

Assessing the Effects of Climate Change on Population Displacement and Migration Patterns in Coastal Communities

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Abstract

One of the biggest global issues influencing migration patterns is climate change, especially in coastal regions that are susceptible to flooding, extreme weather, and sea level rise. With its vast coastline and varied climate, Pakistan is confronted with serious climate-related migration problems, particularly in Karachi, Thatta, Gwadar, Badin, and Muzaffargarh. The purpose of this study is to look into how migration patterns in these five specific Pakistani regions are affected by climate change. The study aims to offer a localized understanding of how climate change influences population mobility by analysing socioeconomic and climatic aspects. Data was collected from 350 people in these regions using a cross-sectional survey design. A systematic online questionnaire was used to collect data, and stratified random sampling was used to guarantee representation from every region. Multiple linear regression, logistic regression, and structural equation modelling (SEM) were among the statistical studies. This study discovered a high positive correlation between migratory patterns and climate change variables, such as flooding, temperature rises, and sea level rise. The likelihood of migration was influenced by indirect socioeconomic factors as well as direct effects of climate change. The SEM analysis showed that the association between migration and climate change is somewhat mediated by climate awareness. In conclusion, migration in Pakistan's coastal villages is greatly influenced by climate change, with both the direct environmental effects and the socioeconomic circumstances being important factors. Comprehensive adaption plans and increased climate knowledge are crucial. Climate resilience should be the main emphasis of policy through early warning systems, infrastructure upgrades, and socioeconomic assistance initiatives. Enhancing economic and educational possibilities is essential for managing climate-induced migration and fostering community resilience.

Keywords: Climate Change; Migration Patterns; Coastal Communities; Sea Level Rise; Socio-Economic Factors.

I. INTRODUCTION

As is now clear from observations of rising global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level, the climate system is unquestionably warming. This could cause irreversible damage to the earth system, with the effects being most severe in the tropics, which are primarily found in developing nations (IPCC

2007a) (Warner et al., 2010). Global mean temperatures rose by 0.74o C between 1991 and 2005, according to an analysis of the instrumental climate record for the previous century (Solomon et al 2007). However, the trend has not been unfirming, with warming primarily occurring after 1975 and between 1920 and 1945 (Cuff and Goudie 2009). Human activity has probably had a noticeable effect on the warming trends that have been seen (Schneider and Lane 2006). During the period of fast industrialization and population growth, there is a strong association between rising global temperatures and rising quantities of carbon dioxide and other greenhouse gases (GHGs)(Bardsley & Hugo, 2010). Exploration of the instrumental record thus shows that temperatures are rising, and that they are rising at a decreasing rate.

Future changes must be estimated in order to forecast the climate of the twenty-first century and beyond (Goose 2010). To determine the extent and rate of sea-level change brought on by causes connected to global warming, climate model simulations are frequently used (Maldonado et al., 2013). In this regard, the IPCC created a number of "alternative" futures (scenarios) discussing how different socioeconomic and technical elements may affect future emissions and climate change in order to address the uncertainties surrounding climate system dynamics and future GHG emissions. In general, they are categorized as scenario families A1, B1, A2, and B2. The four scenario families depict potential global economic futures (A1), and the A1 family is further divided into three groups that represent different energy technology breakthroughs, namely, A1FI (fossil intensive), A1T (predominantly non-fossil) and A1B (balanced across energy sources), global environmental (B1), regional economic (A2) and regional environmental (B2) (Chowdhury et al., 2020).

II. REVIEW OF LITERATURE

Certain coastal characteristics can be located, identified, and mapped using remote sensing. Patio-temporal changes and their effects on the ecosystem can also be evaluated (Zoran and Anderson 2006). When combined with GIS, satellite remote sensing has been used extensively and is acknowledged as a potent and successful method for identifying LULC change (Barua & Eslamian, 2024). Building LULC data sets and comprehending and tracking land development patterns and processes are made possible by satellite remote sensing, which offers affordable multispectral and multitemporal data.

Global sea level may be rising at a pace of more than one millimetre per year, according to research by Peltier and Tushingham (1989) on secular sea level trends taken from tide gauge data of suitably long duration. However, there has been a legitimate hesitancy to interpret the observed secular SLR as a global-scale signal that could be connected to the GHG because the tide gauge network's coverage of the oceans is extremely non-uniform and the tide gauge data show significant spatial variability (Dasgupta et al., 2022).

Published numbers for the long-term, global MSLR derived from tide gauge data show significant scatter, ranging from roughly 1 mm yr-1 to 3 mm yr-1, according to Douglas (1991). A global set of 21 such stations in nine maritime regions with an average record length of 76 years during the 1880-1980 period yielded an MSLR value of 1.8 mm yr-1 ± 0.1 (Adamo & de Sherbinin, 2011). This finding gives assurance that many historical tidal gauge records are of very good quality and that carefully chosen long tide gauge records measure the same underlying sea level

trend.

The most significant research on global sea level change using tidal gauges have included data from the Cascais tide gauge since it contains one of the longest time series, according to Antunes and Taborda (2009). Its extensive use and significance are due to its continuity, quality, and dependability (Raleigh et al., 2008). In contrast to the 1.8 mm yr⁻¹ found in previous studies for the 1920–1990 period, the results indicate rates of 2.1 mm yr⁻¹ and 2.5 mm yr⁻¹ for the decades of 1900 and 2000, respectively. A tentative estimate of the absolute and relative SLR for the ensuing decades was made possible by such rates, which were consistent with an SLR acceleration scenario.

Only a small number of prior investigations of Indian tide-gauge records have been published. Only four stations' records were collated by Rossiter (1954), who only mentioned three of them up until 1920 (Daraz et al., 2024). More recent was Pirazzoli (1986), which plotted trends up to 1973 for all but one of the stations and listed just the longer records for six stations up to 1978. It was particularly noteworthy that the record for Bombay between 1952 and 1962 reversed the whole trend for the preceding 30 years. Summary regressions for twelve Indian tide-gauge sites were provided by Arur and Basir (1982) using years that differed from those reported by Lennon (1976) and updates through 1982. The cross-sectional design of this study, which only records one time point, and its dependence on self-reported data, which could introduce bias, are among its drawbacks. The study used proven instruments for data collection, which improved reliability, and stratified random sampling to improve representativeness in order to overcome these problems. A thorough examination of the effects of climate change on migratory patterns was also made possible by the combination of multiple regression and structural equation modeling, which offered a more nuanced understanding of linkages. The Study's Goals

1. to evaluate the study area's observed past-sea level changes and Land Use Land Cover (LULC) changes.
2. To forecast local sea level increases in the future under various IPCC SRES scenarios for the research region.
3. To investigate how SLR affects coastal natural resources and the social communities that depend on them, as well as to determine which areas are at risk of flooding due to SLR by taking real-time measurements of the research area's ground level.
4. To develop a strategy plan for SLR adaptation as a preventative/proactive reaction.
5. To develop a framework for involving important study area stakeholders in SLR communication and community-level capacity building, while highlighting the necessity of mainstreaming adaptation choices within policies.

Research questions

1. What are the projections of sea level changes at different SRES scenarios at local-level viz., Bay of Bengal region of Tamil Nadu coast?
2. What are the likely consequences of impact of climate change induced SLR on natural resources of Tamil Nadu coast?

3. Who is the coastal natural resource dependent communities that will be influenced by rising sea level in the Tamil Nadu coast?
4. What are the adaptation measures required at the cadastral level to safeguard both coastal natural resources and its dependent social communities to rising sea level on the Tamil Nadu coast?
5. What are the roles of concerned stakeholders and what policy approach needs to intervene?

III. MATERIALS AND METHODS

1. Research Design

This study used a cross-sectional survey approach because it provides a picture of the current effects of climate change on migratory patterns by collecting data at a specific moment in time.

2. Study Setting

Surveys for the study were carried out in Karachi, Thatta, Gwadar, Badin, and Muzaffar-garh, which reflect various socioeconomic and environmental situations in Pakistan. As a large coastal city, Karachi confronts significant climatic threats, and Thatta and Badin are susceptible to saltwater intrusion and flooding. Rapidly developing Gwadar is also impacted by climate change, and Muzaffargarh, while being inland, gets river flooding.

3. Target Population

Households that had either experienced or were at risk of migration due to climate change made up the possible responders. This choice made sure that participants accurately represented the study's aim and provided insightful information about how migration is influenced by climate change in a variety of contexts.

4. Demographic Characteristics of Participants

socioeconomic and demographic traits of the participants while reducing the study's reference point. Because the effects of climate change and migration trends may differ depending on the age group, it is essential to comprehend age demographics. For example, older people may be more impacted by the direct effects of climate change, whereas younger people may relocate in search of economic possibilities.

5. Data Collection Tool

To effectively and systematically gather quantitative data for this investigation, a standardized questionnaire was employed. This instrument was suitable for measuring particular variables and aiding in the analysis of data. Demographic data, including age, gender, education, and socioeconomic status; perceptions of and experiences with the effects of climate change; migration patterns, including migration history, motivations, and preferred destinations; and socioeconomic impacts, with an emphasis on the effects on livelihoods, housing, and community structures, were all covered in the questionnaire. Likert scales, binary choices, and multiple-choice questions were used to measure the variables, which were administered online to guarantee a larger reach and participant convenience.

6. Data Analysis

The statistical program SPSS version 21 was used to examine the data. The associations between climate change variables and migration patterns were investigated using statistical techniques such as logistic regression, multiple linear regression, and structural equation modeling (SEM). A structured questionnaire with a variety of questions designed to collect quantitative data is used to measure the variables.

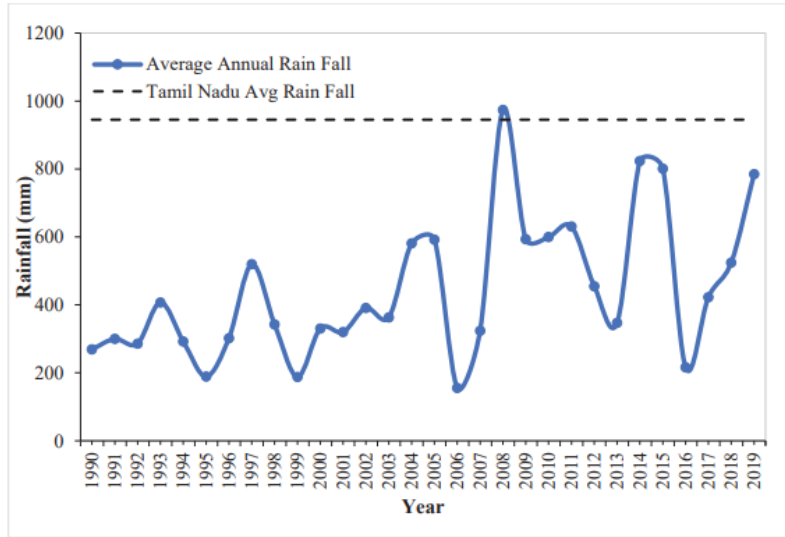


Figure 1: 30 Years of Rainfall Pattern

Human settlements are at serious risk from climate change, particularly in locations that are susceptible to flooding and coastal erosion. Pakistan has numerous issues from climate change because of its vast coastline and varied climatic circumstances. On the other hand, nothing is known about the unique migratory patterns in the many provinces and regions of the nation.

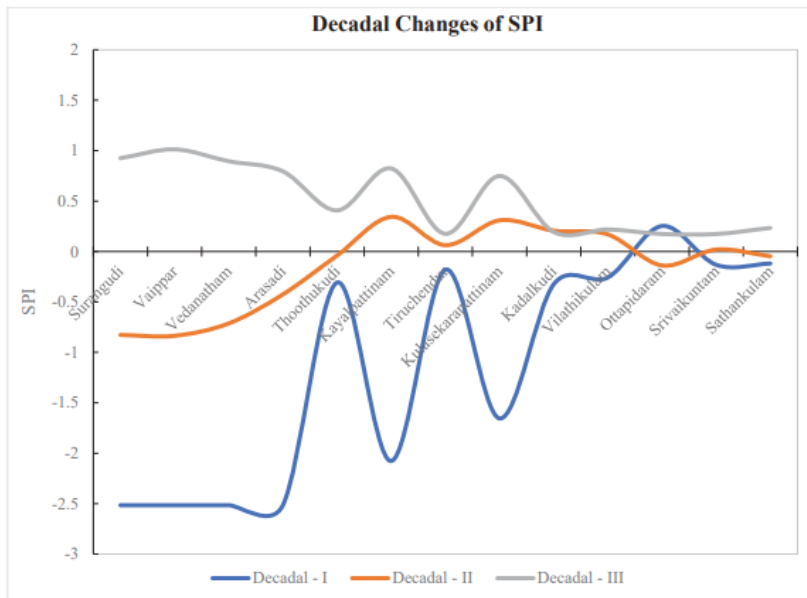


Figure 2: Station Wise Decadal Changes of SPI

By concentrating on five different areas, this study fills this knowledge vacuum and provides vital information for sensible policymaking and flexible approaches to lessen the effects of migration on climate change. The Sustainable Development Goals-13 (climate action) and expanding global mitigation strategies to address the stress of climate change, which further prolongs population movement in particular, serve as the driving forces behind this study. The need for this study is fueled by the socioeconomic disruptions brought on by climate-related occurrences as well as the dearth of localized studies.

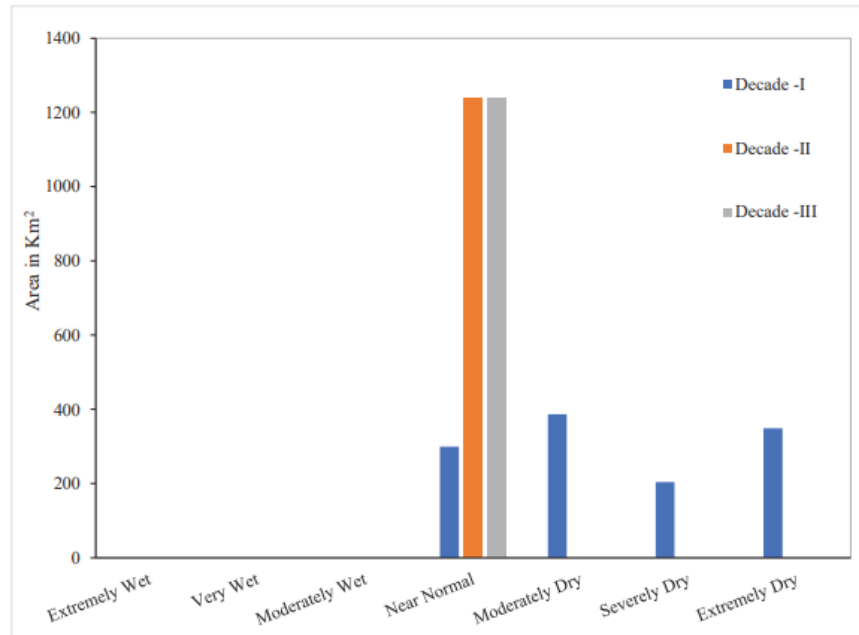


Figure 3: Spatial Distribution of Decadal Changes _ SPI

The goal is to add to the body of knowledge that already exists and guides both local and national responses to climate change that are resilient and adaptable. In order to provide sustained resilience and adaption measures for communities living in coastal regions, this study is essential in filling a major vacuum in the literature by offering empirical evidence on how migration is impacted by climate change while mitigating striking results-based policy actions. By examining several coastal and inland locales in relation to socioeconomic status and environmental dynamics, this exploration offers a distinct perspective. Finally, this study provides a thorough understanding of the complex effects of climate change on migration by combining quantitative data with qualitative evaluations, providing practical measures for mitigating the effects of climate change on the lives of inhabitants at macro and micro levels.

IV. CONCLUSION

The research area's climate change scenario was examined using both terrestrial and oceanic climate factors. Three decades (30 years) of rainfall data, spanning from 1990 to 2019, were analysed. The findings show that the trend of yearly rainfall over time indicates that it becomes relatively low when compared to state rainfall. However, there is a lot of rainfall in 2008. Seasonally, the NE Monsoon has a comparatively large amount of rainfall. The study finds that during the first and third decades, there is a deficiency in rainfall in the study area. According to

the research area's monsoon tendency, there was a considerable amount of rainfall during the NE monsoon and light rainfall during the post-monsoon season. According to the spatial analysis, Thoothukudi's southern region experiences considerable rainfall, while its northern coastal portions receive little. Data on land surface temperatures was used to retrieve the Urban Heat Island study. According to the UHI study, a tiny region was impacted by the violent heat island in 1997, whereas the majority of the study area was covered by a green island. The violent heat island zones encircle a greater area in 2005 and 2009. However, in 2015, the green island was elevated and the dangerous heat island parts were diminished.

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