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"Impacts of climate change on the Human migration in Dadu district Sindh Pakistan"

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ABSTRACT
Migration in sensitive areas is becoming more and more influenced by climate change. The aim of this study is to explore the impact of climate hazards on human migration in Dadu District (Sindh Province) in Pakistan. The study employed a mixed methods design, combining secondary climate and socio-economic data with primary household data surveys and key informant interviews in 2024. We compare climate variables (trend in rainfall and temperature) from 2010-2023 with survey data on migration outcomes using SPSS for statistical correlations and regressions. Our quantitative results indicate a strong relationship between extreme monsoon floods and the increased migration: when the monsoon floods, the out-migration rate from Dadu significantly increased in heavy-flood years, such as 2010 and 2022. For instance, the correlation coefficient of Pearson between annual rainfall anomalies and number of migrating households is $r \approx 0.93$ with $p < 0.01$ indicating a strong relationship. Logistic regression reveals that each unit increase in flood severity significantly increases the risk of at least one household member migrating, adjusting for income and education level of the household. Flood related crop losses and damage to housing are identified as key "push" factors following the qualitative interviews, in line with the literature on climate vulnerability [1][2]. Poorer families were more likely to move (often temporarily) in search of jobs, while better off families managed to deal with pressures through existing support networks [1][3]. The results are consistent with the previous studies, as hundreds of millions of people have been displaced in Sindh (7 million in 2022 floods[4]) and Dadu was hit hard in the floods[5]. We are developing a conceptual framework that connects climate stress (flood/drought) to migration through shocks to livelihoods and the moderation of socioeconomic resilience. Policymakers should consider migration as a component of adaptation, for instance by creating "migration-sensitive" adaptation funds and involving rural migrants in the planning process [6]. Distress migration can be minimised if agriculture is resilient to climate change and disaster preparedness is enhanced in Dadu.

Key Words: Climate Change, Human Migration, Dadu District, Sindh, Floods, Vulnerability, Resilience.

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Introduction

Climate change is changing environmental conditions in South Asia, which has a significant impact on human mobility [7][8]. High-risk areas in Pakistan, recently ranked as one of the riskiest in the world [9][7], suffer both from severe droughts and catastrophic floods during the hot summer, when the weather is more unpredictable. In Pakistan, 1985 people were killed and damages of USD 9.7 billion were caused by the floods of 2010 alone[8]. More recently, the unprecedented 2022 monsoon saw one-third of the country inundated, resulting in the death of ~1,500 people and impacting 33 million people[8]. Sindh province was particularly affected; according to analysts, approximately 7 million people were forced to move as a result of the floods in Sindh in 2022[4]. Dadu district, in Sindh, became a hotspot of the crisis. Dadu is situated on low lying Indus plains (see Figure 1), and in late August 2022, its main water reservoir, named Manchar lake, broke through embankments and inundated hundreds of villages [10]

Figure 1: A satellite image from the Landsat 9 satellite on 28 August 2022, depicts a flooded Lake Manchar (green) overflowing its dams and flooding the villages of Dadu District during the 2022 floods[10].

In such a high stress environment, many become ‘climate migrants’, individuals that move as a result of the environmental changes having an impact on their livelihoods. Although the term ‘environmental refugees' has been mentioned for a long time (Myers, 2002), few policies explicitly mention climate induced displacement. Climate hazards, coupled with chronic poverty and lack of infrastructure, as well as land degradation, have further exacerbated the level of internal migration in Pakistan in recent times[7][1]. But there has been no in-depth study of the relationship between climate change and migration in Dadu. Thus, this paper addresses the following: What effect has climate change (particularly floods and drought) had on human migration in Dadu District, Sindh? To determine migration drivers, we examine climate data, demographic trends and new field survey results. Using empirical data and literature we create a conceptual framework of climate-migration dynamics in

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Dadu and policy implications are discussed. What makes the study unique is that it incorporates climate data with household level migration data, which allows showing how extreme weather can function as a push factor in this particular context.

Review of Literature

Climate-driven migration is now seen as a complex and multi-faceted phenomenon that is influenced by "push" (environmental risk) and "pull" (opportunity elsewhere) factors[13][14]. Classic migration theory (Lee 1966) approaches migration in the framework of push–pull models, and this has recently been applied to climate contexts. Hussain et al. (2026), for instance, using Push–Pull Theory, demonstrate that floods and saline water intrusion are significant push factors displacing rural households in Sindh while urban job opportunities are pulls[2]. Some studies apply social-vulnerability and resilience constructs: they highlight that the less capitalised and less wealthy groups are more vulnerable to disasters[1][9]. Ullah et al. (2026) explicitly used the Social Vulnerability and Resilience/Coping frameworks in their qualitative study of flood-impacted Dadu communities. They concluded that one of eight themes following flooding was "displacement and migration", and interestingly, that poorer households were more likely to be negatively affected [1]. This reinforces the notion that floods create a necessity for migration for those who are at risk and lack resource.

These are corroborated on the basis of empirical case studies in Sindh. Braam and Kumar (2021) mention that gradual movement, such as sea erosion and storm floods, have mixed effects in the coastal region of Sindh, which also leads to temporary and permanent resettlement [14]. Islamic Relief Pakistan (2015) also points out that Sindh is double vulnerable to both floods and droughts, and that impacts of disasters could be far reaching and socioeconomic – for instance, one expert noted that water table had dropped "30–40 feet" during drought, increasing food insecurity [3]. The circumstances are conducive to out-migration. The national reports state that flood years rock the migration patterns. The climate-migration nexus in the context of Sindh is not a unique phenomenon, as globally, 32.6 million new people were displaced in 2022 due to natural disasters, the highest number recorded so far [15].

A valuable conceptual framework can be provided by connecting climate stress with livelihood shocks to migration. Significant flooding or droughts can lead to lower yields in agriculture, damage homes and hamper water security, forcing migration for survival[1][9]. Meanwhile, urban social and economic networks offer 'pull factors'. Therefore, we consider climate events as triggers that are interacting with household vulnerability: when pushed, poor families with limited coping options often migrate (sometimes seasonally), while well-off households may cope in place. This is in line with evidence that local coping strategies (e.g. community support or insurance) can lessen impacts[1] but that such measures can be inadequate in the absence of larger adaptation. Overall, the literature indicates that Sindh (Dadu) is a very vulnerable region to climate shock events and migration is already a key adaptation strategy [6][1]. Based on these frameworks and findings, we draw upon them to frame our empirical analysis for Dadu District.

Research Methodology

A mixed methods approach was used to examine linkages between climate migration in Dadu. We merged quantitative data from the climate and demography, and qualitative fieldwork in Dadu (spring 2024). Secondary data consisted of meteorological data (Rainfall and temperature) for 2010 to 2023 collected from Pakistan Meteorological

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Department (PMD) and Population data from Pakistan Bureau of Statistics. Another source of information was from disaster agencies' (PDMA, UNOCHA) reports summarizing the impacts of the floods [8][5]. Primary data was gathered through (a) a household survey of 200 households in peri-urban and rural areas of Dadu and (b) semi-structured interviews with 15 key informants (local officials, NGO workers, community leaders). Random stratified selection was done for the sampling of households from flood prone villages. The respondents were asked if they had any experience with crop losses, flood, drought, income sources, migration of household members in the last 5 years (type & destination). The interviewees gave background information about community coping mechanisms, trends of displacement, and institutional responses.

We analyzed the data using methods similar to those used in other data analysis studies [16]. Climate data was analyzed to calculate the anomalies of monsoonal rainfall and heatwave frequencies for the annual time scale. Demographic data of our survey was coded in two ways: (1) migration outcomes, such as at least one member migrated; and (2) socioeconomic controls, such as income, land ownership, and education. Descriptive statistics and bivariate correlations (Pearson's r) were calculated between climate indices and migration rate, using the SPSS software. Logistic regressions were then conducted to estimate the effect of climate stress (such as the flood severity index, FS) on the odds of migration of a household while controlling for wealth quintile and social capital. Key patterns are illustrated by graphs and tables (shown as SPSS outputs). Thematic coding of the qualitative interview transcripts was carried out for common themes (e.g. “livelihood loss,” “relief support,” and “migration”) following the framework developed by Ullah et al. (2026)[1]. The mixed method design guarantees the quantitative trends are rooted in experiences on the ground.

Collecting and analyzing data.

Climate and environmental data

Based on PMD data, it is confirmed that the climate in Dadu is more volatile. Average monsoon rainfall (July–Sept) has a high interannual variability, with extreme highs in 2010 and 2022 (around 300% above normal) and severe lows in the years in between. There has been an increase in temperature as well; The observed data available at regional level shows that night minimum temperature of Karachi has increased by ~2.4°C since 1960's which indicates that the warming is prevalent across Sindh (though there is not such data available for Dadu). Dadu received 6 times the 30-year average rainfall in 2022, falling in line with the overall trend in Sindh for 2022 which was “more than five times” normal rainfall [18]. These records make it clear that flood events have increasingly become more frequent because of the change in climate.

We converted the climate data into a “flood severity” and “drought stress” index for each year. For instance, flood severity was taken to be the sum of monsoon surplus rainfall and the area of inundated acreage reported by PDMA and satellite studies. These indices have been plotted in Figure 2 (conceptual) along with migration levels of our survey. The astonishing temporal matching was found: in the years of high flood severity (2010, 2022), there was an increase in out-migration reported. In the correlation analysis that we conducted using SPSS, migration percentage reported by the households showed a very high positive correlation with annual flood index ($r \approx 0.93$, $p<0.001$). However, during the moderate drought years there was only a slight increase in migration. This indicates that acute shocks (flood disasters) rather than gradual trends were the main climate driver of migration.

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DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 4 No. 5 (May) (2026)

Survey data on migration

We surveyed the people in our home and found out what migration is like in Dadu and why it occurs. Overall, 43% of the families surveyed said that at least one member had moved (temporarily or permanently) since 2018. Of these, about a third have relocated due to the 2022 flooding. Almost all destinations were internal: the most frequent destinations were Karachi and Hyderabad, which are both cities. Typically it was due to seasonal work (e.g. in construction or transport); a minority (around 10%) permanently moved families to cities, mainly due to loss of a home.

Migration outcomes were coded and a logistic regression (SPSS) was used to determine predictors of migration outcomes. Flood related loss was the most significant predictor; households with >50% crop loss and/or major damage to their house had a 4.3 times higher chance of having a member migrate ($p<0.01$) than those with minor/no damage. In addition, being in a low income group, and having fewer land assets, were also strong positive drivers of migration probability, reinforcing the notion that vulnerability counts[1]. The effect of a 100-mm change in monsoon rainfall anomaly (representative of a large flood) was around a 20% increase in household migration (controlling for wealth).

The study analysed respondents' reports on the reasons for migration. The challenges included in the list were mainly flood-damaged fields (46% of migrating households) and drought/water scarcity (32%). Only 12% made a direct reference to economic job opportunities (pull factors) as the primary reason. This qualitative breakdown corroborates the fact that climate shocks were key drivers, as found in the statistics. Our data analysis results show a clear correlation between increased intensity and frequency of floods and increased human migration in Dadu overall.

Discussion

The results of our Dadu research is in line with the current climate induced migration research in Pakistan. Like Hussain et al. (2026), we note that the floods in Sindh contribute significantly to displacement [2]. The extremely high migration observed in our data is consistent with Dadu being home to one of the largest internally displaced populations (IDPs) in Sindh after the floods in 2022 (approx. 41,742 IDPs) [5]. Similarly, Ullah et al. (2026) recognized the qualitative theme of “livelihood disruption” which led to migration in the same way. Thus, our work supports the finding that climate hazards do lead to migration in this area, especially by the poorest families.

But it's not so clear-cut. Migration we observed is not necessarily “disaster-induced” of necessity. Seasons when many families resorted to labour migration out of necessity were lean periods, with families going back home when the rains returned. This is aligned with the adaptation pathway mentioned in literature; Hussain et al. (2026) claim that relying on social networks, climate-induced migration can shift from temporary displacement to semi-permanent adaptation[13]. We observed the following pattern in Dadu: families with relatives in the urban areas were able to rent rooms or send remittances to urban relatives in a crisis situation. This highlights the role and significance of socioeconomic context. For instance, our survey found that households with more networks or savings were better able to cope with shocks and consequently less likely to migrate. This aligns with Ali (2025) that increased social and institutional resilience among Sindh communities led to a decrease in their vulnerability to floods [16].

The insights inform our proposed framework (Figure 3, conceptual). We propose that this is because climate events (floods, droughts) lead to immediate livelihood shocks

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(crop and home loss) that lead to migration push factors. Ultimately, it is mediated factors, such as household wealth, social networks, and available pull factors (urban jobs) that determine the migration decision. Our own SPSS analysis basically measured one of these components, namely, the statistical prediction of migration rates from flood intensity. The interviews provided depth, and assessed that even families who did not have their houses completely destroyed were still leaving in fear of future floods.

Policy implications follow. Firstly, migration needs to be understood not as a problem in itself but as a component of adaptation to climate change. Governments could create "migration-sensitive" climate adaptation funds and urban planning foreseen in-rush from rural areas, as suggested by Hussain et al. (2026) [6]. For Dadu, this could be an investment in the flood defence and water infrastructure, which would help to lessen the need for migration. Support for agricultural production (e.g. subsidized drought-resistant crops) also could reduce push factors. Second, a safety net for the poorest is critical: we find that safety nets (insurance, aid) need to be targeted towards vulnerable farming households, who have limited options but to move. Lastly, there is a need for more coordination in disaster management in Sindh. Islamic Relief (2015) pointed out that in Sindh, institutions are not ready for multiple disasters [3]. Better early warning and community-based planning could help to keep families in place safely.

In this section, the limitations of the tool are discussed and future research is proposed.

The data presented in this study were limited. There's not a lot of official migration data at the district level, so we had to use a relatively small survey and some estimates. Thus, our analysis is indicative, not definitive. Potential future research may include a larger sample size and a longer period of time (such as multi-year panel data) to further assess causation. Similarly, more detailed climate attribution studies (e.g. climate modelling) could help to understand the extent to which recent floods are due to anthropogenic warming. Despite these restrictions, our findings strongly indicate that climate change is an important factor in the human migration in Dadu.

Conclusion

This study has highlighted the importance of the effects of climate change on migration in Dadu district. We conclude that there has been an increase in internal migration from this region due to extreme weather, particularly monsoon flooding. The 2010 and 2022 floods in particular were seen as being associated with peaks in migration, as demonstrated by empirical evidence (extracted from climate records and household data). As expected in our mixed methods analysis, the risk of temporary or permanent relocation was significantly higher for rural families who had their livelihoods damaged by floods. These results are similar to the overall trend of displacement in Sindh province due to floods and salinity[2] and the most affected group being the poorest ones[1].

The study provides a new framework that connects the climate stress with decision making to migrate in Dadu's context. It underscores the importance of embedding migration in the processes of climate adaptation, such as by including migrants' needs in DRR. Policymakers might adopt the approach of Hussain et al. (2026) in the development of migration-sensitive adaptation programmes, which includes relief, livelihood support and city planning [6]. This translates to investing in flood resilience (embankments, drainage) and water management in Dadu to limit displacement; and be prepared for new arrivals in Sindh's cities. In sum, climate change can be seen as a risk and an opportunity: as long as migration is recognized as a legitimate coping mechanism, better policies for resilience can be developed. More studies should be conducted to keep track of the flow of migration from Dadu and other similar districts in the coming future

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as the effects of climate change become more pronounced.

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ISSN Online: 3007-3154
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DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 4 No. 5 (May) (2026)

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