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Fiscal decentralization and water and sanitation provision: Evidence from Pakistan

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ABSTRACT

Fiscal decentralization offers promise in enhancing the delivery of public services. However, its success relies on good governance, accountability, and locality-specific policies. This study examined the influence of fiscal decentralization on the provision of water and sanitation services in Pakistan. It targets both provincial-level and urban-rural differentials during 1990–2020. Based on secondary panel data and using the Pooled Mean Group (PMG) estimator in a Panel ARDL environment, the study found that provincial spending has a negative relationship with rural area sanitation services and that provincial revenue has a negative relationship with rural region water services in the long run. In the short term, provincial spending has a positive impact on sanitation facilities at the aggregate level, as well as within the rural region, and provincial revenue has a positive effect on urban sanitation services. Additional provincial-level analysis identifies varied impacts of fiscal decentralization on water and sanitation services. The study suggests an increase in financial transparency, building institutional capacity, improving infrastructure, drainage networks, and ensuring timely and equitable transfers of revenues to provincial governments. The study offers policy suggestions to practitioners for the implementation of decentralization approaches to yield enhanced water and sanitation outcomes in Pakistan.

Contribution/ Originality: This study contributes by providing a province-specific analysis of fiscal decentralization in Pakistan, which is lacking in existing literature. It uses rural-urban disaggregated data to assess its impact on water and sanitation services. The primary contribution is documenting recent policy shifts and offering empirical evidence previously unexplored in existing studies.

1. INTRODUCTION

Decentralization is considered vital for the achievement of efficient delivery services. Therefore, many developing countries around the world are delegating responsibilities to lower tiers of government. The interest in decentralization has further grown recently, with new or intensifying reforms announced in countries like Bolivia, Turkey, France, Japan, Kenya, Cambodia, and India, to mention just a few (Faguet & Pöschl, 2015; Hooghe & Marks, 2016; Rodden, 2006). The academic response to the decentralization debate has been similarly bountiful, with hundreds of articles published across all relevant literature. Proponents of decentralization argue that it can foster good governance, contribute to the improvement of the lives of ordinary people by bringing decision-making processes closer to the people, and enhance coverage, scope, and quality of service delivery.

Pakistan opted for a decentralization policy in 2009 in the form of the 7th National Finance Commission Award (NFC) and the 18th Amendment to the Constitution. Under the 7th NFC award, the provincial share was increased from 44% to 57% of the divisible amount (Sabir, 2010). After the seventh NFC award, provinces have become more powerful both financially and politically due to the adoption of new standards for resource distribution (Mustafa, 2011; Sabir, 2010). The 18th Amendment to the Constitution delegated key administrative responsibilities to the provinces. These two initiatives have provided provincial governments with a larger administrative and fiscal space to enhance their overall socioeconomic and governance mechanisms, including the efficient provision of water and sanitation services.

Water and sanitation were included as objective number 6 in the Sustainable Development Goals (SDGs), which replaced the Millennium Development Goals (MDGs) to address problems of inadequate sanitation and a shortage of drinking water. It is expected that by 2030, the world will be prosperous in eradicating poverty and hunger in all their manifestations through the SDGs programs (World Health Organization, 2017). The enormous negative consequences on the economy of inadequate sanitation and a lack of clean water are tied to global efforts to remove these issues. Their significant negative impacts on the economy, lack of clean water, and poor sanitation are two issues that the world is working to overcome. Many people worldwide lack access to improved sanitation systems and drinkable water. Currently, 3.6 billion and 2 billion people lack access to safely managed water and sanitation services, respectively (WHO/UNICEF, 2021). Inadequate sanitation and a lack of drinking water are two significant causes of death worldwide. Every day, more than 700 children under the age of five die from diarrhoea related to contaminated water, subpar sanitation, and inadequate hygiene (WHO/UNICEF, 2021). Children under five who live in nations with persistent conflict are 20 times more likely to die from illnesses linked to poor water quality and sanitation than from direct violence (World Health Organization (WHO), 2019).

Like other socioeconomic issues, Pakistan's situation in terms of clean drinking water and sanitation services is unsatisfactory. In Pakistan, 21 million people do not have access to clean water near their homes, and 70 million people lack access to decent toilets (WaterAid, 2024).[1] Every year, 53,000 Pakistani children die from diarrhea because of inadequate water and sanitation. Children who have diarrhea regularly are more likely to fall behind in class or quit altogether. Additionally, it can lead to stunting, which now affects about 44% of children in Pakistan (UNICEF, 2019).[2]

The gloomy situation of water and sanitation services in Pakistan has motivated this work. In Pakistan, many underserved areas are either rural or outside of the cities, where socioeconomic development is slower. In response, the study investigates whether the issues could be resolved using the decentralized governance design. According to Veiga, Kurian, and Ardakanian (2015), decentralization is becoming a preferred governance design when it comes to delivering necessities like water and sewage services. Governments and other reformers are now attempting to link service levels and costs, offer incentives that boost the efficiency of allocating water resources, lower costs, and increase the sustainability of water delivery systems (World Bank, 2010).

It was observed that many studies on water and sanitation have been done in the context of decentralization (Asthana, 2003; Dinan, Cropper, & Portney, 1999; Laryea-Adjei & Van Dijk, 2012; Oates, 2002). Interestingly, despite facing challenges in water and sanitation provisions, Pakistan exhibits an empirical relationship between decentralization and the provision of sanitation and water services. This study fills the research gap and contributes several key policy discourses in the literature. To begin with, the nexus between fiscal decentralization and improved water and sanitation coverage is examined using provincial statistics. Pakistan is a country where reforms towards decentralization have transformed provincial duties under the 18th Amendment and the 7th NFC Award, but whose

[1] www.wateraid.org/where-we-work/pakistan, retrieved on 25 June 2024.

[2] https://www.unicef.org/pakistan/wash-water-sanitation-and-hygiene, retrieved on 25 June 2024.

implications on fundamental service delivery are yet to be explored. Second, it contributes to the international literature by presenting evidence from a lower-middle-income country context, where political, institutional, and capacity limitations intersect with decentralization in distinct ways.

The study is structured as follows: Section 2 covers the literature review. Section 3 discusses data and methodology. Section 4 elaborates on results and discussions. Section 5 describes conclusions and policy implications.

2. LITERATURE REVIEW

2.1. Concept and Measurement of Decentralization

A single definition does not characterize decentralization. It was defined differently by several authors, each considering their particular set of circumstances. After reviewing more than 40 definitions of decentralization in the literature, Dubois and Fattore (2009) concluded that "the concept refers to both a structure and a process; it focuses on questions of authority, responsibility, and power as well as functions and resources; and it emphasizes the transferring entity (Central government) and the receiving entities (Sub-national government)". According to Aidt and Eterovic (2011), decentralization is the shifting of responsibilities, authority, and resources from the central to the regional levels of government so that policy planning in the financial and service delivery sectors may be done more efficiently.

Depending on the definition and viewpoint, there are many techniques to measure decentralization. Measures of fiscal decentralization include vertical imbalance and ratios of subnational-center revenue and expenditure. Decentralization is calculated using both structural and administrative decentralization indicators, as well as political decentralization indicators such as municipal elections and political divisions (Blume & Voigt, 2011; Dziobek, Gutierrez Mangas, & Kufa, 2011; Martinez-Vazquez & Timofeev, 2010; Martinez-Vazquez, Lago-Peñas, & Sacchi, 2017). These indicators can be measured in a variety of ways. According to Martinez-Vazquez et al. (2017), no single definition of decentralization can capture all of its multiple aspects. The fiscal decentralization indicators will be used in this study's econometric estimation, notwithstanding the limitations of any of these metrics.

Although decentralization has been characterized in a variety of ways, it has been broadly divided into three categories: political, administrative, and fiscal decentralization.

- Political decentralization: By distributing decision-making authority at the local level, political decentralization seeks to increase the influence of the general population and its elected representatives (Topal, 2005; World Bank, 2014).
- Administrative decentralization aims to reassign power, responsibility, and funding for delivering public services among several governmental echelons. Planning, funding, and management of some public tasks are transferred from the central government to lower levels of government, semi-autonomous public authorities or companies, or local, regional, or functional authorities (Rondinelli, 1999). De-concentration, delegation, and devolution are the three main types of administrative decentralization. De-concentration only permits slightly more autonomy than centralized systems under their structures (Schneider, 2003). Under delegation, political authority is transferred to local governments or partially autonomous groups that report to the central government but are not under its control (Schneider, 2003). Devolution is the process by which decision-making, financial, and management responsibilities are transferred to largely independent local governmental corporations. Increasing the economic independence of sub-national governments through several initiatives is known as fiscal decentralization (Falleti, 2004).
- Fiscal decentralization refers to a series of policies designed to increase the financial autonomy of subnational governments (Falleti, 2004). It is the main form of decentralization, without which decentralization is considered worthless.

2.2. Water and Sanitation Empirical Findings

Like other socioeconomic variables, extensive scholarly work has also been done on decentralization and its impact on the provision of water and sanitation services. Asthana (2008) showed that the decentralization of water utilities increased corruption in many states of India. In the Indian state of West Bengal, Chakrabarti (2013) found that decentralization causes political meddling in water distribution. In Zambia, Lungu and Harvey (2009) study showed that decentralization fails to work smoothly to deliver the mandate of the local authority to provide water supply, sanitation, and hygiene services. In Tanzania, Masanyiwa, Niehof, and Termeer (2014) established that decentralization of the water sector increases inequalities in water supply. Kwach, Adam, and Shangazi (2016) studied the effect of decentralization on water supply facilities in Tanzania. Based on primary data collected from a sample of 375 respondents, the results showed that there was no concrete influence of decentralization on water supply facilities for most of the respondents. However, there was little benefit in terms of water delivery. Furthermore, it was also established that factors like the weak execution of decentralization water projects, bureaucratic hindrance, embezzlement, insufficient financing, and a deficiency of modern technology were responsible.

Mwihaki (2018) study showed that sustaining wastewater management decentralization in Zimbabwe. Leigh and Lee (2019) suggested that decentralized measurements are very effective in sustaining urban water management. In Mexico, cost recovery jumped from 30% to roughly 80% after the government delegated control of irrigation systems to users' associations (Water and Sanitation Program- World Bank, 2003). Decentralisation increased access to water and sanitation services, according to Taiwo (2020), who studied data from all across the world. The beneficial effect is more potent in rural areas than in national and metropolitan areas. The study demonstrates that institutional factors and wealth are also essential to improving access to sanitation and water services.

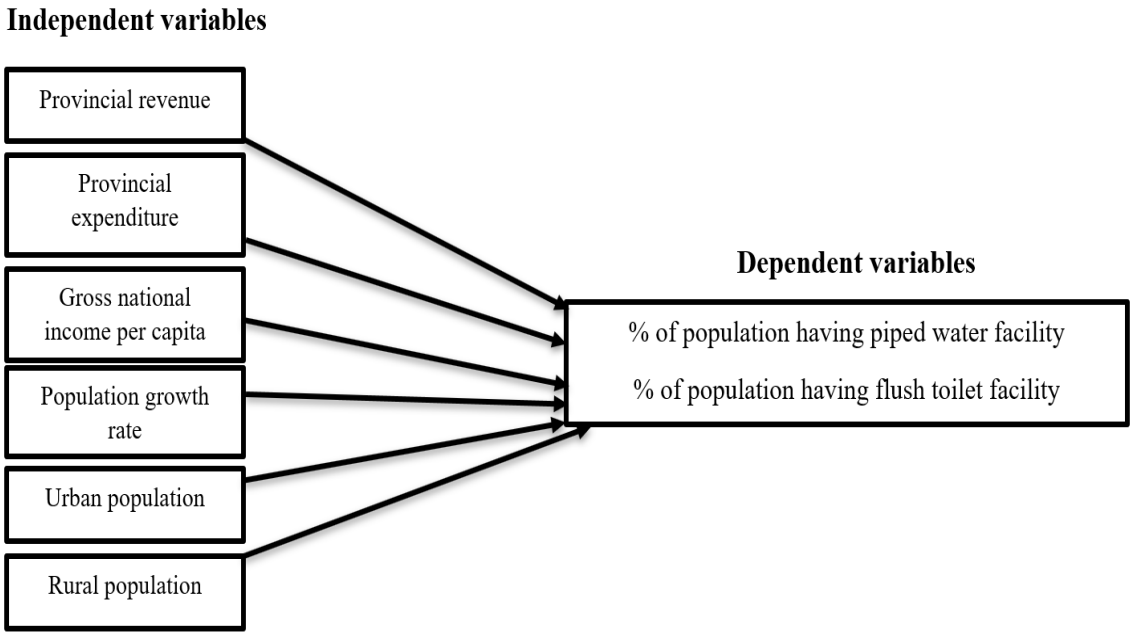

Figure 1. Conceptual framework.

Figure 1 illustrates the conceptual framework of the study. It shows the relationship between fiscal and demographic factors and access to basic water and sanitation services in Pakistan. The independent variables, such as provincial revenue, provincial expenditure, gross national income per capita, population growth rate, urban population, and rural population, influence the dependent variables: the percentage of the population with access to piped water and flush toilet facilities. This framework captures how fiscal capacity and demographic composition potentially shape public service delivery outcomes across provinces.

2.3. Hypotheses of the Study

Fiscal decentralization contributes to increasing the financial autonomy of sub-national governments (Falleti, 2004). Provincial revenue could mean increased financial autonomy and funds that may be directed towards different services, such as water. It has been established that fiscal decentralization indicators, such as revenue/expenditure ratios, are utilized to quantify decentralization (Martinez-Vazquez et al., 2017). This hypothesis presumes that as provincial revenue rises, there may be a positive relationship between the offer and enhancement of water services as a result of greater financial capability at the provincial level. Similar to water services, sanitation services could also be improved through greater provincial revenue. Fiscal decentralization could translate to more money in the coffers for different public service sectors, such as sanitation. Asthana (2008) focused on the effects of decentralization on service delivery, and the idea was that greater fiscal resources at the provincial level could help sanitation services. Thus, this hypothesis is that as provincial revenue increases, there may be a positive correlation with sanitation service provision and improvement.

Decentralization usually entails the transfer of obligations, such as financing, for service provision to lower levels of government (Rondinelli, 1999). As provincial spending in the water sector expands, it will tend to have a positive effect on water service provision and quality. Research has identified that aspects such as a lack of funding restrain decentralization programs involving water services (Kwach et al., 2016). Therefore, this assumption proposes that provincial spending in the water sector is greater and may be positively linked to better water services. Just like water services, high provincial spending on the sanitation service could have a direct impact on sanitation service delivery. Mwihaki (2018) underscored the need for wastewater management through decentralization methods. This hypothesis suggests that increased provincial spending on sanitation services can lead to improved sanitation outcomes, as more funds are allocated for infrastructure, maintenance, and development.

Based on existing literature, this study developed the following hypothesis,

H_1: There is a significant association between provincial revenue and water services.

H_2: There is a significant association between provincial revenue and sanitation services.

H_3: There is a significant association between provincial expenditure and water services.

H_4: There is a significant association between provincial expenditure and sanitation services.

Table 1. Variables and measurements.

Variable	Description	Measurement
Dependent variables		
PIPW	Percentage of households with a Piped Water facility	Number of households with a piped water facility divided by the total households in a province.
PIPWU	Percentage of households with a Piped Water facility in Urban Areas	Number of urban households having the piped water facility divided by total households in an urban area of that province.
PIPWR	Percentage of Households with Piped Water Facility in Rural Areas	Number of rural households having the piped water facility divided by total households in rural areas of that province.
FT	Percentage of Households with Flush Toilets	Number of households with flush toilet facilities divided by the total number of households in a province.
FTU	Percentage of Households with Flush Toilets in Urban Areas	Number of urban households with flush toilet facilities divided by the total households in the urban area of that province.
FTR	Percentage of Households with Flush Toilets in Rural Areas	Number of rural households having the flush toilets facility divided by total households in rural areas in that province.
Independent variables		
PRS	Percentage of Provincial Revenue in Aggregate Revenue	Provincial Revenue Divided by National Revenue
PEXS	Percentage of Provincial Expenditure in Aggregate Expenditure	Provincial expenditure divided by national expenditure
GNIPC	Gross national income per capita	Local Currency (Rupees)
POP	Population Growth Rate	Growth Rate
UPOP	Urban Population	Percentage of the total population living in urban areas
RPOP	Rural Population	Percentage of the total population living in rural areas

Source: Global Data Lab and Pakistan Bureau of Statistics. https://globaldatalab.org/ and http://www.pbs.gov.pk. Retrieved on 20th May 2024.

3. DATA AND METHODOLOGY

3.1. Data

The study analyzed provincial secondary data over the period spanning the years 1990 to 2020. The provincial indicators, such as revenue and expenditure shares, GNI per capita, population growth, and water and flush toilet facilities, were used, including urban and rural disaggregation. The selection of these periods covers major political and fiscal reforms, such as the 2001 Devolution Plan and the 18th Amendment of 2010. This period is also sufficient for capturing both short- and long-term dynamics of these indicators. The primary sources of these data include national and provincial sources, such as the Pakistan Handbook of Statistics and the Ministry of Finance, as well as international databases like the World Bank and UNDP. These sources were found to be the most reliable and consistent for reporting and analysis as presented in Table 1.

3.2. Model and Estimation

To analyze the influence of decentralization on water and sanitation services, this study relies on provincial water and sanitation services, along with the rural-urban composition of these services, which are found in extant studies to analyze the influence of decentralization on water and sanitation (Sepulveda & Martinez-Vazquez, 2011; Taiwo & Kayode, 2020). These indicators directly reflect basic service delivery outcomes and highlight urban-rural disparities. The influence of decentralization on water and sanitation is controlled using key fiscal variables like revenue share in aggregate revenue (PRS), provincial expenditure (PEXS), gross national income per capita (GNIPC), and population growth rate (POP). These are the critical factors influencing public service provision. Some of these fiscal variables have also been used in some notable studies (Sepulveda & Martinez-Vazquez, 2011; Taiwo & Kayode, 2020). Hence, the functional form by which decentralization influences water and sanitation services in Pakistan can be expressed as follows:

$$y_{it} = \theta(\, PRS_{it}, PEXS_{it}, POP_{it}, GNIPC_{it}) \qquad (1)$$

Where could be either the percentage of households with piped water (PIPW) or the percentage of households with flush toilets (FT) at the provincial level (also rural-urban areas), θ represents a function mapping the explanatory variables to y; Moreover, the other variables are as explained previously. The explicit form of (3.2) is expressed as follows.

$$y_{it} = \tau_0 + \tau_1 PRS_{it} + \tau_2 PEXS_{it} + \tau_3 Pop_{it} + \tau_4 GNIPC_{it} + \epsilon_{it} \qquad (2)$$

Model Specifications,

$$FT_{it} = \alpha + \beta_1 PRS_{it} + \beta_2 PEXS_{it} + \beta_3 GNIPC_{it} + \beta_4 POP_{it} + \mu_{it} \quad \text{Model (1)}$$

$$PIPW_{it} = \alpha + \beta_1 PRS_{it} + \beta_2 PEXS_{it} + \beta_3 GNIPC_{it} + \beta_4 POP_{it} + \mu_{it} \quad \text{Model (2)}$$

$$FTR_{it} = \alpha + \beta_1 PRS_{it} + \beta_2 PEXS_{it} + \beta_3 GNIPC_{it} + \beta_4 RPOP_{it} + \mu_{it} \quad \text{Model (3)}$$

$$FTU = \alpha + \beta_1 PRS_{it} + \beta_2 PEXS_{it} + \beta_3 GNIPC_{it} + \beta_4 UPOP_{it} + \mu_{it} \quad \text{Model (4)}$$

$$PIPWR = \alpha + \beta_1 PRS_{it} + \beta_2 PEXS_{it} + \beta_3 GNIPC_{it} + \beta_4 RPOP_{it} + \mu_{it} \quad \text{Model (5)}$$

$$PIPWU = \alpha + \beta_1 PRS_{it} + \beta_2 PEXS_{it} + \beta_3 GNIPC_{it} + \beta_4 UPOP_{it} + \mu_{it} \quad \text{Model (6)}$$

3.3. Cross-Section Dependence Test

To ensure the validity of panel estimations, it is crucial to address potential cross-sectional dependence (CSD) among the variables. Ignoring CSD can lead to inconsistent standard errors and biased results. The Pesaran (2004) cross-sectional dependence (CD) test is utilized for this purpose. The CD test statistic is calculated as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1} \cdot \sum_{j=1+1}^{N-1} p_{ij}\right) \qquad (3)$$

Where N is the number of provinces and T is the period.

3.4. Panel Unit Root Tests

In panel data analysis, cross-sectional dependence can cause misleading results when conducting conventional unit root tests assuming independence across cross-sections. To address this issue, it is essential to use tests that are robust to cross-sectional dependence. Notably, the cross-sectionally Augmented Dickey-Fuller (CADF) test and the cross-sectionally Augmented IPS (CIPS) test, proposed by Pesaran (2007). These tests are more advanced than standard ADF and IPS tests in that they incorporate cross-sectional averages of the variables into their methodology. The CADF test applies the augmented Dickey-Fuller test individually to every cross-section. The CIPS test, on the other hand, sums the individual CADF test statistics from across the panel at the same time. The CIPS test statistic can be represented as follows:

$$CIPS(N,T) = N^{-1}\sum_{i=1}^{N} t_i(N,T) \quad (4)$$

3.5. Pooled Mean Group (PMG) Estimator

The study employed the Pooled Mean Group (PMG) estimator within a Panel ARDL framework, as it is well-suited to the data structure and research objectives. Notably, the PMG method permits heterogeneous short-run dynamics while maintaining homogeneous long-run relationships across provinces. This approach is theoretically justified because provinces can respond differently in the short term but are expected to converge in the long run under unified national policies and economic conditions. The technique effectively handles variables with heterogeneous integration orders (I(0) and I(1)), bypassing the need for pre-testing for unit roots, which is a limitation in other panel estimation methods. Additionally, the PMG estimator identifies both short-run responses and long-run equilibrium relationships between fiscal decentralization and the provision of water and sanitation services, which is crucial for understanding the dynamic relationship over time. Given the dataset's design, characterized by a high time dimension (T = 31 years) and a low cross-section (N = 4 provinces), the PMG estimator yields efficient and consistent estimates, accounting for standard correlated effects and province-specific slope differences while incorporating basic dynamic effects.

$$\Delta y_{i_t} = \delta_{it} + \beta_i \Delta x_{it} + \pi_i f_t + \sum_{t=n}^{t} \psi_{ij}\, \Delta D_{it} + \Omega_i ECM_{it-1} + u_{it} \quad (5)$$

Where δ_{it} represents the constant term, and Δ denotes changes over time, Ω_i is the speed of adjustment and u_{it} is the error term.

In the second stage, the averages of the coefficients across provinces are estimated as.

$$\hat{\beta}_{PMG} = N^{-1}\sum_{i=1}^{N} \hat{\beta}_i \quad (6)$$

The outlined methodological framework guarantees a thorough examination of the correlation between fiscal decentralization and water and sanitation services in Pakistan; by tackling challenges such as cross-sectional dependence and non-stationarity and utilizing sophisticated estimation methods like the PMG, the study endeavors to offer dependable and resilient findings to guide policy-making processes.

4. RESULT AND ANALYSIS

Table 2 shows the descriptive statistics of various socioeconomic indicators in Pakistan from 1990 to 2020. Notably, the average gross national income per capita stands at 8.07 with limited deviation, indicating a relatively stable income distribution. Population growth averages 1% annually with no significant variance, suggesting consistent demographic trends. Urban areas accommodate an average of 28% of the population. In comparison, rural areas house 72%, reflecting the predominant rural-urban demographic divide. Expenditure and revenue shares in the budget both average 25%, indicating equilibrium in financial allocations. Access to piped water and flush toilets varies notably between urban and rural areas, with urban areas enjoying higher percentages across the board. The variability in access to these amenities suggests disparities in infrastructure development. These statistics provide an overview of socioeconomic conditions, highlighting areas of strength and disparities that warrant attention.

Table 2. Descriptive statistics.

Variables	Mean	Std dev	Minimum	Maximum
GNIPC	8.07	0.22	7.7	8.54
Population growth	1%	0%	0%	2%
Urban population	28%	13%	15%	53%
Rural population	72%	13%	47%	85%
Expenditure share	25%	15%	7%	49%
Revenue share	25%	15%	6%	51%
Piped water	30%	10%	12%	51%
Piped water urban	60%	13%	17%	87%
Piped water rural	19%	11%	4%	47%
Flush toilet	45%	24%	6%	89%
Flush toilet urban	83%	14%	51%	99%
Flush toilet rural	31%	23%	3%	84%

The empirical analysis begins by testing a pairwise correlation between the variables of interest. Table 3 shows the correlation matrix of several vital variables. The correlation coefficients of these variables reveal significant relationships among them. Notably, there is a strong positive correlation (0.851) between the percentage of households with flush toilets (FT) and gross national income per capita (GNIPC), indicating that higher income per capita is associated with a higher percentage of households having flush toilets. Provincial expenditure (PEXS) and GNIPC also show a moderate positive correlation (0.509), suggesting that higher provincial expenditure is linked with higher GNIPC. Similarly, provincial revenue share (PRS) and GNIPC display a moderate positive correlation (0.508). Additionally, there is a moderate positive correlation (0.358) between FT and the percentage of households with piped water (PIPW), indicating that areas with better sanitation facilities also tend to have better water facilities.

Table 3. Correlation matrix.

	FT	PIPW	GNIPC	PEXS	PRS	POP
FT	1.000	-	-	-	-	-
PIPW	0.358	1.000	-	-	-	-
GNIPC	0.851	0.074	1.000	-	-	-
PEXS	0.525	-0.252	0.509	1.000	-	-
PRS	0.530	-0.252	0.508	0.970	1.000	-
POP	-0.113	0.225	0.020	-0.641	-0.595	1.000

Table 4. Cross-sectional dependence test.

Variables	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
PIPW	63.95***	15.58***	15.51***	7.37***
FT	137.21***	36.72***	36.66***	11.58***
GNIPC	125.67***	33.39***	33.32***	11.14***
PEXS	19.71***	2.80***	2.74***	1.68*
PRS	21.49***	3.32***	3.25***	2.92***
POP	40.93***	8.93***	8.86***	-1.87*
FTR	124.98***	33.19***	33.12***	11.05***
FTU	128.33***	34.16***	34.09***	11.23***
PIPWR	50.59***	11.72***	11.65***	6.43***
PIPWU	57.95***	13.84***	13.78***	6.72***
RPOP	54.10***	12.73***	12.66***	2.94***
UPOP	46.00***	10.39***	10.33***	3.28***

Note: *** and * denote 1% and 10% levels of significance, respectively.

Table 4 shows the cross-sectional dependence among the variables. The results from the Breusch-Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM, and Pesaran CD tests indicate a significant presence of cross-sectional dependence among the variables. This finding suggests that the water and sanitation indicators and their

determinants are not independent across provinces. It means the changes in one province are likely to influence or be influenced by changes in others. The significant test statistics $p<0.01$ and $p<0.05$ across these tests confirm the interconnectedness of water and sanitation services between different regions in Pakistan.

Table 5 shows the results based on CIPS and CADF test statistics. The results of the test statistics indicate the integration order of each variable, revealing whether they become stationary after differencing. The statistical results show that variables such as PIPW (Percentage of households with Piped Water facility), FT (Percentage of households with flush toilets), GNIPC (Gross National Income Per Capita), POP (Population Growth Rate), FTR (Percentage of households with flush toilets in rural areas), FTU (Percentage of households with flush toilets in urban areas), PIPWR (Percentage of households with piped water facility in rural areas), PIPWU (Percentage of households with piped water facility in urban areas), RPOP (Rural Population Percentage), and UPOP (Urban Population Percentage) are integrated of order one (I(1)). It means these series become stationary after their first difference is taken. On the other hand, PEXS (Percentage of provincial expenditure in aggregate expenditure) and PRS (Percentage of provincial revenue in aggregate revenue) are integrated of order zero (I(0)), indicating these variables are stationary at their level form without needing differencing.

Table 5. Unit root test statistics.

Variables	CIPS		CADF		Order
	I (0)	I (1)	I (0)	I (1)	
PIPW	0.161	-5.028***	5.838	40.636***	I(I)
FT	-0.07	-8.326***	8.588	69.851***	I(I)
GNIPC	3.225	-5.864 ***	0.589	47.552***	I(I)
PEXS	-2.883***	-9.371***	23.837***	79.830***	I(0)
PRS	-3.553***	-10.005***	27.505***	85.377***	I(0)
POP	-0.304	-9.095***	10.243	74.296***	I(I)
FTR	2.512	-8.935***	0.981	75.690***	I(I)
FTU	0.974	-7.719***	3.004	64.275***	I(I)
PIPWR	-0.624	-7.520***	7.969	62.462***	I(I)
PIPWU	3.195	-5.392***	2.058	46.173***	I(I)
RPOP	3.552	-2.509***	0.992	21.901***	I(I)
UPOP	2.286	-3.926***	2.826	32.901***	I(I)

Note: *** denotes 1% level of significance.

Tables 6 and 7 show co-integration test results based on the Westerlund co-integration test. The empirical results indicate strong evidence of co-integration among the variables. This result suggests that there are long-term equilibrium relationships in the provision of water and sanitation services across different provinces and between rural and urban areas in Pakistan. In other words, despite short-term fluctuations, the variables move together over the long run, maintaining a balanced relationship in the context of fiscal decentralization and water and sanitation service provision.

Table 6. Westerlund co-integration (Water and sanitation services).

Statistics	Model I	Model II
	FT	PIPW
	Z-Statistics	Z-Statistics
Gt	-6.213***	-5.515***
Robust Prob.	0.000	0.000
Ga	-5.843***	-5.541***
Robust Prob.	0.000	0.000
Pt	-6.891***	-5.343***
Robust Prob.	0.000	0.000
Pa	-6.784***	-5.311***
Robust Prob.	0.000	0.000

Note: *** denotes 1% level of significance.

Table 7. Westerlund co-integration (Rural-Urban water and sanitation services).

Statistics	Model III	Model IV	Model V	Model VI
	FTR	FTU	PIPWR	PIPWU
	Z-Statistics	Z-Statistics	Z-Statistics	Z-Statistics
Gt	-6.541***	-6.142***	-5.346***	-5.336***
Robust prob.	0.000	0.000	0.000	0.000
Ga	-6.463***	-5.166***	-5.899***	-5.798***
Robust prob.	0.000	0.000	0.000	0.000
Pt	-6.241***	-6.866***	-5.134***	-6.244***
Robust prob.	0.000	0.000	0.000	0.000
Pa	-6.551***	-6.812***	-5.146***	-5.226***
Robust prob.	0.000	0.000	0.000	0.000

Note: *** denotes 1% level of significance.

4.1. Regression Results: Water and Sanitation Services

Table 8 shows the PMG regression model outcomes. The empirical results highlight the dynamics between fiscal decentralization and water and sanitation services in Pakistan. In the long run, Gross National Income per Capita (GNIPC) has a significant and positive impact on both the percentage of households with flush toilets (FT) and piped water (PIPW). This finding indicates that higher income levels lead to improvements in water and sanitation infrastructure. Interestingly, the long-term impact of provincial expenditure (PEXS) and provincial revenue share (PRS) on these services is not significant, suggesting that other factors play a more critical role in long-term infrastructure development. Population growth rate (POP) has a significant negative impact on PIPW, implying that rapid population growth may strain water facilities.

Table 8. PMG regression results (Water and sanitation services).

Variable	Model I	Model II
	FT	PIPW
	Long-run coefficients	Long-run coefficients
	Coefficient	Coefficient
GNIPC	1.830*** (4.925)	0.631* (1.2098)
PEXS	-0.573 (-1.099)	-0.125 (-0.196)
PRS	-0.896 (-1.173)	-0.597 (-1.271)
POP	-0.261 (-1.517)	-0.562 *** (-2.981)
	Short-run coefficient	Short-run coefficient
C	-0.872*** (-3.193)	-0.054 (-1.309)
D(GNIPC)	1.313** (2.144)	-0.334 (-0.765)
D(PEXS)	0.123* (1.682)	0.075 (1.559)
D(PRS)	0.328 (1.625)	-0.040 (-0.269)
D(POP)	-0.019 (-0.431)	-0.031 (-0.841)
ECM (-1)	-0.344*** (-2.975)	-0.375*** (-2.771)

Note: t-statistics are in the parentheses.
***, **, and * denote 1%, 5%, and 10% levels of significance, respectively.

In the short run, the model reveals different dynamics. Changes in GNIPC have a significant positive impact on FT but not on PIPW, suggesting that income fluctuations immediately affect sanitation facilities more than water facilities. Short-term changes in PEXS and PRS show some influence, having a slight significance for FT. The

coefficient of the error correction term (ECM) is significant for both models, indicating that the system corrects towards long-run equilibrium after short-term deviations.

The significant positive impact of GNIPC on both water and sanitation services underscores the importance of economic growth for infrastructure improvement. However, the need for significant long-term effects of PEXS and PRS raises questions about the efficiency and effectiveness of fiscal decentralization in enhancing water and sanitation services. The negative impact of population growth on PIPW suggests that without adequate planning and investment, population increases could exacerbate water supply issues. The short-term results show that immediate policy changes in fiscal expenditures can influence sanitation services but not water services, highlighting a potential area for policy intervention. The significance of the error correction term across models indicates that while there are short-term fluctuations, the system tends to stabilize towards its long-term equilibrium, suggesting robust underlying relationships between the variables.

Table 9. Province-specific PMG regression results (Water and Sanitation Services).

Variable	Punjab		Sindh	
	Model I	Model II	Model I	Model II
	FT	PIPW	FT	PIPW
	Coefficient	Coefficient	Coefficient	Coefficient
C	-0.437 (-1.857)	-0.005 (-0.096)	-1.652 (-0.780)	0.014 (0.875)
D(GNIPC)	-0.090 (-0.120)	-0.291 (-0.634)	0.803*** (8.792)	-1.551*** (-13.984)
D(PEXS)	-0.046 (-0.279)	0.133 (1.329)	0.067** (3.320)	-0.065 (-1.698)
D(PRS)	0.224 (1.457)	-0.357** (-3.889)	0.183*** (11.188)	-0.111** (-3.357)
D(POP)	-0.031** (-4.014)	-0.086*** (-19.407)	0.072*** (20.877)	-0.055*** (-6.448)
ECM (-1)	-0.096*** (-33.269)	-0.077*** (74.344)	-0.288*** (-15.940)	-0.039*** (5.968)
	Khyber Pakhtunkhwa		Balochistan	
Variable	Model I	Model II	Model I	Model II
	FT	PIPW	FT	PIPW
	Coefficient	Coefficient	Coefficient	Coefficient
C	-0.562 *** (-2.901)	-0.168 (-0.143)	-0.837* (-1.930)	-0.055 (-1.116)
D(GNIPC)	2.739*** (43.794)	0.014 (0.307)	1.799*** (7.515)	0.492*** (10.079)
D(PEXS)	0.176*** (11.051)	0.091*** (4.149)	0.296**s (3.787)	0.139*** (8.397)
D(PRS)	-0.010 (-0.489)	-0.046* (-1.840)	0.913*** (15.686)	0.355*** (30.286)
D(POP)	0.020* (3.168)	0.077*** (7.599)	-0.139*** (-6.637)	-0.059*** (-12.631)
ECM (-1)	-0.086*** (-52.236)	-0.352*** (-10.398)	-0.105*** (-21.854)	-0.064*** (-35.913)

Note: t-statistics are in the parentheses.
***, **, and * denote 1%, 5%, and 10% levels of significance, respectively.

The results from PMG Regression in Table 9 at the provincial level reveal clear dynamics in water and sanitation services in Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan. The negative short-term effect of provincial revenue share (PRS) on piped water provision (PIPW) in Punjab suggests potential inefficiency or misallocation of funds. Meanwhile, population growth (POP) significantly overburdens water and sanitation services, affecting both facilities (FT) and piped water (PIPW). The large ECM coefficient indicates a strong tendency to return to long-term equilibrium, which promotes stability over time. Gross national income per capita (GNIPC) exhibits a

contradictory effect in Sindh, positively impacting sanitation (FT) but negatively affecting water services (PIPW), possibly due to prioritization issues. The positive effect of provincial revenue share (PRS) on sanitation, contrasted with its negative impact on water services, further supports this observation. For Khyber Pakhtunkhwa, both income (GNIPC) and provincial expenditure (PEXS) positively influence water and sanitation services, indicating effective resource utilization.

The significant ECM (-1) in Khyber Pakhtunkhwa also suggests robust long-term adjustment. Balochistan benefits from the positive impacts of income (GNIPC) and expenditures (PEXS) on both services, with provincial revenue share (PRS) enhancing both. However, population growth (POP) negatively impacts service provision, highlighting demographic pressures. The consistent significance of ECM (-1) across provinces indicates resilient systems that correct short-term deviations. These findings show that though fiscal decentralization (PEXS and PRS) and socioeconomic conditions (GNIPC and POP) determine the provision of services, the efficiency differs across provinces. Effective management of resources and combating population growth are essential. The findings imply that fiscal decentralization could improve services if complemented with good governance and customized provincial policies.

Table 10 shows a number of strong associations between socioeconomic indicators and the availability of flush toilets in rural (FTR) and urban (FTU) regions, as well as provincial expenditure share (PEXS) and provincial revenue share (PRS). First, there is a statistically significant positive relationship between gross national income per capita (GNIPC) and the availability of flush toilets in rural areas (FTR). This finding indicates that with an increase in income levels, the probability of having flush toilet facilities increases, especially in rural locations. Conversely, there is a negative and significant relationship between provincial expenditures share (PEXS) and rural access to flush toilets (FTR), suggesting that increased provincial expenditures share could limit access to flush toilets. Similarly, the negative and significant correlation between rural population (RPOP) and rural access to flush toilets (FTR) implies that higher rural population proportions contribute to decreased access to flush toilets. When comparing the correlation between GNIPC and flush toilets in cities (FTU), the effect of GNIPC is observed to be weaker than its influence on FTR. Several reasons, such as divergences in infrastructure development priorities and access to resources, can explain this difference. Additionally, although the negative correlation between urban population (UPOP) and flush toilet access in urban zones (FTU) is strong, its magnitude is relatively less compared to its influence on rural access (FTR). This difference could be due to the challenges involved in implementing sanitation infrastructure in highly populated urban centers.

In the short term, provincial expenditure share (PEXS) shows a positive and significant effect on rural area access to flush toilets (FTR). It reveals that more funds expended by provinces could contribute to short-term improvement in rural sanitation facilities. On the other hand, the effect of provincial revenue share (PRS) on flush toilets in urban areas (FTU) is positive but not significant. It implies that revenue allocation might not contribute to the short-term impact on urban sanitation infrastructure.

The findings present a complex relationship between socioeconomic variables and access to piped water infrastructure in both rural (PIPWR) and urban (PIPWU) settings. Firstly, there is a significant negative correlation between gross national income per capita (GNIPC) and piped water access in both environments. This indicates that as income levels increase, access to piped water declines, with this effect being more pronounced in urban areas. Conversely, provincial expenditure share (PEXS) shows a positive but statistically insignificant relationship with piped water access, suggesting that provincial funding may not substantially influence infrastructure development. Additionally, provincial revenue share (PRS) exhibits a negative association with rural piped water access compared to urban areas, implying a more complex dynamic in revenue allocation and infrastructure development, particularly in rural regions. Population distribution also plays a role; rural population growth (RPOP) correlates with reduced access to piped water in rural communities. Furthermore, an increase in urban population shares (UPOP) negatively impacts access to piped water facilities in urban communities

In the short term, the analysis highlights the contemporaneous interplay between socioeconomic factors and access to piped water facilities in rural (PIPWR) and urban (PIPWU) areas. Gross national income per capita (GNIPC) has a positive coefficient. It signifies a possible expansion of piped water coverage with income growth; the relationship is insignificant in both rural and urban settings. In a similar vein, provincial expenditure share (PEXS) and provincial revenue share (PRS) variation have negative coefficients but are not statistically significant. It indicates that short-term changes in provincial financial allocation do not strongly influence piped water coverage.

Additionally, the changes in the rural population (RPOP) demonstrate a positive and significant relationship with better piped water coverage in rural regions. It highlights the short-term advantage of demographic change. On the other hand, changes in urban population (UPOP) are not statistically significant in having any impact on piped water accessibility in cities. Interestingly, the highly significant and negative coefficients of the error correction term (ECM) reflect a strong adjustment process towards the long-run equilibrium after any departure. It reflects the robustness of the system in correcting short-run imbalances in piped water availability.

Table 10. PMG Regression Results on Rural-Urban Water and Sanitation Services.

Model III		Model IV	Model V	Model VI
FTR		**FTU**	**PIPWR**	**PIPWU**
Long-run coefficients				
Variable	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
GNIPC	1.279***	0.116**	-0.696**	-1.240***
	(3.39)	(2.258)	(-2.417)	(-9.688)
PEXS	-1.456***	-0.048	0.381	0.050
	(-3.639)	(-1.311)	(1.494)	(0.388)
PRS	0.018	-0.044	-0.364***	-0.073
	(0.036)	(-1.005)	(-2.707)	(-1.057)
RPOP	-7.900***		-4.921***	
	(-3.775)	----	(-4.621)	------
UPOP		-0.096***		-1.052***
	-----	(-3.299)	---	(-8.081)
Short-run coefficient				
C	7.472	2.742***	11.301***	2.541
	(1.413)	(3.565)	(3.023)	(1.457)
D(GNIPC)	0.621	-0.077	1.651	0.251
	(0.860)	(-0.620)	(1.442)	(0.434)
D(PEXS)	0.295*	0.011	-0.099	-0.156
	(1.793)	(0.360)	(-0.352)	(-0.955)
D(PRS)	0.254	0.031*	-0.080	-0.200
	(1.444)	(1.704)	(-0.397)	(-0.933)
D(RPOP)	1.501		3.176**	
	(0.629)	----	(2.011)	------
D(UPOP)		-0.267		0.092
	-----	(-0.994)	------	(0.117)
ECM (-1)	-0.258**	-0.692***	-0.388***	-0.234***
	(-2.391)	(-3.909)	(-3.069)	(-2.471)

Note: t-statistics are in the parentheses.
***, **, and * denote 1%, 5%, and 10% levels of significance, respectively.

The province-level analysis presented in Table 11 shows varied socioeconomic forces shaping access to water and sanitation facilities in Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan provinces of Pakistan. In Punjab, increased income is related to lower access to flush toilets in urban locations, but this association is not significant for rural locations. This result is contrary to common wisdom and emphasizes the necessity for further investigation into the subtleties of rural and urban infrastructure development in the province. Additionally, the strong negative effect of provincial revenue share on rural access to piped water reinforces the difficulty in equitable resource provision for vital services in Punjab.

In Sindh, the inverse correlation between income levels and flush toilet access in rural and urban regions indicates a cause for concern, where rising incomes might not equate to better sanitation infrastructure. On the other hand, the positive effect of provincial expenditure share on rural flush toilet access indicates the possibility of positive change through targeted financial commitment. Despite this, the large positive impact of provincial revenue share on urban access to flush toilets poses questions regarding the efficiency and fairness of resource allocation and calls for a closer look at Sindh's urban infrastructure investment policies.

While in Khyber Pakhtunkhwa, the positive relationship between income levels and access to flush toilets in both rural and urban regions indicates advancements in sanitation infrastructure development, the negative relationship with provincial expenditure share reflects the complexity of resource distribution in determining infrastructure outcomes. The remarkable role of provincial revenue share on access to flush toilets also shows the paramount importance of fiscal policies in influencing sanitation infrastructure in Khyber Pakhtunkhwa.

In Balochistan, the strong correlation between income levels and access to piped water highlights the value of economic development for enhancing access to basic services. The strong positive effect of provincial expenditure share on both rural and urban access to piped water indicates the crucial role played by focused financial inputs in resolving water infrastructure issues. Nevertheless, the strong influence of provincial revenue share over piped water access poses questions regarding the efficiency of revenue allocation systems in Balochistan, calling for policymakers to review resource reallocation policies in ensuring the fair development of water infrastructure.

4.2. Robustness Check

Furthermore, to check the consistency of empirical findings, researchers employed a robustness check by creating a fiscal decentralization dummy. The results obtained from the robustness analysis are almost consistent with previous empirical findings. Table 12 presents the results of the robustness check, where a fiscal decentralization (FD) dummy variable equal to 1 for years with decentralization and 0 otherwise—was introduced to validate the consistency of the main findings. The results confirm the robustness of the earlier analysis. Specifically, fiscal decentralization positively and significantly affects access to piped water in the short run, as shown by the significant coefficient in Model II. However, in Model I, the FD dummy has a significant negative effect on access to sanitation services (flush toilets) in the long run, aligning with prior results. These findings indicate that while decentralization enhances water service delivery in the short term, its long-term influence on sanitation may be limited or uneven across regions.

Table 13 presents province-specific results of the robustness check using the FD dummy variable. The findings reveal notable variation in the impact of fiscal decentralization across provinces and between water and sanitation services. In Punjab and Sindh, FD has a significant negative effect on both flush toilet and piped water access. It suggests that decentralization may not have translated into improved service delivery in these provinces.

In contrast, results for Khyber Pakhtunkhwa and Balochistan show a more nuanced picture.

FD negatively affects sanitation access in both provinces. It has a significant positive impact on water services, particularly in Khyber Pakhtunkhwa. These findings reinforce the earlier conclusion that fiscal decentralization has contributed more to improvements in water services than in sanitation, though the effects are uneven across regions. This provincial disaggregation highlights the importance of local governance capacity and implementation effectiveness in shaping decentralization outcomes.

Table 11. Province-specific results on rural-urban water and sanitation services.

Punjab					Sindh			
Variable	Model III	Model IV	Model V	Model VI	Model III	Model IV	Model V	Model VI
	FTR	FTU	PIPWR	PIPWU	FTR	FTU	PIPWR	PIPWU
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
C	0.035 (0.056)	3.137*** (6.024)	4.368 (0.707)	-0.42 (-0.568)	22.78 (0.432)	4.495*** (4.944)	12.187 (0.501)	0.876* (2.96)
D(GNIPC)	0.836 (1.561)	-0.223*** (-19.971)	5.008 (0.946)	1.738 (1.338)	-1.481* (-2.802)	-0.340 *** (-30.968)	1.167 (0.217)	-1.039** (-5.697)
D(PEXS)	-0.04 (-0.397)	-0.047** (-21.06)	0.547 (0.633)	-0.644* (-2.856)	0.599*** (9.071)	0.010*** (8.977)	-0.786 (-0.975)	-0.004 (-0.195)
D(PRS)	0.324* (3.492)	-0.008*** (-4.135)	0.018 (0.023)	-0.839** (-4.068)	-0.048 (-0.573)	0.037*** (30.117)	-0.571 (-0.648)	0.059* (2.616)
D(RPOP)	1.691 (0.806)	-----	7.102 (0.537)	------	7.972 (0.73)	------	-0.105 (-0.001)	-----
D(UPOP)	-----	-0.199*** (-45.857)	-----	-1.091* (-2.863)	-----	-0.923*** (-9.031)	-----	-2.335 (-0.871)
ECM (-1)	-0.332*** (-2.574)	-0.756*** (-27.733)	-0.151*** (-21.689)	-0.350*** (-5.369)	-0.795*** (-28.551)	-1.061*** (-29.4)	-0.449*** (-17.963)	-0.085*** (-30.209)
Khyber Pakhtunkhwa					**Balochistan**			
Variable	Model III	Model IV	Model V	Model VI	Model III	Model IV	Model V	Model VI
	FTR	FTU	PIPWR	PIPWU	FTR	FTU	PIPWR	PIPWU
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
C	0.823 (0.755)	0.784*** (5.404)	7.235 (0.495)	2.184 (1.797)	6.248 (0.534)	2.554*** (5.635)	21.414 (0.91)	7.525*** (4.165)
D(GNIPC)	1.647** (3.845)	0.205*** (8.93)	-0.009 (-0.012)	-0.084 (-0.325)	1.482* (2.9)	0.05 (1.115)	0.438*** (8.689)	0.388*** (14.327)
D(PEXS)	0.066** (4.635)	-0.015*** (-20.487)	0.103** (4.239)	0.014 (1.784)	0.554** (4.77)	0.096*** (13.477)	-0.261*** (-14.332)	0.012* (2.598)
D(PRS)	0.018 (1.168)	0.016*** (19.915)	-0.169*** (-6.208)	-0.036** (-4.129)	0.721*** (7.402)	0.079*** (14.368)	0.400*** (35.985)	0.017*** (4.709)
D(RPOP)	-0.378 (-0.72)	------	-1.522 (-1.657)	------	-3.281 (-0.135)	-----	4.184 (1.109)	-----
D(UPOP)	-----	0.145*** (19.91)	----	0.028 (0.42)	-----	-0.489 (-2.745)	-----	-0.904*** (-10.293)
ECM (-1)	-0.025*** (-24.288)	-0.209*** (-19.824)	-0.235*** (-17.187)	-0.198*** (-19.241)	-0.211*** (-30.309)	-0.740*** (-22.535)	-0.717*** (-38.375)	-0.691*** (-38.494)

Note: t-statistics are in the parentheses.
***, **, and * denote 1%, 5%, and 10% levels of significance, respectively.

Table 12. Aggregate water and sanitation services.

Model I		Model II
FT		PIPW
Long-run coefficients		Long-run coefficients
Variable	Coefficient	Coefficient
GNIPC	1.342*	1.849**
	(2.882)	(1.993)
POP	0.434***	0.003
	(2.937)	(0.007)
FD	-0.154***	0.028
	(-4.766)	(0.601)
Short-run coefficient		Short-run coefficient
C	-1.346*	0.011
	(-2.281)	(0.071)
D(GNIPC)	0.204	1.334**
	(0.519)	(2.581)
FD	-0.066	0.361*
	(-0.435)	(1.903)
D(POP)	-0.084	-0.039
	(-1.347)	(-0.875)
ECM (-1)	-0.193**	-0.101***
	(-2.337)	(-7.744)

Note: t-statistics are in the parentheses.
***, **, and * denote 1%, 5%, and 10% levels of significance, respectively.

Table 13. Province-Specific Rural-Urban Water and Sanitation Services.

	Punjab		Sindh	
	Model I	Model II	Model I	Model II
	FT	PIPW	FT	PIPW
Variable	Coefficient	Coefficient	Coefficient	Coefficient
C	-0.625**	0.358	-2.102*	0.191
	(-3.202)	(0.538)	(-1.843)	(0.194)
D(GNIPC)	1.023*	-0.002	-0.797***	1.136***
	(2.783)	(-0.002)	(-5.096)	(17.312)
D(POP)	-0.146***	-0.060***	-0.217***	0.035***
	(-46.466)	(-7.879)	(-22.482)	(8.080)
FD	-0.208***	-0.069***	-0.211***	-0.009***
	(-67.897)	(-24.085)	(-44.979)	(-5.251)
ECM (-1)	-0.089***	-0.076***	-0.311***	-0.103***
	(-41.489)	(-25.773)	(-17.482)	(-16.914)
Khyber Pakhtunkhwa			Balochistan	
	Model I	Model II	Model I	Model II
	FT	PIPW	FT	PIPW
Variable	Coefficient	Coefficient	Coefficient	Coefficient
C	-2.569	-0.185	-0.086	-0.319
	(-1.700)	(-0.106)	(-0.505)	(-0.427)
D(GNIPC)	0.009	2.421***	0.581***	1.779***
	(0.214)	(33.381)	(12.027)	(6.690)
D(POP)	0.069***	0.025***	-0.042***	-0.158***
	(12.090)	(4.631)	(-10.683)	(-7.265)
FD	-0.120***	0.151***	-0.081***	0.039***
	(-42.931)	(41.951)	(-57.334)	(3.194)
ECM (-1)	-0.354***	-0.137***	-0.017***	-0.089***
	(-24.838)	(-40.066)	(-5.863)	(-17.673)

Note: t-statistics are in the parentheses.
***, **, and * denote 1%, 5%, and 10% levels of significance, respectively.

Table 14 presents the robustness analysis using disaggregated rural and urban data. The researchers examine the impact of fiscal decentralization on water and sanitation services using the decentralization dummy. Models III

and IV analyze flush toilet access in rural (FTR) and urban (FTU) areas, while Models V and VI assess piped water access in rural (PIPWR) and urban (PIPWU) areas.

The results reveal that fiscal decentralization has a significant negative long-term effect on rural sanitation, while its impact on urban sanitation is negative but statistically insignificant. Conversely, FD positively and significantly influences rural piped water access, while its effect on urban piped water is positive but not significant in the long run. In the short run, FD shows a small but statistically significant positive effect only in the urban water model. It suggests that short-term gains in urban water services are.

These demonstrate that the effectiveness of fiscal decentralization varies between rural and urban settings. It has relatively stronger benefits observed in rural water supply. However, the negative or insignificant impact on sanitation in rural areas highlights a critical policy gap that needs targeted interventions to ensure equitable service delivery.

Table 14. Rural-Urban decomposition of water and sanitation services.

	Model III	Model IV	Model V	Model VI
	FTR	FTU	PIPWR	PIPWU
Long-run coefficients				
Variable	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
GNIPC	3.195***	1.028***	0.840*	0.306**
	(5.946)	(4.774)	(2.678)	(5.671)
FD	-0.159***	-0.066	0.202**	0.002
	(-3.337)	(-1.357)	(2.116)	(0.280)
C	-28.191*	0.995*	10.048	0.992*
	(-2.024)	(2.290)	(1.592)	(2.011)
Short-run coefficients				
D(GNIPC)	1.526	-0.108	0.459	0.028
	(1.211)	(-0.195)	(0.746)	(0.163)
FD	-0.132	-0.263	0.147	0.038**
	(-0.493)	(-1.486)	(1.261)	(2.470)
D(RPOP)	-0.053	-0.292	1.305	-0.081
	(-0.043)	(-0.796)	(0.908)	(-0.289)
ECM (-1)	-0.481*	-0.405**	-0.385*	-0.347**
	(-2.044)	(-3.031)	(-1.564)	(-2.113)

Note: t-statistics are in the parentheses.
***, **, and * denote 1%, 5%, and 10% levels of significance, respectively.

Table 15 presents a province-wise robustness analysis using rural-urban disaggregated models. The study assessed the impact of fiscal decentralization on sanitation (FTR, FTU) and water services (PIPWR, PIPWU). The findings indicate significant variation across provinces. In Punjab and Sindh, FD has a significant negative impact on rural sanitation but a positive and significant effect on rural piped water. Notably, FD also shows small but significant negative effects on urban piped water in both provinces. It indicates the limited decentralization benefits in urban water provision.

In Khyber Pakhtunkhwa, FD negatively affects both rural and urban sanitation but positively influences rural piped water access. In contrast, Balochistan shows a clear divergence, where FD negatively impacts sanitation access but significantly improves piped water access in both rural and urban areas. This result indicates that FD has a positive effect on rural water services.

The findings align with previous research: fiscal decentralization appears more effective in improving water service delivery, particularly in rural areas, than in sanitation services, which remain negatively and insignificantly across most provinces. These results demonstrate the heterogeneous performance of decentralization, emphasizing the need for region-specific strategies and improved institutional capacity to translate fiscal autonomy into effective service delivery.

Table 15. Province-specific rural-urban decomposition of water and sanitation services.

Punjab					Sindh			
Model III		**Model IV**	**Model V**	**Model VI**	**Model III**	**Model IV**	**Model V**	**Model VI**
FTR		**FTU**	**PIPWR**	**PIPWU**	**FTR**	**FTU**	**PIPWR**	**PIPWU**
Variable	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
C	-48.882	0.562	-1.651	1.203***	-55.410	2.142	26.155	2.282***
	(-0.219)	(1.556)	(-0.443)	(7.275)	(-0.222)	(1.775)	(0.576)	(5.043)
D(GNIPC)	5.084	1.461	0.654	-0.229***	1.412	-1.086***	-1.243*	-0.289***
	(1.439)	(1.714)	(1.150)	(-16.034)	(0.331)	(-8.586)	(-2.613)	(-18.261)
D(RPOP)	-3.686	0.049	3.225	0.171***	1.680	-1.345	4.176	-0.919***
	(-0.167)	(0.120)	(0.709)	(26.529)	(0.015)	(-0.429)	(0.366)	(-6.278)
FD	-0.300***	0.065***	0.087***	-0.003***	-0.106**	-0.117***	0.219***	-0.010***
	(-6.157)	(5.201)	(10.526)	(-12.793)	(-3.226)	(-94.013)	(25.996)	(-78.336)
ECM (-1)	-0.801***	-0.384***	0.058***	-0.411***	-0.966***	-0.538***	-1.026***	-0.774***
	(-27.745)	(-17.726)	(13.369)	(-22.152)	(-24.363)	(-21.944)	(-30.042)	(-23.216)
Khyber Pakhtunkhwa					**Balochistan**			
Model III		**Model IV**	**Model V**	**Model VI**	**Model III**	**Model IV**	**Model V**	**Model VI**
FTR		**FTU**	**PIPWR**	**PIPWU**	**FTR**	**FTU**	**PIPWR**	**PIPWU**
Variable	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
C	-1.863	1.144	1.851	0.037	-6.608	0.134***	13.838	0.445***
	(-0.375)	(1.230)	(0.449)	(1.259)	(-0.575)	(12.720)	(0.631)	(3.869)
D(GNIPC)	-0.667	-0.656***	1.701**	0.210***	0.274*	-0.153***	0.725	0.419***
	(-0.782)	(-3.370)	(3.872)	(8.033)	(2.996)	(-6.872)	(1.772)	(8.527)
D(RPOP)	1.220	0.326***	-0.263	0.223***	0.574	-0.198*	-1.917	0.201
	(1.091)	(6.159)	(-0.455)	(28.699)	(0.093)	(-2.387)	(-0.109)	(0.969)
FD	-0.131***	-0.159***	0.037***	-0.006***	-0.098***	-0.053	0.463***	0.029***
	(-18.752)	(-81.450)	(8.495)	(-17.687)	(-38.082)	(-134.169)	(27.288)	(12.153)
ECM (-1)	-0.035***	-0.657***	-0.063***	-0.010**	-0.123***	-0.041***	-0.508***	-0.193***
	(-21.292)	(-22.652)	(-13.219)	(-2.170)	(-32.949)	(-34.436)	(-39.961)	(-9.245)

Note: t-statistics are in the parentheses.
***, **, and * denote 1%, 5%, and 10% levels of significance, respectively.

5. CONCLUSION

The decentralized government framework ensures effective provision of public services and goods so that inequality at the individual household or regional rural-urban levels is decreased. The research explores the role of fiscal decentralization in improving the availability of enhanced water and sanitation facilities based on provincial-level and urban-rural-level data in Pakistan. The empirical results showed mixed results for the provincial revenue and expenditure on total water and sanitation services and rural-urban decompositions across the provinces. The analysis done by using the PMG Regression Model on water and sanitation services in Pakistan provides important information on the relationship between fiscal decentralization and socioeconomic determinants of water and sanitation. In the long term, Gross National Income per Capita (GNIPC) is found to be a strong catalyst for water and sanitation infrastructure improvement, underscoring the critical influence of economic growth on the quality of access to basic services. On the other hand, the effect of provincial expenditure (PEXS) and provincial revenue share (PRS) on these services in the long run is shown to be non-significant, indicating that the effects of other determinants are possibly more predominant for long-term infrastructure development.

The short-term dynamics demonstrated complex interactions among socioeconomic factors and the coverage of water and sanitation facilities. While GNIPC changes significantly influence flush toilet facilities (FT), their effect on piped water facilities (PIPW) is not observed, reflecting differential responses to income variations by infrastructure types. Short-run PEXS and PRS changes have modest significance for FT, indicating that policy interventions are feasible in the short term to impact sanitation services. The significance of the error correction term (ECM) further indicates the system's tendency to converge towards long-term equilibrium amid short-term volatility, highlighting strong underlying relationships between variables. The provincial analysis reveals differential dynamics across Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan.

In Punjab, the issue of resource mobilization for public services in an equitable manner is highlighted by the strong negative association of provincial revenue share with rural access to piped water. In Sindh, the inverse correlation of income levels with flush toilet access questions the efficiency and equity of resource allocation, specifically at the urban level. Khyber Pakhtunkhwa shows improvement in the development of sanitation infrastructure. However, the inverse relationship between provincial expenditure share and flush toilet accessibility indicates resource allocation complexities. Balochistan points to the possible advantages of economic development in enhancing access to basic services, but with problems in the mechanisms of distributing revenue.

5.1. Policy Implications

The study presents particular policy recommendations for every province in Pakistan. For Punjab, policymakers need to focus on investments in rural water networks to mitigate inequalities in access, particularly with the severe adverse effect of provincial revenue share (PRS) on rural piped water access (PIPWR). Moreover, effective policies for population management are needed to mitigate pressure on infrastructure, given the severe pressure on both water and sanitation services (FT and PIPW) owing to population growth (POP).

In Sindh, investments in urban infrastructure for enhancing sanitation facilities need to be given priority, given the inverse relationship between urban sanitation access and income levels (FTU). Reconsidering mechanisms of distribution for provincial revenue share (PRS) will enable the distribution of resources more evenly, specifically for developing urban infrastructure.

In Khyber Pakhtunkhwa, although efficient use of resources can be observed, judicious resource allocation is necessary to maximize infrastructure results, particularly concerning the detrimental effect of provincial expenditure share (PEXS) on access to sanitation. Population growth (POP) policies should be further developed to prevent their negative impacts on infrastructure, primarily water supply services.

In Balochistan, policy efforts must be aimed at improving rural water access (PIPWR) to support proportional infrastructure development, as well as guaranteeing transparency and economy in resource allocation procedures due

to the profound effect of provincial revenue share (PRS) on infrastructure. These province-specific policy implications highlight the necessity for special strategies to overcome regional disparities and utilize local socioeconomic forces towards proportional and sustainable water and sanitation infrastructure development in Pakistan.

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