area before and after UGPL implementation.

This outcome supports the inference that the UGPL system has led to a meaningful change—specifically, an increase—in the cultivated land area. The use of the non-parametric Wilcoxon Signed Rank Test is appropriate in this context, as it accounts for the paired nature of the data and does not assume a normal distribution of the differences.

In summary, the statistical evidence confirms that the UGPL intervention has had a significant positive impact on agricultural land use, particularly by increasing the extent of land brought under cultivation.

### Related-Samples Wilcoxon Signed Rank Test



<b>Total N</b>	372
<b>Test Statistic</b>	465.000
<b>Standard Error</b>	47.894
<b>Standardized Test Statistic</b>	4.854
<b>Asymptotic Sig. (2-sided test)</b>	.000

The Wilcoxon Signed Rank Test results demonstrate that the UGPL system has significantly influenced the extent of cultivated land among beneficiaries. Although a large proportion of landholdings remained unchanged (342 cases), the observed changes were exclusively positive (30 cases), with no recorded reductions in cultivated area. The test's high Z-score (4.854) and the corresponding p-value (0.000) confirm that the increase in cultivation post-intervention is statistically significant. This outcome reinforces the effectiveness of UGPL as an infrastructure intervention in improving land utilization and potentially enhancing agricultural productivity.

<b>Comparative Data on Landholding of Respondents (Beneficiaries vs. Non-Beneficiaries)</b>									
<b>Particulars</b>	<b>Beneficiaries</b>				<b>Non-Beneficiaries</b>				<b>Average Difference</b>
	<b>N</b>	<b>Mi n</b>	<b>Max</b>	<b>Average</b>	<b>N</b>	<b>Mi n</b>	<b>Max</b>	<b>Average</b>	
Total Land	372	0.49	12.95	3.962	372	0.65	11.33	4.385	-0.423
Irrigated Land	372	0.49	12.95	3.687	372	0.49	8.9	3.932	-0.245
Non-Irrigated Land	45	0.49	6.47	0.276	89	0.32	4.15	1.897	-1.621
Cultivated Area	372	0.49	11.33	3.921	372	0.49	11.33	4.224	-0.303
Fallow Land	16	0.16	2.43	0.627	40	0.32	0.05	1.498	-0.871
Source: Based on Field Survey									

The comparative analysis of landholding between beneficiaries and non-beneficiaries of the Underground Pipeline (UGPL) system, based on field survey data, reveals notable differences in land use and access. The table presents five key variables: total land, irrigated land, non-irrigated land, cultivated area, and fallow land, along with the average difference between the two groups.

In terms of total landholding, non-beneficiaries hold slightly more land on average (4.385 hectares) compared to beneficiaries (3.962 hectares), resulting in an average difference of -0.423 hectares. Similarly, the average irrigated land is higher among non-beneficiaries (3.932 hectares) than beneficiaries (3.687 hectares), with a difference of -0.245 hectares. These findings suggest that, on average, non-beneficiaries possess slightly larger and better-irrigated holdings than their beneficiary counterparts.

The most pronounced difference is observed in non-irrigated land, where non-beneficiaries hold a significantly larger area (1.897 hectares) compared to beneficiaries (0.276 hectares), yielding an average difference of -1.621 hectares. This indicates that a substantial portion of land under non-beneficiaries remains dependent on rain-fed agriculture, whereas beneficiaries appear to have transitioned more land to irrigated status, likely due to the benefits of UGPL.

Regarding cultivated area, non-beneficiaries again have a marginally higher average (4.224 hectares) than beneficiaries (3.921 hectares), showing a difference of -0.303 hectares. Lastly, in the case of fallow land, non-beneficiaries report a higher average (1.498 hectares) compared to beneficiaries (0.627 hectares), with a difference of -0.871 hectares. This suggests that beneficiaries may be using their land more effectively, potentially due to improved irrigation facilities reducing the need to leave land fallow.

In summary, although non-beneficiaries generally possess more land, beneficiaries appear to make more efficient use of their landholdings, especially by reducing non-irrigated and fallow land. This supports the conclusion that access to the UGPL system positively influences land utilization and agricultural productivity.

Based on the above analysis, a noticeable quantitative difference is observed in the total cultivated area between beneficiaries and non-beneficiaries. To determine whether this difference is statistically significant between two or more independent groups, a statistical test is required. For this purpose, a normality test was conducted to examine the distribution of the data.

The results of the normality test revealed that the data does not follow a normal distribution, indicating a non-normal distribution. Therefore, instead of parametric tests, a non-parametric test is more appropriate for this analysis.

In the present study, to assess the distribution of total cultivated area between beneficiaries and non-beneficiaries, the Mann–Whitney U Test, a non-parametric method for independent samples, was employed. This test is used to evaluate whether the distributions of cultivated land in both groups are statistically similar.

$H_0$  (Null Hypothesis): The distribution of total cultivated area is the same for beneficiaries and non-beneficiaries.

$H_1$  (Alternative Hypothesis): The distribution of total cultivated area differs between beneficiaries and non-beneficiaries.

<b>Independent-Samples Mann-Whitney U Test Summary</b>			
Null Hypothesis	Test	Sig.	Decision
The distribution of Total Cultivated Area In Hectares is the same across categories of Types of Respondents.	Independent-Samples Mann-Whitney U Test	0.087	Retain the null hypothesis.
Asymptotic significances are displayed. The significance level is .05.			
Source: Based on Field Survey			

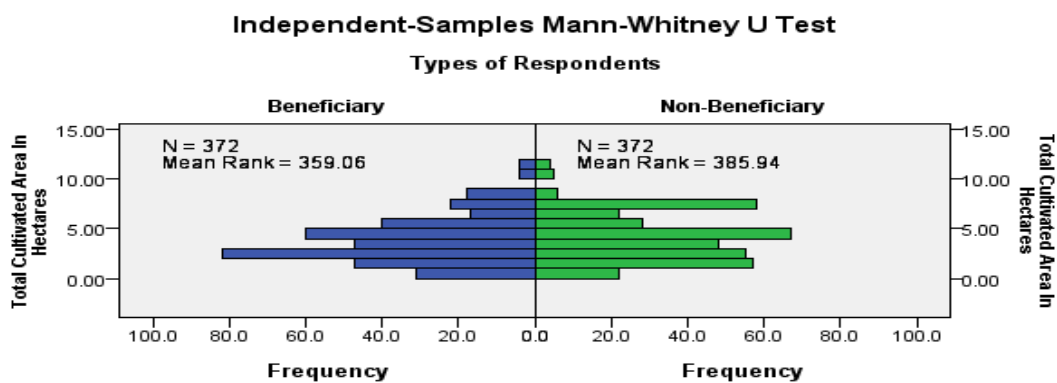
The results of the Independent-Samples Mann-Whitney U Test assess whether there is a statistically significant difference in the distribution of total cultivated area between two groups: beneficiaries and non-beneficiaries of the Underground Pipeline (UGPL) system. The null hypothesis states that the distribution of cultivated land (measured in hectares) is the same for both groups.

The test produced a significance value (p-value) of 0.087, which is greater than the conventional significance level of 0.05. As a result, the null hypothesis is retained, indicating that there is no statistically significant difference in the distribution of cultivated area between beneficiaries and non-beneficiaries.

Although the descriptive statistics show that non-beneficiaries have a slightly higher average cultivated area, the Mann-Whitney U Test suggests that this observed difference is not statistically meaningful. In other words, the variation in cultivated land between the two groups could be due to random chance rather than a systematic effect of UGPL implementation.

In conclusion, while UGPL beneficiaries may exhibit improved land use patterns in some areas (e.g., reduced fallow and non-irrigated land), the total cultivated area does not significantly differ between the groups, as confirmed by the Mann-Whitney U Test results.

### Independent-Samples Mann-Whitney U Test



<b>Total N</b>	744
<b>Mann-Whitney U</b>	74,193.500
<b>Wilcoxon W</b>	143,571.500
<b>Test Statistic</b>	74,193.500
<b>Standard Error</b>	2,919.734
<b>Standardized Test Statistic</b>	1.713
<b>Asymptotic Sig. (2-sided test)</b>	.087

The graphical and statistical summary of the Independent-Samples Mann-Whitney U Test provides insight into the distribution of total cultivated area between beneficiaries and non-beneficiaries of the Underground Pipeline (UGPL) system.

The histogram indicates that non-beneficiaries (mean rank = 385.94) tend to have a slightly higher total cultivated area compared to beneficiaries (mean rank = 359.06). Both groups have an equal sample size of 372, making the comparison balanced.

The Mann-Whitney U test yielded a U-value of 74,193.500, with a standardized test statistic (Z) of 1.713 and a standard error of 2,919.734. The resulting p-value (Asymptotic Sig., 2-sided test) is 0.087, which exceeds the conventional significance threshold of 0.05. Therefore, the null hypothesis is retained, suggesting that there is no statistically significant difference in the distribution of total cultivated land between beneficiaries and non-beneficiaries.

Despite the non-beneficiaries showing a slightly higher mean rank, this difference is not strong enough to be considered statistically meaningful. The outcome implies that, in terms of total cultivated area, the UGPL system has not led to a significant divergence between the two groups.

In conclusion, while descriptive data suggest some differences, the statistical test confirms that these are not significant. Thus, the distribution of cultivated land remains broadly comparable between UGPL beneficiaries and non-beneficiaries.

After the implementation of UGPL, the availability of water for the farming community is expected to improve significantly, particularly benefiting those farmers who have limited access to traditional irrigation sources. As a result, the overall agricultural conditions for this group are likely to improve. In the present study, the extent of landholding in the selected area has been presented as follows.

Details of Landholding Categories of Beneficiaries Before and After UGPL Implementation					
Type of Landholding	Before UGPL		After UGPL		Percentage Difference
	Number	Percentage	Number	Percentage	
Marginal	31	8.33	31	5.65	-2.68

Small	51	13.71	51	13.98	0.27
Semi-Medium	129	34.68	129	24.73	-9.95
Medium	161	43.28	147	51.61	8.33
Large	–	–	14	4.03	4.03
Source: Based on Field Survey					

The table presents a comparative analysis of landholding categories among beneficiaries before and after the implementation of the Underground Pipeline (UGPL) system, highlighting shifts in landholding patterns based on standard classifications: marginal, small, semi-medium, medium, and large.

Before UGPL implementation, the majority of beneficiaries fell under the medium (43.28%) and semi-medium (34.68%) categories, followed by small (13.71%) and marginal (8.33%) farmers. Notably, there were no beneficiaries in the large landholding category at that time.

Following the introduction of the UGPL system, the medium landholding category increased significantly to 51.61%, reflecting an 8.33 percentage point rise, suggesting that some farmers improved their landholding status, likely due to better irrigation and land productivity. In contrast, the semi-medium category dropped to 24.73%, marking a decrease of 9.95 percentage points, possibly due to upward shifts into the medium and large categories.

The marginal category also saw a reduction, from 8.33% to 5.65% (a 2.68 percentage point decline), indicating that marginal farmers may have either expanded their landholdings or reclassified under improved conditions. The small landholding group remained relatively stable, with only a slight increase of 0.27 percentage points.

A noteworthy change is the emergence of the large landholding category, which was absent before UGPL but accounted for 4.03% of beneficiaries afterward. This shift points to a potential consolidation or expansion of landholdings among a small subset of beneficiaries.

In summary, the UGPL intervention appears to have contributed to upward mobility in landholding categories, with reductions in marginal and semi-medium holdings and growth in medium and large holdings. This transition suggests improved land utilization and possibly enhanced economic status among beneficiary farmers.

Comparative Information on Landholding Types of Respondents (Beneficiaries vs. Non-Beneficiaries)					
Type of Landholding	Beneficiaries		Non-Beneficiaries		Percentage Difference
	Number	Percentage (%)	Number	Percentage (%)	
Marginal	31	8.33	21	5.65	2.68
Small	51	13.71	52	13.98	-0.27
Semi-Medium	129	34.68	92	24.73	9.95
Medium	147	39.52	192	51.61	-12.09
Large	14	3.76	15	4.03	-0.27

Source: Based on Field Survey

The table presents a comparative overview of landholding categories among beneficiaries and non-beneficiaries of the Underground Pipeline (UGPL) system, based on standardized landholding classifications: marginal, small, semi-medium, medium, and large. The data highlights both numerical and percentage distributions across the two groups and identifies the percentage point differences between them.

Among beneficiaries, the highest proportion of respondents falls under the medium landholding category (39.52%), followed by semi-medium (34.68%), small (13.71%), marginal (8.33%), and large (3.76%) farmers. In contrast, non-beneficiaries are more heavily concentrated in the medium category (51.61%), followed by semi-medium (24.73%), small (13.98%), large (4.03%), and marginal (5.65%).

The most significant difference appears in the medium landholding group, where non-beneficiaries (51.61%) outnumber beneficiaries (39.52%) by 12.09 percentage points, suggesting that medium-sized landholders are more prevalent among non-beneficiaries. Conversely, beneficiaries have a higher representation in the semi-medium category, with a 9.95 percentage point lead over non-beneficiaries, indicating that this group may have benefited more from the UGPL intervention.

Marginal landholders also make up a slightly larger share among beneficiaries (8.33%) compared to non-beneficiaries (5.65%), with a 2.68 percentage point difference, possibly reflecting the inclusion of smaller farmers in the beneficiary pool. The small and large

categories show negligible differences between the two groups (-0.27 percentage points each), indicating a relatively balanced representation.

In conclusion, the comparative data suggests that while medium landholders dominate among non-beneficiaries, the UGPL beneficiary group includes a more balanced mix, with stronger representation from semi-medium and marginal farmers. This distribution may reflect targeted inclusion efforts or varying levels of engagement with the UGPL system across landholding sizes.

### Impact of UGPL on Land Value

Information regarding the per-acre land value in the context of UGPL implementation is crucial for understanding the changes in the agro-economic worth of land and the influence of improved irrigation facilities. This data allows for a comparative analysis of land prices before and after UGPL implementation, as well as between beneficiaries and non-beneficiaries. Such insights are valuable for guiding future agricultural investment, land management practices, and policy formulation.

Comparative Information on Per-Acre Land Value of Beneficiaries Before and After UGPL Implementation (in ₹)							
No. of Respondents	Before UGPL			After UGPL			Average Difference (₹)
	Min (₹)	Max (₹)	Average (₹)	Min (₹)	Max (₹)	Average (₹)	
372	60,000	60,00,000	20,00,000	61,000	90,00,000	20,50,000	50,000

Source: Based on Field Survey

The table presents a comparative analysis of the per-acre land value of beneficiaries before and after the implementation of the Underground Pipeline (UGPL) system, based on responses from 372 beneficiaries. The data includes minimum, maximum, and average land values in Indian Rupees (₹), providing insight into how the UGPL system may have influenced agricultural land valuation.

Before the implementation of UGPL, the per-acre land value ranged from ₹60,000 to ₹60,00,000, with an average value of ₹20,00,000. After the implementation, the land value increased, ranging from ₹61,000 to ₹90,00,000, with the average rising to ₹20,50,000. This reflects an average increase of ₹50,000 per acre in land value following UGPL implementation.

The increase in both the minimum and maximum land values indicates that the UGPL system has positively influenced the agricultural land market. The enhancement in irrigation infrastructure likely improved the productivity and marketability of land, which in turn elevated its valuation. The relatively small yet significant average increase of ₹50,000 suggests that the UGPL system contributed to land value appreciation, making farmland more economically attractive and potentially more profitable for the owners.

In summary, the data shows a clear positive trend in per-acre land value post-UGPL, underscoring the economic benefits of improved irrigation facilities. The findings highlight that infrastructural interventions like UGPL not only enhance agricultural efficiency but also contribute to the appreciation of rural asset value.

Comparative Information on Per-Acre Land Value of Respondents (in ₹)					
Group	No. of Respondents	Minimum (₹)	Maximum (₹)	Average (₹)	Average Difference (₹)
Beneficiaries	372	61,000	90,00,000	20,50,000	-7,50,000
Non-Beneficiaries	372	80,000	60,00,000	28,00,000	

Source: Based on Field Survey

The table provides a comparative analysis of per-acre land value between beneficiaries and non-beneficiaries of the Underground Pipeline (UGPL) system. It includes data from 372 respondents in each group and presents minimum, maximum, and average land values in Indian Rupees (₹), along with the average difference.

Among beneficiaries, the per-acre land value ranges from ₹61,000 to ₹90,00,000, with an average value of ₹20,50,000. For non-beneficiaries, the range is ₹80,000 to ₹60,00,000, and the average land value is ₹28,00,000. This results in an average difference of ₹-7,50,000, indicating that non-beneficiaries, on average, hold land of higher market value compared to beneficiaries.

While the maximum land value is higher among beneficiaries—suggesting a few high-value holdings post-UGPL—the higher average land value among non-beneficiaries may be due to factors such as better location (e.g., proximity to roads or markets), naturally fertile soil, or superior pre-existing infrastructure. It may also suggest that beneficiaries, despite improvements from the UGPL system, still own land that is relatively less valuable on the open market.

In summary, the data indicates that although UGPL beneficiaries have experienced land value appreciation, as observed in prior comparisons, their average per-acre land value remains lower than that of non-beneficiaries. This may reflect broader structural or locational disparities between the two groups that are not fully offset by the UGPL intervention.

## 9. Key Findings:

**Land Utilization Shifts:** Following UGPL implementation, beneficiaries saw an expansion in average total cultivated land (from 3.747 to 3.921 hectares) and a sharp reduction in non-irrigated land (from 1.153 to 0.276 hectares), indicating a successful transition from rain-fed to irrigated agriculture.

**Statistical Significance of UGPL:** The Related-Samples Wilcoxon Signed Rank Test confirmed that the increase in cultivated area post-intervention is highly statistically significant ( $p = 0.000$ ).

**Upward Mobility in Landholdings:** Access to UGPL facilitated upward mobility in socio-economic land categories for beneficiaries; the percentage of medium landholders grew by 8.33% and large landholders emerged at 4.03%, while marginal and semi-medium holdings decreased.

**Beneficiaries vs. Non-Beneficiaries:** Although non-beneficiaries held slightly more land and higher initial irrigated acreage on average, beneficiaries minimized waste significantly better, sustaining far lower amounts of fallow land (0.627 hectares) compared to non-beneficiaries (1.498 hectares).

**Cultivated Area Distribution:** The Independent-Samples Mann–Whitney U Test revealed that the difference in total cultivated area distribution between beneficiaries and non-beneficiaries was not statistically significant ( $p = 0.087$ ), implying variations may stem from pre-existing baseline traits.

**Appreciation of Asset Value:** UGPL adoption caused a direct positive appreciation in land marketability, yielding an average land value increase of ₹50,000 per acre for beneficiary farmers. However, non-beneficiary land maintained a higher baseline average value due to external structural variables like location or natural fertility.

## 10. Suggestions:

**Targeted Extensions for Marginal Farmers:** Since marginal and small farmers represent a vulnerable tier, extension programs should prioritize technical assistance to help smaller socio-economic landholding groups seamlessly integrate with UGPL networks.

**Localized Water-Sharing Cooperatives:** Given that a large portion of landholdings remained statistically unchanged in net size, setting up community chaks or water-sharing groups could optimize local pipeline flow and maximize spatial coverage.

**Integration of LULCC Modeling:** Agricultural departments should employ Land Use and Land Cover Change (LULCC) models alongside current survey tools to map future land conversion scenarios, safeguarding fertile belts from urban sprawl.

### **11. Recommendation:**

It is strongly recommended that the Government of Gujarat scales up infrastructural investments in Underground Pipeline (UGPL) systems across rain-fed agricultural zones. The empirical data proves that UGPL acts as an effective intervention tool to combat the climate-induced and urban pressures stripping away active agrarian fields. By significantly reducing unproductive fallow land and expanding critical irrigation coverage, scaling this infrastructure will directly support national targets for sustainable natural resource management, appreciate rural asset values, and boost long-term food security.

### **12. Conclusion:**

This study demonstrates that the implementation of the Underground Pipeline (UGPL) system in Gujarat functions as a vital catalyst for improved land utilization and agricultural efficiency. Statistically, the infrastructure has secured definitive positive transitions for beneficiary farmers, significantly optimizing their irrigation capabilities, reducing vulnerable rain-fed dependence, and enhancing rural land asset values. While broader structural and locational disparities mean that non-beneficiaries still hold higher average open-market land values, beneficiaries clearly demonstrate superior resource efficiency by converting previously uncultivated fallow land into productive zones. Ultimately, expanding modern irrigation frameworks like UGPL is essential for mitigating the severe spatial strains of urbanization and securing sustainable development for India's rural ecosystems.

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