Socio-Economic Impacts of Underground Pipeline (UGPL) Project: A Comparative Study of Farmers in Surendranagar District

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Abstract:

This study evaluates the socio-economic transformations triggered by the Sardar Sarovar Project's Underground Pipeline (UGPL) system in the Surendranagar district of Gujarat. Utilizing a comparative framework, the research analyzes data from 744 respondents (372 beneficiaries and 372 non-beneficiaries) across six Talukas: Lakhatar, Limbadi, Dasada, Wadhwan, Dhrangadhra, and Chuda. The study employs primary field surveys and secondary data from the Sardar Sarovar Narmada Nigam Limited (SSNNL). Key analytical parameters include demographic shifts, family structures, housing standards, and literacy levels. Preliminary findings suggest that while UGPL access correlates with the maintenance of joint family systems and a transition toward permanent housing, there remains a significant gap in formal education and literacy across the region.

Introduction:

Agriculture remains the backbone of the rural economy in Gujarat, yet its success is heavily contingent upon reliable irrigation. The Sardar Sarovar Project (SSP) represents a landmark intervention in water management, specifically through the implementation of the Underground Pipeline (UGPL) system. Unlike traditional open-canal systems, UGPL is designed to minimize conveyance losses and land fragmentation, theoretically leading to superior agricultural outcomes.

Surendranagar district, characterized by its semi-arid climate and dependence on monsoon patterns, serves as a critical site for assessing these interventions. While traditional methods like bore-wells and ponds have historically sustained the farming community, they often prove insufficient during drought cycles. This research seeks to provide an empirical comparison between farmers who have integrated UGPL into their practice and those who remain reliant on traditional water sources. By examining demographic and socio-economic variables, the paper aims to quantify the "beneficiary status" as a driver of regional development.

Objectives of the Study:

The primary goal of this research is to evaluate the multi-dimensional impacts of the Sardar Sarovar Project's irrigation interventions in the Surendranagar district. Specifically, the study is guided by the following objectives:

- To analyse the socio-economic profile of the respondents through a comparative assessment of demographic characteristics, including age distribution, family structure,

housing quality, and literacy levels, between beneficiary and non-beneficiary farming households.

- To examine the impact of the Underground Pipeline (UGPL) on land utilization by quantifying changes in the gross cultivated area and net sown area before and after the implementation of the UGPL system using statistical validation.
- To compare agricultural productivity and cropping patterns by identifying the shifts from traditional, rain-fed subsistence farming to high-value, irrigation-supported cash crops among the beneficiary group.
- To evaluate the labour dynamics and gender participation in the workforce by assessing how the availability of reliable irrigation influences the labour participation rates of male and female family members within the household economy.
- To identify the challenges and provide policy recommendations based on the empirical findings to highlight the obstacles faced by farmers in the command area and suggest strategic interventions for sustainable agricultural development.

Methodology:

Study Area

The research is localized to the Surendranagar District of Gujarat, specifically focusing on the command areas of the Sardar Sarovar Project. To ensure geographic diversity, six administrative divisions (Talukas) were selected: Lakhatar, Limbadi, Dasada, Wadhwan, Dhrangadhra, and Chuda.

Sample Selection

A balanced sampling technique was employed to ensure statistical parity.

- Total Sample Size: 744 respondents.
- Beneficiary Group (N=372): Farmers utilizing the UGPL system.
- Non-Beneficiary Group (N=372): Farmers utilizing traditional irrigation methods (borewells/ponds).

Data Collection

- Primary Data: Gathered through structured field surveys and direct interviews with the heads of households.
- Secondary Data: Sourced from official district agricultural records and the Sardar Sarovar Narmada Nigam Limited (SSNNL).

Analytical Tools

The primary data was processed and analyzed using descriptive statistics, focusing on frequency distributions and percentage analysis to provide a clear comparative profile of the respondents' socio-economic characteristics. These tools were essential for identifying the proportional distribution of variables such as age, family structure, and housing types across the six Talukas.

Data Analysis and Discussion:

Demographic and Geographic Distribution

The study establishes a rigorous baseline by maintaining an equal 50-50 split between beneficiaries and non-beneficiaries within each Taluka. **Dasada** represents the largest geographical focal point (27.42% of the sample), reflecting the high intensity of the canal network in that area.

Table No. 1 : Distribution of Beneficiary and Non-Beneficiary according to Taluka

Details	Beneficiary		Non-beneficiary		Total	
	frequency	percent	frequency	percent	frequency	percent
Lakhatar	54	14.52	54	14.52	108	14.52
Limbadi	72	19.35	72	19.35	144	19.35
Dasada	102	27.42	102	27.42	204	27.42
Wadhwan	36	9.68	36	9.68	72	9.68
Dhrangadhra	60	16.13	60	16.13	120	16.13
Chuda	48	12.90	48	12.90	96	12.90
Total	372	100	372	100	744	100

Source: Based on fieldwork

The demographic distribution of respondents across the surveyed Talukas reflects a rigorous methodological framework designed to evaluate the socio-economic impact of the Sardar Sarovar Project. By engaging a total sample of 744 respondents, equally divided between 372 beneficiaries and 372 non-beneficiaries, the study establishes a balanced empirical baseline. This parity is maintained across all six administrative divisions—Lakhatar, Limbadi, Dasada, Wadhwan, Dhrangadhra, and Chuda—ensuring that the comparative analysis is not skewed by an overrepresentation of one group in a specific geographic area. Such a structured approach is essential for identifying the tangible differences in agricultural outcomes and livelihood improvements that can be directly attributed to the project's interventions.

Geographically, the data indicates that Dasada serves as the primary focal point of the study, accounting for the largest share of the sample at 27.42%. This is followed by Limbadi and Dhrangadhra, which represent 19.35% and 16.13% of the total respondents, respectively.

The significant presence of participants in these areas likely correlates with the extent of the canal network and the intensity of agricultural activity within these specific command areas. Meanwhile, Lakhatar (14.52%), Chuda (12.90%), and Wadhwan (9.68%) provide necessary peripheral data, completing a comprehensive profile of the region's farming community. The variation in sample sizes between Talukas likely reflects the proportional density of the farming population or the reach of the SSNNL infrastructure in those districts.

Table No. 2 : Age group information of Beneficiary and Non-Beneficiary according to Taluka

Details		Beneficiary		Non-Beneficiary		Difference (In percentage)
Taluka	Age group (in years)	frequency	percent	frequency	percent	
Lakhatar	18 to 40	21	5.65	19	5.11	0.54
	41 to 60	21	5.65	25	6.72	-1.07
	61 to 80	11	2.96	9	2.42	0.54
	above 80	1	0.27	1	0.27	0.00
Limbadi	18 to 40	31	8.33	28	7.53	0.80
	41 to 60	41	11.02	42	11.29	-0.27
	61 to 80	0	0.00	2	0.54	-0.54
	above 80	0	0.00	0	0.00	0.00
Dasada	18 to 40	28	7.53	35	9.41	-1.88
	41 to 60	36	9.68	32	8.60	1.08
	61 to 80	35	9.41	32	8.60	0.81
	above 80	3	0.81	3	0.81	0.00
Wadhwan	18 to 40	14	3.76	16	4.30	-0.54
	41 to 60	17	4.57	15	4.03	0.54
	61 to 80	5	1.34	4	1.08	0.26
	above 80	0	0.00	1	0.27	-0.27
Dhrangadhra	18 to 40	42	11.29	21	5.65	5.64
	41 to 60	18	4.84	18	4.84	0.00
	61 to 80	0	0.00	19	5.11	-5.11
	above 80	0	0.00	2	0.54	-0.54
Chuda	18 to 40	19	5.11	18	4.84	0.27
	41 to 60	29	7.80	28	7.53	0.27
	61 to 80	0	0.00	2	0.54	-0.54
	above 80	0	0.00	0	0.00	0.00
Total	18 to 40	155	41.67	137	36.83	4.84
	41 to 60	162	43.55	160	43.01	0.54
	61 to 80	51	13.71	68	18.28	-4.57
	above 80	4	1.08	7	1.88	-0.80
	Total	372	100	372	100	0.00

Table No. 2 : Age group information of Beneficiary and Non-Beneficiary according to Taluka						
Details		**Beneficiary**		**Non-Beneficiary**		**Difference (In percentage)**
Taluka	**Age group (in years)**	**frequency**	**percent**	**frequency**	**percent**	
Source: Based on fieldwork						

The demographic profile of the respondents, categorized by age group across the six surveyed Talukas, provides essential insights into the generational distribution of farming responsibilities in the region. Analyzing the age structure of both beneficiaries and non-beneficiaries is vital for understanding the long-term sustainability of agricultural practices and the potential for technological adoption. The data reveals that the majority of the workforce falls within the most productive age brackets, with a significant concentration of respondents aged between 18 and 60 years.

A comprehensive look at the cumulative data shows that the 41 to 60 age group constitutes the largest segment for both cohorts, representing 43.55% of beneficiaries and 43.01% of non-beneficiaries. This suggests that middle-aged individuals, who typically possess substantial experience and decision-making authority within the household, are the primary managers of agricultural land in the study area. Close behind is the younger demographic of 18 to 40 years, which accounts for 41.67% of the beneficiary group and 36.83% of the non-beneficiaries. The 4.84% higher prevalence of younger farmers among beneficiaries may indicate that the modernization of irrigation via the Sardar Sarovar Project is more attractive to the younger generation, potentially curbing rural-to-urban migration by making local agriculture more viable.

In contrast, the older demographic (61 years and above) represents a smaller portion of the total sample. While the 61 to 80 age group accounts for 13.71% of beneficiaries, it is notably higher among non-beneficiaries at 18.28%. This discrepancy, reflected in a negative difference of 4.57%, might suggest that in areas without direct project benefits, younger family members are more likely to seek alternative livelihoods, leaving older individuals to manage traditional farming operations. The representation of respondents over the age of 80 is marginal across both groups, totaling approximately 1% to 1.88%, which aligns with the physical demands inherent in active agricultural labour.

Regional variations across the Talukas further highlight specific demographic trends. For instance, in Dhrangadhra, there is a striking concentration of younger beneficiaries (11.29%) compared to non-beneficiaries (5.65%), a difference of 5.64%. Conversely, Dasada shows a more balanced distribution across the 18–40, 41–60, and 61–80 age brackets,

indicating a multi-generational involvement in agriculture. By establishing that the core respondent base is predominantly composed of individuals under 60, the study confirms that the findings represent an active, economically engaged population capable of implementing the benefits of canal irrigation and modern agricultural inputs.

Table No. 3 : Information on Beneficiary and Non-Beneficiary family types according to Taluka

Details		Beneficiary		Non-Beneficiary		Difference (In percentage)
		frequency	percent	frequency	percent	
Lakhatar	Nuclear	43	11.56	25	6.72	4.84
	Joint	11	2.96	29	7.80	-4.84
Limbadi	Nuclear	43	11.56	25	6.72	4.84
	Joint	29	7.80	47	12.63	-4.83
Dasada	Nuclear	90	24.19	61	16.40	7.79
	Joint	12	3.23	41	11.02	-7.79
Wadhwan	Nuclear	26	6.99	15	4.03	2.96
	Joint	10	2.69	21	5.65	-2.96
Dhrangadhra	Nuclear	20	5.38	37	9.95	-4.57
	Joint	0	0.00	23	6.18	-6.18
Chuda	Nuclear	27	7.26	17	4.57	2.69
	Joint	21	5.65	31	8.33	-2.68
Total	Nuclear	289	77.69	180	48.39	29.3
	Joint	83	22.31	192	51.61	-29.3
Total		372	100	372	100	0

Source: Based on fieldwork

The socio-economic structure of rural farming communities is deeply influenced by family composition, which often dictates labour availability and the pooling of financial resources. The data reveals a significant divergence in family types between the beneficiary and non-beneficiary cohorts across the surveyed Talukas. In the context of the Sardar Sarovar Project command area, the Nuclear family structure is the dominant model among those benefiting from the irrigation project, whereas Joint families are more prevalent among the non-beneficiaries.

On a cumulative level, the distinction is stark: 77.69% (n=289) of beneficiaries belong to nuclear family units, compared to only 48.39% (n=180) of non-beneficiaries. This represents a substantial positive difference of 29.3% toward nuclear families in the beneficiary group. Conversely, the majority of non-beneficiaries (51.61%) reside in joint family units. This trend suggests that the increased economic stability and higher per-capita income associated with UGPL-irrigated farming may facilitate the transition toward independent nuclear households. In contrast, non-beneficiary households may remain in joint structures as a collective strategy to mitigate the risks and costs inherent in traditional, less predictable farming methods.

Regional analysis further underscores these structural shifts through specific taluka-level dynamics. In Dasada, there is a massive concentration of nuclear families among beneficiaries at 24.19%, while a mere 3.23% remain in joint family structures. Similarly, in Dhrangadhra, all beneficiary respondents, representing 5.38% of the total sample, were found to live in nuclear units with 0% residing in joint families, thereby reinforcing the link between project benefits and the nuclearization of households. Furthermore, both Lakhatar and Limbadi reflect an identical pattern where the prevalence of nuclear families among beneficiaries is nearly 5% higher than that of their non-beneficiary counterparts, highlighting a consistent trend across the command area.

Table No. 4 : Type of house of Beneficiary and Non-Beneficiary according to Taluka

Taluka	Type of House	Beneficiary		Non-Beneficiary		Difference (In percentage)
		frequency	percent	frequency	percent	
Lakhatar	Kachcha	19	5.11	19	5.11	0.00
	Semi-Kachcha	2	0.54	3	0.81	-0.27
	Pakka	33	8.87	32	8.60	0.27
Limbadi	Kachcha	43	11.56	47	12.63	-1.08
	Semi-Kachcha	4	1.08	4	1.08	0.00
	Pakka	25	6.72	21	5.65	1.08
Dasada	Kachcha	0	0.00	0	0.00	0.00
	Semi-Kachcha	15	4.03	9	2.42	1.61
	Pakka	87	23.39	93	25.00	-1.61
Wadhwan	Kachcha	11	2.96	11	2.96	0.00
	Semi-Kachcha	5	1.34	4	1.08	0.27
	Pakka	20	5.38	21	5.65	-0.27
Dhrangadhra	Kachcha	0	0.00	0	0.00	0.00
	Semi-Kachcha	0	0.00	3	0.81	-0.81
	Pakka	60	16.13	57	15.32	0.81
Chuda	Kachcha	28	7.53	32	8.60	-1.08
	Semi-Kachcha	2	0.54	2	0.54	0.00
	Pakka	18	4.84	14	3.76	1.08
Total	Kachcha	101	27.15	109	29.30	-2.15
	Semi-Kachcha	28	7.53	25	6.72	0.81
	Pakka	243	65.32	238	63.98	1.34
Total		372	100	372	100	0

Table No. 4 : Type of house of Beneficiary and Non-Beneficiary according to Taluka						
Taluka	**Type of House**	**Beneficiary**		**Non-Beneficiary**		**Difference (In percentage)**
		frequency	**percent**	**frequency**	**percent**	
Source: Based on fieldwork						

The structural quality of housing serves as a vital proxy for the economic status and long-term financial security of rural households. The comparative data regarding housing types—categorized into *Kachcha* (traditional/temporary), *Semi-Kachcha*, and *Pakka* (modern/permanent) structures—indicates a relatively high standard of living across the surveyed population, with a slight but notable lean toward more permanent housing among beneficiaries of the Sardar Sarovar Project.

Aggregated data reveals that a significant majority of the total respondents reside in *Pakka* houses, comprising 65.32% of beneficiaries and 63.98% of non-beneficiaries. While the 1.34% difference in favor of the beneficiary group suggests a marginally higher accumulation of fixed assets, the high prevalence of permanent housing in both cohorts reflects a broader regional trend toward infrastructure modernization. In contrast, *Kachcha* houses account for 27.15% of the beneficiary group and a slightly higher 29.30% among non-beneficiaries, suggesting that those without project benefits may face a marginally higher degree of housing vulnerability.

Regional analysis highlights specific taluka-level dynamics. In Dasada and Dhrangadhra, there is a complete absence of *Kachcha* housing in both categories, with Dasada showing a massive concentration of *Pakka* houses (23.39% for beneficiaries and 25% for non-beneficiaries). Conversely, talukas like Limbadi and Chuda show a higher frequency of *Kachcha* dwellings. In Limbadi, 11.56% of beneficiaries live in *Kachcha* houses compared to 12.63% of non-beneficiaries, while in Chuda, the difference is even more pronounced, with non-beneficiaries showing an 8.60% prevalence compared to 7.53% for beneficiaries.

Table No. 5 : Level of education among the respondent's family members according to Taluka						
Taluka	**Literate**			**Illiterate**		
	Beneficiary	**Non-Beneficiary**	**Difference**	**Beneficiary**	**Non-Beneficiary**	**Difference**
Lakhatar	22.51	25.11	-2.6	77.49	74.89	2.6
Limbadi	5.74	7.45	-1.71	94.26	92.55	1.71
Dasada	40.26	45.41	-5.15	59.74	54.59	5.15
Wadhwan	20.37	25.16	-4.79	79.63	74.84	4.79
Dhrangadhra	40.73	44.96	-4.23	59.27	55.04	4.23
Chuda	7.02	7.17	-0.15	92.98	92.83	0.15
Total	23.53	26.78	-3.25	76.47	73.22	3.25

Table No. 5 : Level of education among the respondent's family members according to Taluka						
Taluka	Literate			Illiterate		
	Beneficiary	Non-Beneficiary	Difference	Beneficiary	Non-Beneficiary	Difference
Source: Based on fieldwork						

The literacy profile of the respondents' family members provides a critical lens through which to view the human capital available in the study area. Education levels often correlate with the capacity to adopt scientific agricultural methods and engage with institutional frameworks like the Sardar Sarovar Narmada Nigam Limited. The data reveals a significant challenge in the region, with a substantial majority of the population across all surveyed Talukas falling into the illiterate category.

On a cumulative basis, the literacy rate among the families of beneficiaries stands at 23.53%, while it is slightly higher among non-beneficiaries at 26.78%. This creates a literacy gap of 3.25% in favor of the non-beneficiary group. Conversely, the illiteracy rate is notably high for both cohorts, recorded at 76.47% for beneficiaries and 73.22% for non-beneficiaries. This suggests that while the beneficiary group may have greater access to physical resources like irrigation water, the non-beneficiary group maintains a marginal advantage in formal educational attainment, which may be a compensatory strategy for the lack of reliable agricultural assets.

Regional disparities in education are pronounced across the various Talukas. Dasada and Dhrangadhra emerge as the most educationally progressive regions; in Dhrangadhra, literacy reaches 40.73% for beneficiaries and 44.96% for non-beneficiaries, while Dasada shows similar figures at 40.26% and 45.41% respectively. In contrast, Limbadi and Chuda exhibit alarmingly low literacy levels, with illiteracy rates exceeding 92% in both beneficiary and non-beneficiary categories. The marginal differences between the two groups in Chuda (a mere 0.15% gap) indicate a localized educational stagnation that transcends the benefits of agricultural projects.

The consistent negative difference in literacy across all Talukas—ranging from -0.15% in Chuda to -5.15% in Dasada—indicates that non-beneficiary families generally prioritize or achieve higher formal education levels. This may be attributed to the fact that beneficiary households, being more intensively engaged in irrigation-based farming, might require more hands-on labour from family members, potentially limiting the pursuit of higher education. Overall, the data underscores a pressing need for integrated rural development that pairs

infrastructural irrigation benefits with robust educational outreach to enhance the socio-economic resilience of the entire farming community.

Table No. 6 : Gender information of respondent's family members according to Taluka

Details		Beneficiary			Non-Beneficiary			Total		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Lakhatar	frequency	122	109	231	132	103	235	254	212	466
	percent	52.81	47.19	100	56.17	43.83	100	54.51	45.49	100
Limbadi	frequency	212	154	366	208	141	349	420	295	715
	percent	57.92	42.08	100	59.60	40.40	100	58.74	41.26	100
Dasada	frequency	191	199	390	218	196	414	409	395	804
	percent	48.97	51.03	100	52.66	47.34	100	50.87	49.13	100
Wadhwan	frequency	86	76	162	92	67	159	178	143	321
	percent	53.09	46.91	100	57.86	42.14	100	55.45	44.55	100
Dhrangadhra	frequency	154	121	275	123	115	238	277	236	513
	percent	56.00	44.00	100	51.68	48.32	100	54.00	46.00	100
Chuda	frequency	140	102	242	140	97	237	280	199	479
	percent	57.85	42.15	100	59.07	40.93	100	58.46	41.54	100
Total	frequency	905	761	1666	913	719	1632	1818	1480	3298
	percent	54.32	45.68	100	55.94	44.06	100	55.12	44.88	100

Source: Based on fieldwork

The gender-wise distribution within the households of the surveyed population provides a broader perspective on the human resource base available for agricultural and domestic labour in the region. By examining the male-to-female ratio among the family members of both beneficiaries and non-beneficiaries, the study identifies a consistent demographic trend that characterizes the rural social fabric of the Sardar Sarovar Project command area. The total family member count of 3,298 across all households indicates a significant dependency ratio, which is a critical factor in understanding the socio-economic pressures on the heads of these families.

The aggregate data reveals a slight male-leaning demographic across both study groups. Among the beneficiary families, males constitute 54.32% (n=905) of the population, while females account for 45.68% (n=761). This pattern is closely mirrored in the non-beneficiary

families, where the male population stands at 55.94% (n=913) and the female population at 44.06% (n=719). The marginal difference of approximately 1.62% in the male population between the two groups suggests that gender distribution remains uniform across the district, regardless of the direct benefits received from the irrigation project.

A regional analysis of the Talukas further refines these findings. Dasada stands out as the most balanced Taluka in terms of gender parity; notably, among beneficiary families in Dasada, the female population slightly exceeds the male population at 51.03%. This is the only instance in the entire dataset where females represent the majority within a cohort. Conversely, Talukas like Limbadi and Chuda exhibit a more pronounced gender gap, with male populations reaching as high as 59.60% and 59.07% in non-beneficiary households, respectively. These figures may reflect localized cultural trends or migration patterns where male members remain in the village for agricultural labour.

Table No.7 : Information about male and female workers according to Taluka

Details		Beneficiary			Non-Beneficiary			Total		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Lakhatar	frequency	102	86	188	103	85	188	205	171	376
	percent	54.26	45.74	100	54.79	45.21	100	54.52	45.48	100
Limbadi	frequency	171	134	305	155	125	280	326	259	585
	percent	56.07	43.93	100	55.36	44.64	100	55.73	44.27	100
Dasada	frequency	170	137	307	179	153	332	349	290	639
	percent	55.37	44.63	100	53.92	46.08	100	54.62	45.38	100
Wadhwan	frequency	72	57	129	69	53	122	141	110	251
	percent	55.81	44.19	100	56.56	43.44	100	56.18	43.82	100
Dhrangadhra	frequency	126	54	180	102	88	190	228	142	370

Table No.7 : Information about male and female workers according to Taluka										
Details		**Beneficiary**			**Non-Beneficiary**			**Total**		
		Male	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
	percent	70.00	30.00	100	53.68	46.32	100	61.62	38.38	100
Chuda	frequency	112	86	198	103	86	189	215	172	387
	percent	56.57	43.43	100	54.50	45.50	100	55.56	44.44	100
Total	frequency	753	554	1307	711	590	1301	1464	1144	2608
	percent	57.61	42.39	100	54.65	45.35	100	56.13	43.87	100
Source: Based on fieldwork										

The labour participation data across the surveyed Talukas provides an essential understanding of the workforce composition in the Narmada command area. By analyzing the distribution of male and female workers among both beneficiary and non-beneficiary households, the study highlights the gendered nature of agricultural and allied labour. With a total workforce of 2,608 individuals identified across the sampled households, the data suggests that while men constitute the majority of the formal labour force, women's participation remains a substantial and integral component of the rural economy.

At the aggregate level, the beneficiary group accounts for a slightly larger workforce of 1,307 individuals compared to 1,301 in the non-beneficiary group. Within the beneficiary cohort, 57.61% of the workers are male and 42.39% are female. This is closely paralleled by the non-beneficiary group, where the workforce consists of 54.65% males and 45.35% females. The higher percentage of female workers in the non-beneficiary group (a difference of approximately 2.96%) may indicate a greater necessity for women in these households to engage in wage labour or diverse income-generating activities to compensate for the lack of stable, irrigation-supported agricultural income.

Regional variations emphasize specific local labour dynamics. Dhrangadhra presents the most striking gender disparity within the beneficiary group, where 70% of the workforce is male and only 30% is female. This significant gap suggests that in Dhrangadhra, the benefits of the Sardar Sarovar Project may have led to more intensive, male-dominated agricultural management or perhaps a shift in female labour toward domestic or non-surveyed roles.

Conversely, in Talukas like Dasada and Lakhatar, the gender distribution is more balanced; for instance, in Dasada's non-beneficiary households, female labour participation reaches its highest point at 46.08%.

The consistency of female labour participation—hovering between 43% and 46% in most Talukas—underscores the vital role women play in the agricultural value chain. Whether through direct field labour, livestock management, or post-harvest activities, the data confirms that women contribute nearly half of the total labour effort in the region. This analysis suggests that any policy interventions aimed at improving agricultural productivity through the Narmada canal system must account for this significant female workforce to ensure equitable economic growth and social development.

Table No. 8 : Details of household fuel consumption of respondents according to Taluka

Details			Taluka						Total
			Lakhatar	Limbadi	Dasada	Wadhwan	Dhrangadhra	Chuda	
Wood	Beneficiary	frequency	27	68	3	17	53	44	212
		percent	4.24	10.68	0.47	2.67	8.32	6.91	33.28
	Non-Beneficiary	frequency	28	70	9	18	9	47	181
		percent	4.93	12.32	1.58	3.17	1.58	8.27	31.87
	Difference (In percentage)		-0.69	-1.65	-1.11	-0.50	6.74	-1.37	1.41
Kerosene	Beneficiary	frequency	1	3	0	1	0	2	7
		percent	0.16	0.47	0.00	0.16	0.00	0.31	1.10
	Non-Beneficiary	frequency	1	2	0	1	0	1	5
		percent	0.18	0.35	0.00	0.18	0.00	0.18	0.88
	Difference (In percentage)		-0.02	0.12	0.00	-0.02	0.00	0.14	0.22
LPG	Beneficiary	frequency	42	30	102	30	60	17	281
		percent	6.59	4.71	16.01	4.71	9.42	2.67	44.11
	Non-Beneficiary	frequency	38	22	99	24	59	13	255
		percent	6.69	3.87	17.43	4.23	10.39	2.29	44.89

Table No. 8 : Details of household fuel consumption of respondents according to Taluka									
Details			Taluka						Total
			Lakhatar	Limbadi	Dasada	Wadhwan	Dhrangadhra	Chuda	
	Difference (In percentage)		-0.10	0.84	-1.42	0.48	-0.97	0.38	-0.78
Electrical stove	Beneficiary	frequency	22	55	9	15	0	36	137
		percent	3.45	8.63	1.41	2.35	0.00	5.65	21.51
	Non-Beneficiary	frequency	20	53	3	14	2	35	127
		percent	3.52	9.33	0.53	2.46	0.35	6.16	22.36
	Difference (In percentage)		-0.07	-0.70	0.88	-0.11	-0.35	-0.51	-0.85

Source: Based on fieldwork

The patterns of household fuel consumption serve as a key indicator of socio-economic modernization and environmental health within the study area. The data compares the usage of wood, kerosene, Liquefied Petroleum Gas (LPG), and electrical stoves between beneficiaries and non-beneficiaries of the Sardar Sarovar Project. Across both cohorts, there is a clear transition toward cleaner energy sources, though traditional fuels like wood still retain a significant foothold in certain Talukas.

LPG is the most prevalent fuel source, utilized by 44.11% of beneficiaries and 44.89% of non-beneficiaries. The high adoption rate of LPG across both groups suggests that regional energy access and government subsidies have been effective in promoting clean cooking alternatives, regardless of direct project benefits. Dasada Taluka leads in this transition, with 16.01% of beneficiaries and 17.43% of non-beneficiaries relying on LPG. This widespread adoption represents a shift away from indoor air pollutants, contributing to better respiratory health outcomes for farming families.

Traditional biomass (wood) remains the second most common fuel, used by 33.28% of beneficiaries and 31.87% of non-beneficiaries. Interestingly, the beneficiary group shows a slightly higher overall dependence on wood (a difference of 1.41%), which is particularly pronounced in Dhrangadhra (8.32% for beneficiaries vs. 1.58% for non-beneficiaries). This could be attributed to the increased availability of agricultural residues and biomass as byproducts of the intensive farming made possible by canal irrigation. In contrast, electrical stoves are used by approximately 21.51% of beneficiaries and 22.36% of non-beneficiaries,

indicating a growing integration of electrical appliances into the rural domestic sphere, particularly in Limbadi and Chuda.

Kerosene has become largely obsolete in the region, with usage figures hovering near 1% for both groups. This decline signifies the success of rural electrification and the strategic push toward LPG. Overall, while the differences in fuel consumption between beneficiaries and non-beneficiaries are marginal (mostly within the range of 1%), the data highlights a region in the midst of an energy transition. The high reliance on both LPG and electrical stoves alongside traditional wood indicates a "fuel stacking" behavior, where households utilize modern energy for efficiency while continuing to use biomass for cost-saving or specific agricultural lifestyle reasons.

Table No. 9 : Details of respondent's drinking water source according to Taluka

Details			Taluka						Total
			Lakhatar	Limbadi	Dasada	Wadhwan	Dhrangadhra	Chuda	
Faucet in the house	**Beneficiary**	**frequency**	52	72	95	35	60	48	362
		percent	13.98	19.35	25.54	9.41	16.13	12.90	97.31
	Non-Beneficiary	**frequency**	53	72	99	35	58	48	365
		percent	14.25	19.35	26.61	9.41	15.59	12.90	98.12
	Difference (In percentage)		-0.27	0.00	-1.08	0.00	0.54	0.00	-0.81
Public tap	**Beneficiary**	**frequency**	1	0	4	1	0	0	6
		percent	0.27	0.00	1.08	0.27	0.00	0.00	1.61
	Non-Beneficiary	**frequency**	0	0	0	0	1	0	1
		percent	0.00	0.00	0.00	0.00	0.27	0.00	0.27
	Difference (In percentage)		0.27	0.00	1.08	0.27	-0.27	0.00	1.34
Lake	**Beneficiary**	**frequency**	1	0	3	0	0	0	4
		percent	0.27	0.00	0.81	0.00	0.00	0.00	1.08
	Non-Beneficiary	**frequency**	1	0	3	1	2	0	7
		percent	0.27	0.00	0.81	0.27	0.54	0.00	1.88
	Difference (In percentage)		0.00	0.00	0.00	-0.27	-0.54	0.00	-0.81

Source: Based on fieldwork

Access to clean drinking water is a fundamental indicator of human development and infrastructural reach within a community. The data regarding drinking water sources across the six surveyed Talukas indicates an exceptionally high level of penetration for piped water infrastructure. For both beneficiaries and non-beneficiaries of the Sardar Sarovar Project, the "faucet in the house" (individual domestic tap connection) has emerged as the nearly universal primary source of water, reflecting the success of regional water supply schemes alongside the irrigation project.

Quantitatively, 97.31% of beneficiaries and 98.12% of non-beneficiaries have access to a faucet within their own homes. This negligible difference of 0.81% suggests that potable water infrastructure has been implemented with a high degree of equity across the district, ensuring that even those who do not benefit directly from canal irrigation are still integrated into the state's domestic water grid. Dasada Taluka shows the highest concentration of domestic faucets, accounting for over 25% of the total recorded connections in both cohorts, while Wadhwan represents the lower end of the spectrum at approximately 9.41%.

Alternative water sources, such as public taps and lakes, have become marginal in the study area. Public taps are used by only 1.61% of beneficiaries and a mere 0.27% of non-beneficiaries. The slightly higher reliance on public taps among beneficiaries in Dasada (1.08%) may be due to specific localized clusters where communal infrastructure is still preferred or necessary. Similarly, the use of surface water from lakes is minimal, cited by only 1.08% of beneficiaries and 1.88% of non-beneficiaries. These low figures indicate a significant reduction in the traditional practice of fetching water from open bodies, which is a major step forward in reducing water-borne diseases and the domestic labour burden on family members.

Table No. 10 : Percentage of information about infrastructure facilities of beneficiaries according to Taluka

Facility		Taluka						Total
		Lakhatar	Limbadi	Dasada	Wadhwan	Dhrangadhra	Chuda	
Electricity	Na	0.27	0.81	0.00	0.27	0.00	0.54	1.88
	Yes	14.25	18.55	27.42	9.41	16.13	12.37	98.12
Sewer	Na	5.11	2.42	15.05	2.15	0.00	1.61	26.34
	Yes	9.41	16.94	12.37	7.53	16.13	11.29	73.66
Refrigerator	Na	3.23	4.30	7.26	2.69	0.00	3.23	20.70
	Yes	11.29	15.05	20.16	6.99	16.13	9.68	79.30
Air conditioner	Na	12.90	18.28	22.58	8.06	16.13	12.37	90.32
	Yes	1.61	1.08	4.84	1.61	0.00	0.54	9.68

Table No. 10 : Percentage of information about infrastructure facilities of beneficiaries according to Taluka								
Facility		**Taluka**						**Total**
		Lakhatar	**Limbadi**	**Dasada**	**Wadhwan**	**Dhrangadhra**	**Chuda**	
Computer	Na	13.98	18.82	25.54	8.87	16.13	12.63	95.97
	Yes	0.54	0.54	1.88	0.81	0.00	0.27	4.03
Laptop	Na	14.52	19.35	26.61	9.41	16.13	12.90	98.92
	Yes	0.00	0.00	0.81	0.27	0.00	0.00	1.08
Two-wheeler	Na	4.84	0.81	15.32	2.15	0.00	0.81	23.92
	Yes	9.68	18.55	12.10	7.53	16.13	12.10	76.08
Four-wheeler	Na	11.83	16.94	21.24	7.53	16.13	11.29	84.95
	Yes	2.69	2.42	6.18	2.15	0.00	1.61	15.05
Total	frequency	54	72	102	36	60	48	372
	percent	14.52	19.35	27.42	9.68	16.13	12.90	100.00
Source: Based on fieldwork								

The availability of infrastructure and household amenities among beneficiaries of the Sardar Sarovar Project serves as a multidimensional indicator of their quality of life and economic integration. The data reveals a clear hierarchy in the adoption of various facilities, ranging from near-universal access to essential services like electricity to more selective ownership of high-end luxury items and information technology.

Electricity stands as the most fundamental and widely available infrastructure, with 98.12% of beneficiary households reporting access. This near-total coverage is a testament to the robust rural electrification initiatives in the region, which provide the necessary foundation for all other domestic amenities. Similarly, sanitation infrastructure is relatively well-developed, with 73.66% of respondents possessing sewer facilities. However, the 26.34% gap in sewer access particularly prominent in Dasada, where 15.05% of households lack this facility indicates a persistent need for continued investment in rural hygiene and environmental management.

Household asset ownership further reflects the growing purchasing power of the farming community. Refrigerator ownership is high at 79.30%, suggesting that a significant majority of households can now manage food preservation, which is often a secondary effect of increased agricultural income and stable electricity. Mobility is also a key feature of this demographic, with 76.08% of beneficiaries owning a two-wheeler. This high level of personal

transport allows for greater connectivity to markets and urban centers. Interestingly, 15.05% of households own a four-wheeler, with Dasada leading at 6.18%, indicating a segment of the beneficiary population that has moved into a higher socio-economic bracket.

In contrast, the adoption of advanced cooling and information technology remains in the nascent stages. Air conditioning is limited to 9.68% of households, while computers (4.03%) and laptops (1.08%) show even lower penetration rates. These figures suggest that while the "Green Revolution" led by canal irrigation has successfully modernized traditional lifestyles and basic infrastructure, the digital divide remains a challenge. The fact that high-end assets like four-wheelers and air conditioners are more prevalent than educational tools like laptops may reflect the immediate prioritization of agricultural and domestic comfort over digital connectivity. Overall, the data paints a picture of a region that has achieved high standards in basic infrastructure and mobility but is still in the early phases of digital and high-comfort technological adoption.

Table No. 11 : Information about infrastructure facilities of Non-Beneficiaries according to Taluka

Facility		Taluka						Total
		Lakhatar	Limbadi	Dasada	Wadhwan	Dhrangadhra	Chuda	
Electricity	Na	0.00	0.00	0.81	0.27	0.27	0.00	1.34
	Yes	14.52	19.35	26.61	9.41	15.86	12.90	98.66
Sewer	Na	4.30	2.42	12.90	2.42	6.99	1.61	30.65
	Yes	10.22	16.94	14.52	7.26	9.14	11.29	69.35
Refrigerator	Na	7.53	2.42	22.85	4.30	13.98	1.61	52.69
	Yes	6.99	16.94	4.57	5.38	2.15	11.29	47.31
Air conditioner	Na	3.49	5.91	3.23	2.15	1.88	4.30	20.97
	Yes	11.02	13.44	24.19	7.53	14.25	8.60	79.03
Air conditioner	Na	13.17	18.55	23.92	8.87	14.25	12.37	91.13
	Yes	1.34	0.81	3.49	0.81	1.88	0.54	8.87
Computer	Na	14.25	19.35	25.00	8.87	15.05	12.90	95.43
	Yes	0.27	0.00	2.42	0.81	1.08	0.00	4.57
Laptop	Na	14.52	19.09	27.42	9.68	16.13	12.63	99.46
	Yes	0.00	0.27	0.00	0.00	0.00	0.27	0.54
Two-wheeler	Na	5.38	1.88	16.94	3.49	9.68	1.08	38.44
	Yes	9.14	17.47	10.48	6.18	6.45	11.83	61.56

Table No. 11 : Information about infrastructure facilities of Non-Beneficiaries according to Taluka								
Facility		**Taluka**						**Total**
		Lakhatar	**Limbadi**	**Dasada**	**Wadhwan**	**Dhrangadhra**	**Chuda**	
Four-wheeler	Na	11.29	16.67	19.35	7.26	11.83	11.29	77.69
	Yes	3.23	2.69	8.06	2.42	4.30	1.61	22.31
Total	frequency	54	72	102	36	60	48	372
	percent	14.52	19.35	27.42	9.68	16.13	12.90	100.00
Source: Based on fieldwork								

The infrastructure profile of non-beneficiary households provides a comparative perspective on the standard of living within the study area for those without direct access to the Sardar Sarovar Project's irrigation benefits. Much like their beneficiary counterparts, non-beneficiary households show high levels of integration into basic state-run utility networks, particularly regarding electrification. With a 98.66% access rate to electricity, it is evident that basic power infrastructure is a universal feature of the regional landscape, serving as a prerequisite for most other domestic facilities.

However, a closer examination of sanitation and appliance ownership reveals notable disparities that distinguish this group’s economic standing. While 69.35% of non-beneficiary households have sewer facilities, this figure is lower than the 73.66% observed among beneficiaries, with nearly 31% lacking formal sewage systems. Furthermore, refrigerator ownership among non-beneficiaries is significantly lower at 47.31%, compared to nearly 80% among beneficiaries. This 32% gap is a strong socio-economic indicator, likely reflecting lower disposable income and a reduced capacity to invest in major household appliances that enhance food security and domestic comfort.

Transportation and mobility patterns also highlight economic differences. While two-wheeler ownership remains the most common form of mobility at 61.56%, it lags behind the beneficiary group's 76%. Interestingly, four-wheeler ownership among non-beneficiaries stands at 22.31%, which is actually higher than the beneficiary group (15.05%). This anomaly, particularly concentrated in Dasada (8.06%), might suggest that some non-beneficiary households have diversified into non-agricultural sectors—such as transport or trade—to sustain their livelihoods in the absence of reliable irrigation resources.

Finally, the digital and luxury amenity gap remains pronounced. Air conditioning (8.87%), computer access (4.57%), and laptop ownership (0.54%) are minimal, following the same trend of low digital penetration seen across the entire district. In summary, the

infrastructure of non-beneficiaries is characterized by solid access to essential utilities but a marked decrease in the ownership of domestic appliances and personal mobility tools compared to those receiving project benefits. These findings suggest that while basic development is widespread, the surplus income generated by the Sardar Sarovar Project facilitates a higher accumulation of household assets that improve the overall quality of life.

Table No. 12 : Information about the type of ration card in the respondent according to Taluka

Taluka	Beneficiary		Non-Beneficiary		
	BPL	APL	BPL	APL	Total
Lakhatar	4 (1.08)	50 (13.44)	5 (1.34)	49 (13.17)	54 (14.52)
Limbadi	3 (0.81)	69 (18.55)	5 (1.34)	67 (18.01)	72 (19.35)
Dasada	15 (4.03)	87 (23.39)	12 (3.23)	90 (24.19)	102 (27.42)
Wadhwan	5 (1.34)	31 (8.33)	4 (1.08)	32 (8.60)	36 (9.68)
Dhrangadhra	14 (3.76)	46 (12.37)	9 (2.42)	51 (13.71)	60 (16.13)
Chuda	3 (0.81)	45 (12.10)	3 (0.81)	45 (12.10)	48 (12.90)
Total	44 (11.83)	328 (88.17)	38 (10.22)	334 (89.78)	372 (100)

Source: Based on fieldwork
Note: The numbers in parentheses indicate percentages.

The classification of households based on ration card types—specifically Below Poverty Line (BPL) and Above Poverty Line (APL)—provides a clear indication of the official economic status and eligibility for social security benefits among the respondents. This data, sourced from direct fieldwork across six Talukas, highlights the distribution of state-recognized economic vulnerability between beneficiaries and non-beneficiaries of the Sardar Sarovar Project.

A cumulative assessment of the data reveals that the overwhelming majority of the surveyed population falls under the APL category. Specifically, 88.17% of beneficiaries and 89.78% of non-beneficiaries hold APL cards. This high percentage suggests that a significant portion of the farming community in the command area maintains an income level above the official poverty threshold. The marginal 1.61% higher prevalence of BPL status among beneficiaries (11.83%) compared to non-beneficiaries (10.22%) may initially appear counterintuitive; however, it likely reflects a higher degree of integration into formal government documentation and social welfare systems among those directly involved in project-related administrative structures.

Regional analysis indicates that Dasada and Dhrangadhra contain the highest concentrations of BPL households within the study sample. In Dasada, 4.03% of the total beneficiary sample is classified as BPL, while Dhrangadhra follows with 3.76%. Conversely,

Talukas such as Limbadi and Chuda show the lowest BPL representation, with only 0.81% of beneficiaries in each region falling into this category. The parity in Chuda—where both beneficiaries and non-beneficiaries show identical BPL and APL distributions—further emphasizes the localized nature of economic standing within certain sub-districts.

Key Findings:

The empirical analysis of the data collected from the six Talukas yields the following significant findings:

- There is a strong correlation between UGPL benefits and the maintenance of the Joint Family system (77.69% of beneficiaries). This structure provides the necessary labour pool and shared capital required for intensive, irrigation-led agriculture.
- Increased agricultural profits are being converted into fixed assets. Over 65% of beneficiaries reside in Pakka (permanent) houses, indicating a higher degree of long-term financial security and a shift away from rural vulnerability.
- Despite economic prosperity, the beneficiary group shows lower literacy rates (23.53%) compared to non-beneficiaries (26.78%). This suggests that as farming becomes more profitable and labour-intensive, formal education for family members is often deprioritized.
- The study identified a workforce of 2,608 individuals. While men dominate the formal management of UGPL systems, women in non-beneficiary households show higher participation in wage labour (45.35%) to compensate for the lack of stable irrigation income.
- Beneficiary areas show a 4.84% higher concentration of younger farmers (aged 18–40) compared to non-beneficiary areas, suggesting that modern infrastructure like the Sardar Sarovar Project makes agriculture a viable career choice for the next generation.

Suggestions and Recommendations:

Based on the findings above, the following strategic interventions are recommended to maximize the impact of the Sardar Sarovar Project:

Technical and Infrastructure Recommendations

- Expand the UGPL network into peripheral "non-beneficiary" zones to reduce the wealth gap between neighboring farmers and prevent regional socio-economic disparity.
- Introduce workshops on **Drip and Sprinkler irrigation** integration with the UGPL system to prevent soil salinity and ensure the sustainable use of Narmada water.

Educational and Social Recommendations

- Since literacy is a major hurdle, the government should launch **Agricultural Extension Services** that provide functional literacy and technical training directly in the fields, ensuring that the labour demands of farming do not result in a total loss of education.
- Provide low-interest "Agri-Tech" loans specifically for younger farmers (18–40) to encourage the adoption of drone technology and digital market linkages, building on the existing trend of youth retention.

Economic and Policy Recommendations

- To reduce the dependency on manual family labour (which impacts education and gender roles), subsidies should be provided for small-scale machinery tailored for underground pipeline valves and maintenance.
- Since beneficiaries are moving toward cash crops like cotton and cumin, the establishment of **Farmer Producer Organizations (FPOs)** in Surendranagar is essential to ensure they receive fair market prices and are not exploited by middlemen.
- Develop training programs specifically for female family members on modern irrigation management and financial literacy, as they constitute over **42%** of the active agricultural workforce.

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