# Disaster Resilience Management through Climate Risk Informed Programming with Systemic Change

**A Flagship CSR initiative of IndusInd Bank**

**In Partnership with**

UNICEF, Mission Samriddhi, Gorakhpur Environmental Action Group and Indian Institute of Technology (Gandhinagar)

# Climate Risks and Sectoral Vulnerabilities

**District Virdhunagar, Tamil Nadu**

Developed by

**Climate Risks and Sectoral Vulnerabilities – District Virdhunagar, Tamil Nadu**

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## Introduction

World Meteorological Organization's (WMO) 'State of the Global Climate' report, released in 2023, highlights severe concerns for the human race. It explicitly states that climate-induced risks, both global and local, are emerging as the greatest threat to humanity. The year 2023 has been recorded as the hottest in Earth's documented history, with the global average temperature rising by 1.45°C above pre-industrial levels, within a margin of uncertainty of ±0.12°C. Extremely worrying, this rise is very close to the threshold limit of 1.5 °C agreed upon by different nations during the Paris Agreement in 2015.

The WMO has expressed serious concern over this rise in the global average temperatures, warning that this will significantly affect the occurrence of extreme weather events, such as heatwaves, torrential rains, and tropical cyclones. Such events will undoubtedly have a direct impact on many development sectors including agriculture, health, education, and WASH all around the world. The effects of such extreme weather events have been well documented in numerous reports and research articles, manifesting in human casualties, injuries, homelessness, or distress displacement. Direct economic losses due to climate risks have surged by almost 151% in the last 20 years (UNISDR 2018).

**The year 2023 has been recorded as the hottest in Earth's documented history**

As in other parts of the world, climate induced risks, including extreme rainfall and floods, heat waves are increasing in India too (Guhathakurta et al., 2011). The warming trend over the Indian Ocean has enhanced moisture supply, leading to extreme rainfall due to cyclones in coastal areas in recent decades (Ray et al., 2019). In the country, floods due to extreme rainfall alone cause losses of about $3 billion per year, which is 10% of the global economic loss (Roxy et al., 2017). There has also been a significant increase in the probability of hydro-climatic hazards all over India (Vittal et al., 2020). Therefore, a comprehensive understanding of climate risks and their impact becomes a prerequisite to trigger collective public action at the local level.

This study report is part of the UNICEF-supported programme entitled **"Climate Risk Informed Programming Project - Nature Solves-Nature Resolves," funded by IndusInd.** The aim is to reach community groups like Mahila Sabhas and farmers through Risk-Informed Gram Panchayat Development Plans (RiGPDP), and mainstream developmental resources in DRR-CCA in selected Gram Panchayats as a pilot project. In the process, the climate risk profile of three selected districts, namely Virudhunagar, Tamil Nadu, Bahraich, Uttar Pradesh; Begusarai, Bihar; Baran, Rajasthan and Dharashiv, Maharashtra, were developed to guide and shape the mindset of key stakeholders to assess the capacity of related line departments and local technical institutions. The goal is to ensure that government development schemes and programs, at both national and state levels, are effectively aligned to contribute to resilient development.

**floods due to extreme rainfall alone cause losses of about $3 billion per year**

## Methodological framework, Approach and Process

The methodologies followed in this study are as suggested by the IPCC (2014). The IPCC defines two streams of vulnerability assessment—the contextual vulnerability assessment and the outcome vulnerability assessment. The first provides a qualitative overview of vulnerability with the help of survey instruments and case studies, while the index-based outcome vulnerability assessment is done by calculating a score, after quantifying a specific set or combination of indicators.

A score-based approach can be used at any scale such as national, sub-national, district, and sub district level (Gbetibouo and Ringler 2009). And, this study used a score-based approach to analyse the climate hazards risk and sectoral vulnerabilities in selected districts to understand the links between sensitivity of the district and its ability to cope and adapt. Risk causing climate hazards were determined based on Indian Meteorological Department (IMD) norms. The sectoral indicators which directly or indirectly increase vulnerability or resilience to climate risks, were used as sensitivity and adaptive capacity indicators. Data from each district for all identified indicators were collected from authentic sources and categorized into five components: **Climate Hazards Index (CHI)**, **Agriculture and allied sector vulnerability Index (AVI), Health Sector Vulnerability Index (HVI), Education sector vulnerability Index (EVI) and Water and sanitation sector vulnerability Index (WSVI).** The facts related to the indicators were analysed, and weightage was assigned to each as per their influence/ contribution to vulnerability using the Principal Component Analysis (PCA) statistical tool to determine indicator specific scores.

To frame out an adaptive strategy and advocacy at local level for climate risk informed programming, data related to climate risks, climate change policies and impacts across different spatial and temporal scales and sectors is essential. NITI Aayog, the 'Think-tank of India' also recognises comprehensive data gathering at the district level as essential for risk planning, developing coping strategies, and adaptation. The recently developed National Data Analytic Portal by the NITI Aayog is a comprehensive platform that provides a single window for this wide range of data at national, state and district levels.

## Identification of indicators

Vulnerability to climate induced risks is multidimensional and determined by a complex interplay of multiple factors (Piya et al. 2012). There are two approaches in the selection of indicators: data driven and theory driven (Vincent 2004); and each approach has its own limitations. Therefore, the best approach is to verify the accuracy of the theory-based indicators with data from authentic sources (Maiti et al. 2015). Theoretically, vulnerability encompasses a variety of perceptions and elements, including sensitivity and the lack of capacity to cope and adapt. IPCC defines vulnerability as "the propensity or pre disposition to be adversely affected" and is determined by the sensitivity and adaptive capacity of the system (IPCC 2014). Sensitivity reflects the extent to which a system is sensitive or responsive to external stress or hazard, such as a drought or flood. Adaptive capacity is the ability of a system (technology, infrastructure, ease of access to resources, wealth, etc.) to cope with the consequences of climate stress, which includes several factors. (McCarthy et al. 2001). Vulnerability to climate change is a function of biophysical and socio-economic factors (O'Brien et al. 2004). Thus, the dynamics of vulnerability are captured through physical, demographic, social, and environmental components to denote sensitivity and adaptive capacity of the system. Considering this, a combined approach was used to select the indicators.

A total of 34 indicators that included climate hazards and four sectors (Agriculture and allied, Health, Education and Water and sanitation) were used in the study to denote the sensitivity and adaptive capacity of the districts (Table 1). The coefficient of variation in annual rainfall, frequency of heavy rainfall events, coefficient of variation in maximum and minimum temperature were calculated from high resolution IMD daily gridded data of the last 30 years (1993-2023). The sectoral indicators, which captured the sensitivity and adaptive capacity of the districts and states, were identified and their data collected from authentic sources. The indicators, the rationale for using them, and their functional relationship with vulnerability are described below in greater detail.

Table 1

| Code | Indicator | Baseline | Source | Relation with climate Vulnerability impact |
|---|---|---|---|---|
| CV_A rain(%) | Coefficient of variation of Annual Rainfall in % | 1993-2023 | IMD daily Gridded data | Exposure (Positive) |
| Fre_Hrain | Frequency of heavy rainfall events | 1993-2023 | IMD daily Gridded data | Exposure (Positive) |
| Con_DRY_ Mday | Consecutive dry days during monsoon | 1993-2023 | IMD daily Gridded data | Exposure (Positive) |
| CV_MaxT | Coefficient of variation of Daily max Temperature % | 1993-2023 | IMD daily Gridded data | Exposure (Positive) |
| CV_MINT | Coefficient of variation of Daily min Temperature % | 1993-2023 | Disaster Management Department, Bihar | Exposure (Positive) |
| Area_ Flood (%) | % of area prone to flood | 2019 | Vulnerability Atlas of India , 2019 BMTPC | Exposure (Positive) |
| Fre_ E Drought | Frequency of Severe to extreme drought event | 1991-2020 | District web portals | Exposure (Positive) |
| **Agriculture and allied sector** | | | | |
| Mar_Small_ LandH | % of marginal and small landholders | 2011 | Census of India , 2011 | Sensitivity (Positive) |
| L_HR | No of Livestock per 000 population | 2019 | The National Data and Analytics Platform | Adaptation (Negative) |
| Rainfed_Agri | % Of The Area Under Rain fed Agriculture | 2021-22 | The National Data and Analytics Platform | Sensitivity (positive) |
| Area _Cov_ PMFVY | Area covered for crop insurance under PMFBY in 000 ha | 2023 | The National Data and Analytics Platform | Adaptation(Negative) |
| Empy_ MNERGA | Average person days per household employed under MNREGA | 2023 | The National Data and Analytics Platform | Sensitivity (Positive) |
| Y_Vari_ FoodGrain (%) | % of Yield variability of food grains | 2021-22 | The National Data and Analytics Platform | Adaptation (Negative) |
| Wo_ Part_ Labour | Women participation in the workforce (%) | 2023 | The National Data and Analytics Platform | Adaptation (Negative) |
| **Health Sector** | | | | |
| Health_ Infra | No of rural healthcare infrastructure facilities per lakh population | 2021-22 | The National Data and Analytics Platform | Adaptation (Negative) |
| Mem_ Insurance | HH with any member covered under a health and insurance / financial scheme | 2020-21 | The National Data and Analytics Platform | Sensitivity (Positive) |
| Child _Vac | Children age 12-23 months fully vaccinated based on information from vaccination card (%) | 2020-21 | The National Data and Analytics Platform | Adaptation (Negative) |
| Child_ Stunt | Children under 5 years who are stunted | 2020-21 | The National Data and Analytics Platform | Sensitivity (Positive) |
| Child _ underweight | Children under 5 years who are underweight | 2020-21 | The National Data and Analytics Platform | Sensitivity (Positive) |

| Code | Indicator | Baseline | Source | Relation with climate Vulnerability impact |
|---|---|---|---|---|
| IMR | Infant Mortality rate (IMR) | 2022-23 | The National Data and Analytics Platform | Adaptation (Negative) |
| Women_ Anaemic | All women age 15-49 years who are anaemic | 2020-21 | The National Data and Analytics Platform | Sensitivity (Positive) |
| **Education Sector** | | | | |
| Women_10_ education | Women with 10 or more years of schooling (%) | 2021-22 | UDISE Plus | Adaptation (Negative) |
| ScL_Girl_Toilet | % of schools with functional girls' toilet | 2021-22 | UDISE Plus | Sensitivity (Positive) |
| Sch_Drinking | Percentage of schools with functional drinking water facilities | 2021-22 | UDISE Plus | Sensitivity (Positive) |
| S&TR | Average Student teacher Ratio | 2021-22 | UDISE Plus | Adaptation (Negative) |
| Drop_out | Average dropout rate in secondary level | 2021-22 | UDISE Plus | Adaptation (Negative) |
| Sch_approach | % of Schools approachable by all-weather roads | 2021-22 | UDISE Plus | Adaptation (Negative) |
| Sch_electricity | Percentage of schools with electricity connection | 2021-22 | UDISE Plus | Adaptation (Negative) |
| **Water and Sanitation Sector** | | | | |
| HHs_Impr_ Drinkingwater | % of households with an improved drinking water sources | 2020-21 | The National Data and Analytics Platform | Adaptation (Negative) |
| Change_GW | Changes in ground water table during last five years (mbGL) | 2021-22 | The National Data and Analytics Platform | Sensitivity (Positive) |
| State_GW | State of ground water utilisation(in %) | 2021-22 | The National Data and Analytics Platform | Sensitivity (Positive) |
| HHs _improv_ Sani | Proportion of HH that have an improved sanitation facilities | 2020-21 | The National Data and Analytics Platform | Adaptation (Negative |
| Area_water_ Bodies | Area under water bodies (%) | 2023 | India Wris web Portal | Adaptation (Negative) |
| No_ODF | No of ODF village | 2023 | The National Data and Analytics Platform | Adaptation (Negative |

## Normalisation of dataset

The identified indicators were from different sources, measured in dissimilar units. Since the Vulnerability Assessment is a rank, all the indicators used in the assessment had to be of common units, for which they needed to be normalized. The normalization process varies depending on the nature of the relationship of an indicator with vulnerability. The following formulae (UNDP 2006) were used to normalize indicators which tend to increase vulnerability with an increase in the values.

For the indicators that had a positive functional relationship with their respective vulnerability index, the normalization was done through the following equation:

$$\text{Normalisation} = \frac{\text{Actual Value - Minimum Value}}{\text{Maximum Value - Minimum Value}}$$

On the other hand, if negative functional relationship occurs, then the following equation has been used for normalization:

$$\text{Normalisation} = \frac{\text{Maximum Value - Actual Value}}{\text{Maximum Value - Minimum Value}}$$

## Assigning weights to indicators through Principal Component Analysis

PCA was used in this study to assign appropriate weights to the indicators (Monterroso et al. 2014). Through this, each indicator was assigned a weight to find out the leading indicator, which further influenced all other indicators. The PCA was carried out using Statistical Package for Social Sciences (SPSS) as detailed in Table 2.

**Table 2**

| S.No | Indicator | Virdhunagar | Begusarai | Bahraich |
|---|---|---|---|---|
| 1 | % of marginal and small landholders | 5.3 | 5.1 | 5.6 |
| 2 | Livstockpopulationper1000population | 5.2 | 0.2 | 4.9 |
| 3 | % of The Area Under Rainfed Agriculture | 0.8 | 0.9 | 0.0 |
| 4 | % Area Covered into crop insurance Under PMFBY in 000ha | 3.4 | 1.9 | 4.6 |
| 5 | Average person days per household employed under MGNREGA | 5.3 | 0.2 | 2.6 |
| 6 | Yield Variability Of Food Grains% | 5.4 | 4.9 | 5.3 |
| 7 | Women Participation In The Workforce(%) | 0.3 | 6.1 | 3.6 |
| 8 | No o fRural healthcare infrastructure facilities per lakh population | 5.0 | 1.6 | 0.0 |
| 9 | % HH with any usual member covered under a health and insurance/ financial scheme | 4.8 | 5.2 | 5.4 |
| 10 | Children age 12-23 months fully vaccinated based on information from vaccination card(%) | 0.4 | 0.3 | 4.4 |
| 11 | Children under 5 years who are stunted | 5.3 | 5.4 | 4.8 |
| 12 | Children under 5 years who are underweight | 5.3 | 5.7 | 3.6 |
| 13 | IMR | 5.3 | 0.8 | 4.7 |
| 14 | % women age 15-49 years who are anaemic | 4.6 | 5.9 | 5.6 |
| 15 | % Women with 10 or more years of schooling | 5.3 | 6.1 | 3.9 |
| 16 | % of schools with functional girls toilet | 4.9 | 4.3 | 5.6 |
| 17 | % of schools with functional drinking water facilities | 0.1 | 5.4 | 4.4 |
| 18 | Average Student teacher Ratio | 5.0 | 4.9 | 5.2 |
| 19 | Average Drop outrate in secondary level | 5.1 | 6.1 | 3.2 |
| 20 | % of Schools Approachable by All-Weather Roads | 1.5 | 2.6 | 2.9 |
| 21 | % of schools with electricity connection | 4.9 | 0.0 | 0.1 |
| 22 | % of households with an with improved drinking water sources | 5.2 | 5.5 | 5.4 |
| 23 | % State of goundwater utilisation (in%) | 2.4 | 2.4 | 0.1 |
| 24 | % Area Under Wetlands in | 2.4 | 2.8 | 4.8 |
| 25 | % of available groundwater used for irrigation Purpose | 4.1 | 4.8 | 0.3 |
| 26 | % of HH that has an improved sanitation facilities | 0.0 | 5.7 | 3.8 |
| 27 | % of ODF plus village to total villages | 2.7 | 5.2 | 5.4 |

## District profile – Virudhunagar, Tamil Nadu

Virdhunagar district is situated in the south-western part of Tamil Nadu, occupying an area of 4288 sq. km. It extends between 9°10'N to 9°50'N latitude and 77°20'E to 78°20'E longitude. Geographically diverse, the district is bordered by the Western Ghats to the west, renowned for their greenery and biodiversity, which act as a natural barrier, influencing the climate by intercepting southwest monsoon winds. Consequently, the western part of the district receives higher rainfall compared to the east, characterized by fertile agricultural lands and gentle slopes. The Vaigai River traverses the district, providing water for irrigation and supporting the local economy.

As per the 2011 census, the district's population stands at 19,43,309, encompassing nine *taluks* and 600 revenue villages. The district is renowned for its rich cultural heritage and substantial contributions to the state's industrial and agricultural sectors.

## Climate profile

The climate of Virudhunagar District is classified as tropical savanna type, characterized by hot summers, mild winters, and moderate to heavy rainfall during the monsoon season. The district traditionally receives its total rainfall from two wings - the southwest monsoon (June to September) and the northeast monsoon (October to December). The intensity and distribution of rainfall during both monsoon periods have undergone noticeable changes over the last 30 years (1993-2023). Already a water-stressed area, changes in rainfall pattern are leading to severe water scarcity and droughts, which ultimately impact directly the agricultural productivity and water availability in the district.

In the present report, the analysis of rainfall patterns, trend and variability have been done based on recent past 30 years (1993-2023) data. This will be helpful to provide valuable insights for climate change adaptation and management for the district authorities.

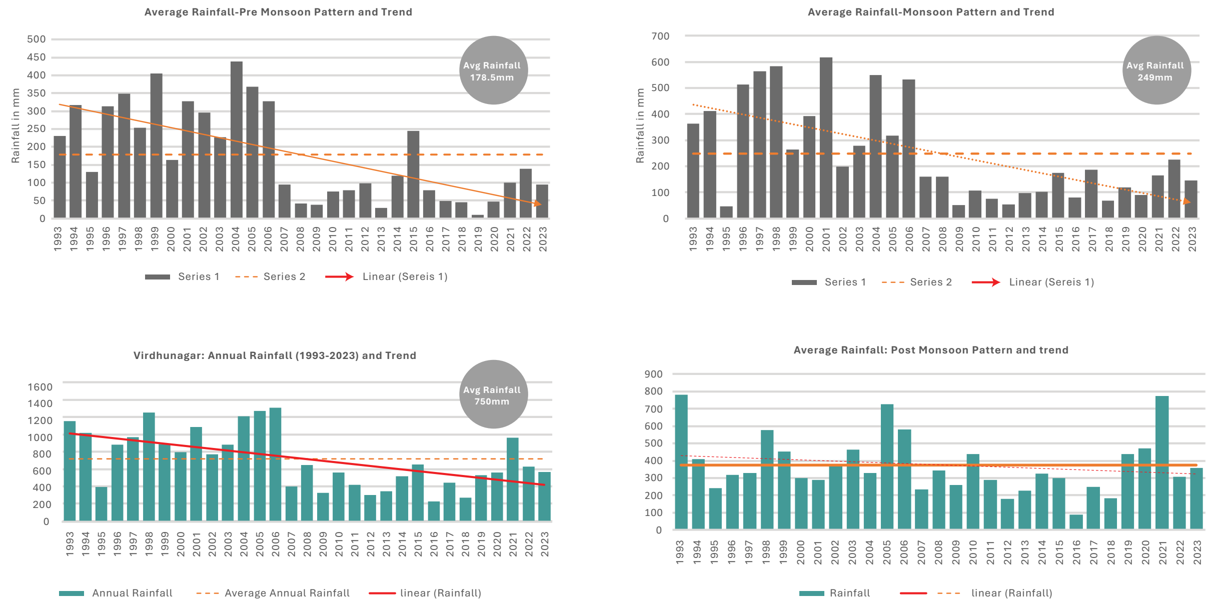
## Trend and variability in rainfall

The district receives approximately 750 mm of rainfall annually. **Chart 1** illustrates the time series of rainfall patterns during the pre-monsoon, monsoon, post-monsoon, and annual periods over the past 30 years. The trend lines for pre-monsoon, monsoon, and annual rainfall depict a significant decrease over the last three decades. Although there is a declining trend during the post-monsoon period as well, the rate of decline is less pronounced, remaining close to the average. Chart 1 also highlights that the year 2007 marks a pivotal period in the rainfall pattern, as the district has not received rainfall exceeding the average since then.

## Mean Rainfall and Seasonal Distribution

The 2023 Global Climate Risk Report clearly indicates that climate change has had a significant impact on rainfall variability. The coefficient of variation in rainfall for the pre-monsoon, monsoon, and post-monsoon months, as well as the annual rainfall, has been calculated and analysed for the period 1993-2023 (Table 3). It is evident from here that the district receives the highest rainfall (22.86%) in October during the post-monsoon season, with an average of 171.48 mm. This is followed by the monsoon season, where June sees the highest average rainfall of 67.23 mm, gradually decreasing towards September. The pre-monsoon season experiences relatively lower average rainfall, with the highest mean rainfall occurring in March at 9.03 mm. The average monthly rainfall of the district highlights significant variability, particularly in February and March during the pre-monsoon season, and in October and November during the post-monsoon season. The monsoon season also shows significant variability, especially in June and July. The annual rainfall variability of the district is 45.26%.

## Chart 1




## Table 3

| Season | Pre-monsoon | | | | Monsoon | | | | Post Monsoon | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Month** | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Annual |
| **Mean** | 6.25 | 9.03 | 35.58 | 75.68 | 67.23 | 57.98 | 51.68 | 71.37 | 171.48 | 147.46 | 45.35 | 11.02 | 750.11 |
| **% of Annual Rainfall** | 0.83 | 1.20 | 4.74 | 10.09 | 8.96 | 7.73 | 6.89 | 9.51 | 22.86 | 19.66 | 6.05 | 1.47 | 100.00 |
| **CV** | 227.36 | 268.98 | 125.26 | 96.21 | 104.83 | 94.91 | 82.70 | 112.33 | 60.62 | 68.00 | 103.71 | 435.96 | 45.26 |

# Potential risks

These rainfall variabilities, as indicated by the CV, may impose significant challenges to agricultural planning and crop management. Farmers may face difficulties in accurately predicting rainfall patterns, which can affect crop selection, irrigation scheduling, and yield projections. Although the region receives low rainfall during the southwest monsoon, higher rainfall during the monsoon and post-monsoon seasons can benefit crops. However, excessive variability may result in waterlogging, soil erosion, and crop damage. Reduced rainfall during the pre-monsoon season may impact crop sowing, particularly crops dependent on early moisture.

The uneven distribution of rainfall throughout the year highlights the need for effective water management strategies, such as developing storage facilities, promoting rainwater harvesting, and efficient irrigation systems. Variability in rainfall can influence groundwater recharge rates, impacting water availability for agricultural and domestic purposes. During periods of low rainfall variability, there may be increased pressure on water resources, leading to public conflicts over water allocation and usage. Similarly, inadequate rainfall during specific months can affect water availability for sanitation and hygiene practices, potentially posing health risks.

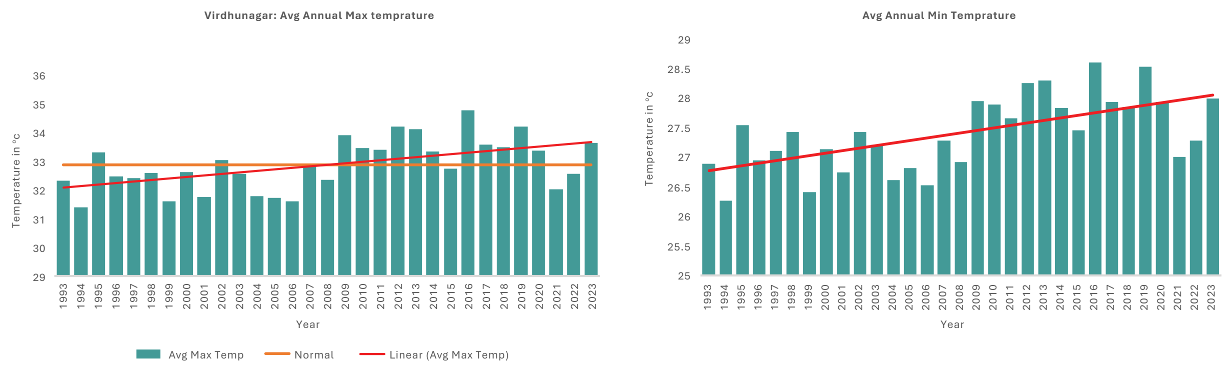
# Temperature scenario

The district experiences a warm climate throughout the year, with relatively high temperatures during the summer months. The average maximum temperature during the summer season (March to June) often exceeds 35°C , with occasional heatwaves. The hot and dry conditions during this period exert challenges for agriculture and increase the risk of heat-related illnesses among the population. During the winter months (December to February), temperatures in Virdhunagar district remains milder, with average minimum temperatures ranging between 20°C to 25°C.

**Chart 2** represents the average maximum and minimum temperature pattern and trend for years1993 to 2023, along with the normal maximum temperature and its digression from normal. The average maximum temperature of the district is 32.88°C. Over the last 30-years period, the average maximum temperature shows an increasing trend, though it is not very significant. The years 2012, 2013, 2016, 2019, and 2023 stand out with higher than average max temperatures, indicating periods of warmth or heatwaves; while years such as 1994, 1999, 2001, 2004, 2005, 2006, 2008, 2015, and 2021 witnessed temperatures below the normal range, suggesting relatively cooler periods. Overall, the average maximum temperature for the entire period is slightly increasing but indicates no significant long-term trend in temperature deviation.

Analysing the data of minimum temperatures over the past three decades reveals a notable trend towards increasing temperatures. While fluctuations occur from year to year, there is an apparent pattern of rising minimum temperatures from the early 1990s to the early 2020s. This trend suggests a potential long-term shift in temperature patterns within the region. However, certain years, such as 2019, stand out with particularly higher minimum temperatures compared to surrounding years, indicating occasional deviations from the overall trend. Increasing minimum temperatures may have various implications, including impacts on agricultural practices, and human health. For instance, warmer nights may disrupt certain plant life cycles and lead to changes in crop cultivation techniques. Moreover, higher minimum temperatures can affect individuals' comfort level and contribute to heat-related health issues, particularly during night-time.

**Chart 2**




# Extreme temperature pattern

Extreme temperature pattern (No. of days above 40-degree temperature) in Virdhunagar district over the last 30 years during the summer months reveals interesting insights. **Chart 3** below indicates the number of days with hot temperatures (above 40 degrees centigrade) for each year. There are noticeable variations from year to year, with some years experiencing significantly more hot days than others. For instance, 1998 had the highest total number of hot days, while certain years like 1997 and 2012 had relatively few hot days.

**Chart 3**

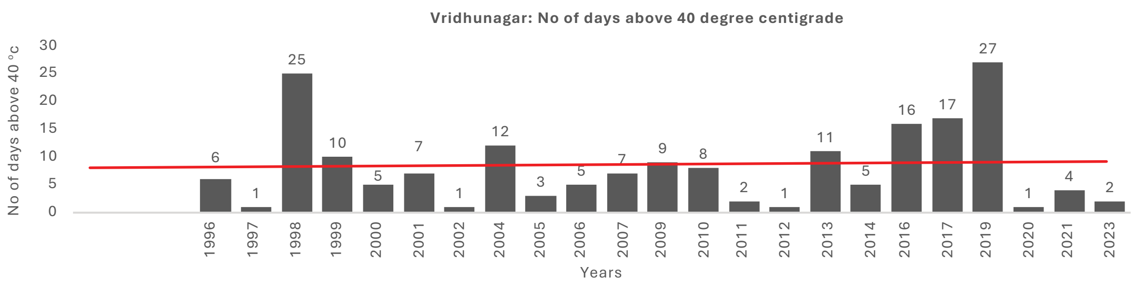
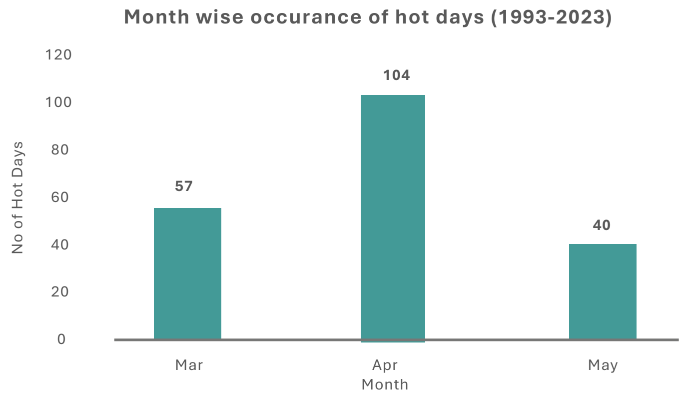


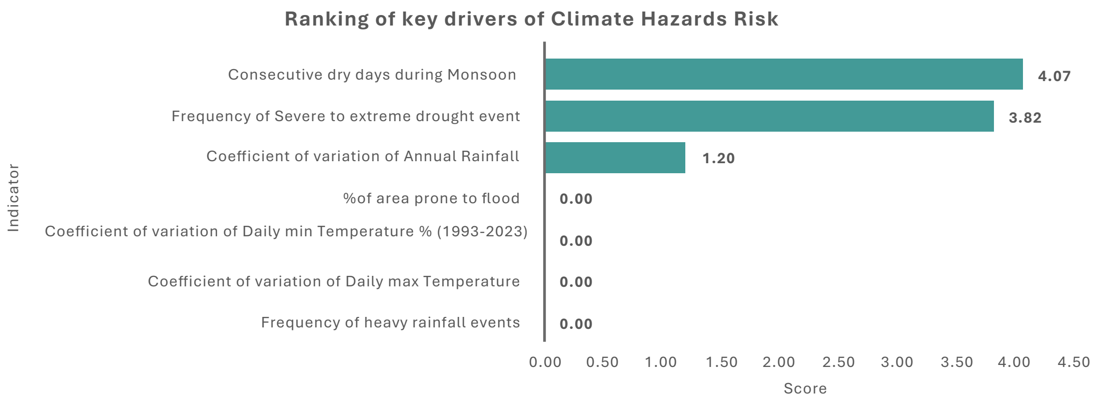
Chart 4




Over the last three decades, there appears to be a visible trend of increasing hot days in Virdhunagar during the summer months (March, April, and May). **Chart 4** shows fluctuations from year to year, but there is an overall pattern of more frequent occurrences of hot days, especially in recent years. In the early 1990s, the number of hot days was relatively low, with occasional spikes. However, as the decades progressed, there is a noticeable uptick in the frequency of hot days, particularly in April. This trend becomes more pronounced in the 2000s and continues into the 2010s and 2020s. The month wise analysis indicates that the highest number of hot days in the district occurred in April, followed by March and then May. This trend highlights the importance of understanding and addressing the impacts of climate change on temperature extremes in the region, as increased frequency of hot days can have implications for public health, agriculture, and water resource management.

# Climate hazards index and ranking of key drivers

Chart 5




Based on the analysis of climate data for rainfall and temperature over the past 30 years, the Climate Hazard Vulnerability Index at the district level has been calculated using seven indicators as tabulated in **Chart 5**. These indicators include the coefficient of variation of annual rainfall, the frequency of heavy rainfall events, consecutive dry days during the monsoon, coefficient of variation of daily maximum and minimum temperatures, percentage of area prone to flood and frequency of severe to moderate drought. The appropriate weightage for each indicator was determined using principal component analysis, and the final score was computed by multiplying the weightage value with the normalized value of each indicator. **Chart 5** above illustrates that in Virdhunagar district, out of the seven climate hazard indicators, indicators of consecutive dry days in summer (4.07), frequency of severe to moderate drought events (3.82), and coefficient of variation in annual rainfall (1.20) have higher scores compared to the state average. Consequently, these indicators play a pivotal role in assessing climate hazard risk in the district.

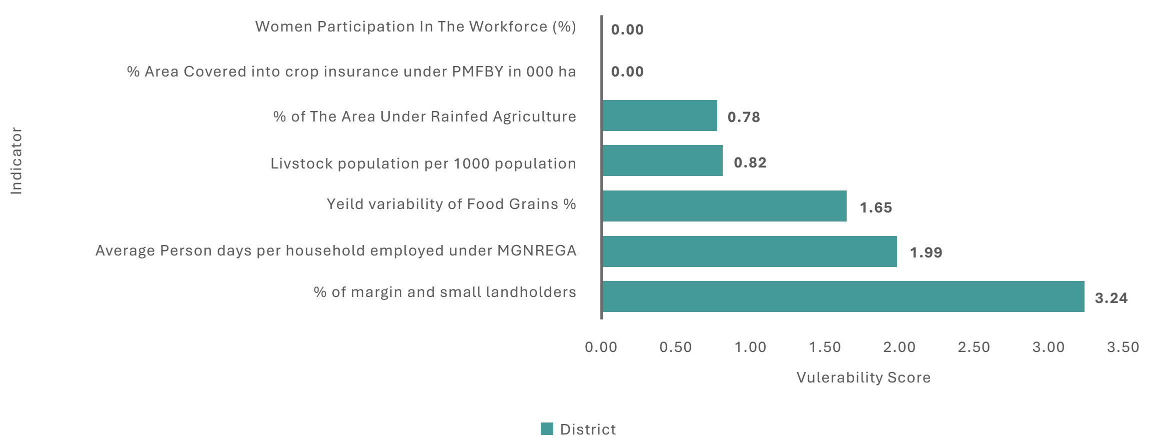
# Sectoral Vulnerability

## Agriculture and Allied sector

The comparative analysis of district-level agriculture sector vulnerability indicators in the district, with reference to the state of Tamil Nadu, reveals several key insights:

- **Marginal and Small Landholders**: Though the district Virdhunagar exhibits a lower percentage of marginal and small landholders (90%) compared to the state average (92.5%), it indicates a higher mass of population dependent on small-scale agriculture, potentially increasing vulnerability to market fluctuations and climate risks as they have a poor adaptive capacity to respond.
- **Livestock Population**: The district's livestock population per 1000 population is slightly lower (543) than the state average (573). While this may mitigate some risks associated with animal husbandry, it also points towards the district's limited diversification opportunities for agricultural livelihoods.
- **Area Under Rainfed Agriculture**: Virdhunagar district has a comparable percentage of area under rainfed agriculture (57.15 %) to the state average (42.47%). Reliance on rain-fed farming practices can increase vulnerability to climate variability and water scarcity.
- **Crop Insurance Coverage**: Interestingly, the district shows higher coverage under crop insurance schemes (57.3%), contrasting with the state average (41.46%). From the governance perspective, this gives a good picture of a larger part of the district covered under the PMFBY, however, it also exposes farmers to a higher financial burden of climate risks induced crop failure or damage.
- **MGNREGA Employment**: Virdhunagar district demonstrates a lower average person-days per household employed under MGNREGA as compared to the state average. While this may provide temporary employment opportunities, it also indicates underlying challenges in agricultural employment and livelihoods.
- **Yield Variability of Food Grains**: The district experiences higher yield variability of food grains (28%), higher than the state average (20%). This variability may affect food security and income stability for farmers.
- **Women's Participation in the Workforce**: The district shows 44% of women's participation in the workforce, reflecting potential gender disparities in agricultural activities and decision-making.

**Chart 6**

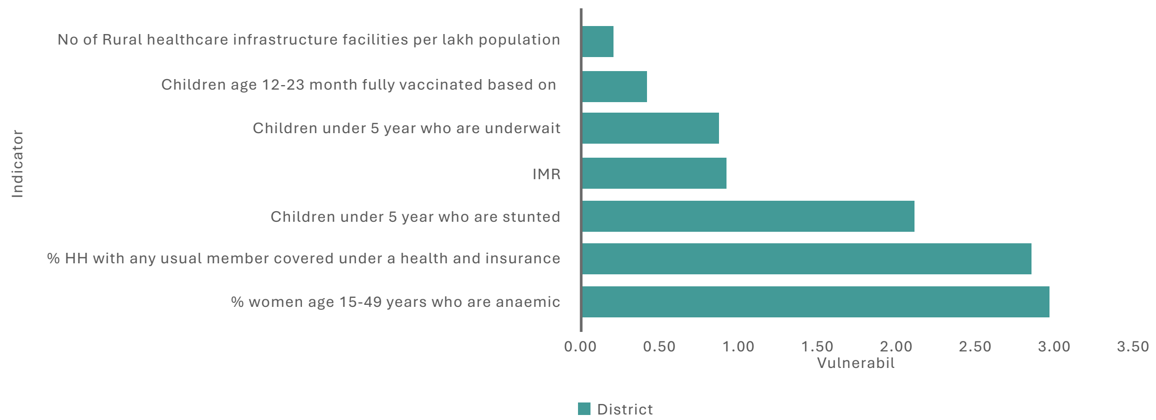



Based on the district's scores, the key drivers of vulnerability appear as the high percentage of marginal and small landholders, significant reliance on MGNREGA employment for livelihood support and yield variability of food grain **(Chart 6).** These factors highlight the importance of targeted interventions to enhance resilience and sustainability in the agriculture sector, including diversification of livelihood options, and gender-inclusive agricultural development programs.

## Health Sector

In the district, seven health related indicators have been taken which shed light on various facets of public health. Notably, the district shows a promising infrastructure support, with a relatively high number of rural healthcare facilities per lakh population (18.43) as compared to the state average (18.69). However, there are significant gaps in health insurance coverage, with only 51.3% of households covered under health or financial schemes in comparison to the state average of 66.5%.

**Chart 7**




Child health indicators reveal concerning trends, with relatively low percentages of fully vaccinated children aged 12-23 months (76.7%) which is lower than the state average and significant proportions of undernourished children under 5 years, indicated by stunting (29.2%) and underweight (23.7%). Additionally, there is a notable prevalence of anaemia among women aged 15-49 years, which is 56.9 % as compared to the state average of 52.9%

Hence, among the indicators, the prevalence of anaemia among women aged 15-49 years emerges as a potential key driver of health vulnerability in Virudhunagar District **(Chart 7).** Anaemia compromises individuals' resilience to climate stressors, exacerbating the health impacts of extreme weather events and environmental changes. Addressing anaemia requires comprehensive strategies, including interventions to improve nutrition, improved access to healthcare, and better women's health services. By prioritizing efforts to reduce anaemia prevalence, increasing health insurance coverage at HHs level and strategy formulation for addressing child nutrition related issues, Virudhunagar district can enhance its capacity to mitigate and adapt to climate-related health risks, ultimately improving the well-being of its population.

## Education Sector

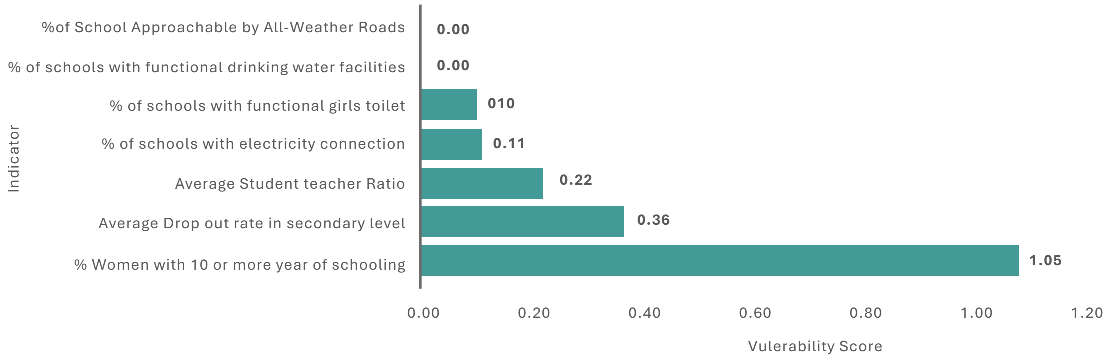
In education sector, as per the common framework of district level vulnerability suggested by the Govt. of India , the study have used seven indicators to assess the educational vulnerability to climate risks viz % Women with 10 or more years of schooling, % of Schools with Functional Girls toilet, % of Schools with Functional Drinking Water facilities, Average Student teacher Ratio, Average Drop-out rate in secondary level, % of Schools Approachable by All-Weather Roads and % of schools with electricity connection. In the education sector, Virudhunagar District exhibits a better position with states average on some indicators. **(Table 4)**

Table 4

| Indicator | District average | State average |
|---|---|---|
| % Women with 10 or more years of schooling | 53.5% | 56.6% |
| % of schools with functional girls' toilet, | 98.6% | 98.7% |
| % of schools with functional drinking water facilities | 99.8% | 97.5% |
| Average Student teacher Ratio | 16.75% | 16.5% |
| Average Drop-out rate in secondary level | 5.05% | 4.47% |
| % of Schools Approachable by All-Weather Roads | 96.67% | 69.46 |

- The comparative analysis between district and state averages in education sector indicators reveals that the district's average percentage of women with 10 or more years of schooling (53.5%) is slightly lower than the state average (56.6%), while both exhibit high percentages of schools with functional girls' toilets and drinking water facilities. The district's average dropout rate in secondary level (5.05%) is marginally higher than the state average (4.47%). Notably, the district surpasses the state average in terms of schools approachable by all-weather roads, indicating better infrastructure resilience. Overall, the district performs well in infrastructure but faces challenges in educational attainment compared to the state average. Based on the score obtained, the key indicators/ drivers of educational vulnerability in the district are (**Chart 8):**

Chart 8




- **% Women with 10 or More Years of Schooling:** The relatively higher score in comparison to state average suggests a potential vulnerability in educational attainment among women, which may impact overall literacy rates and socio-economic development.

- **Average Dropout Rate in Secondary Level**: The higher drop-out rate of students in the district with reference to the state, reflects challenges in retaining students in secondary education, possibly due to socio-economic factors or inadequate support systems.

- **Average Student-Teacher Ratio**: This is the third key driver in education sector of the district which suggests potential challenges in providing individualized attention and quality education to students, which can hinder learning outcomes and academic performance.

Addressing these key indicators should be prioritized to enhance educational resilience and promote inclusive and quality education in the district.

## Water and sanitation Sector

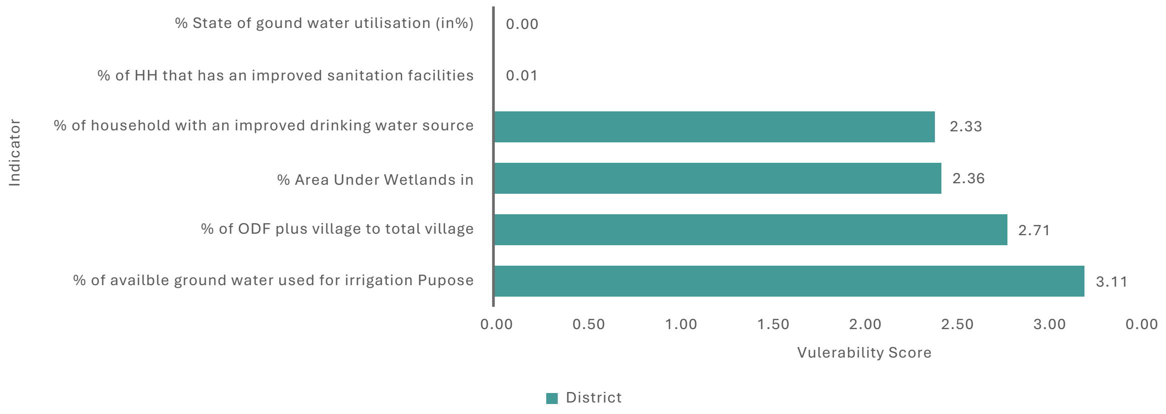
This is an important sector which is directly impacted by climate risks. In the study, six indicators have been selected to assess the sectoral vulnerability. The following table shows the comparative facts between the district and the state against the respective indicators **(Table 5)**

Table 5

| Indicator | District average | State average |
|---|---|---|
| % of households with improved drinking water sources | 97.4 % | 98.6% |
| % State of ground water utilisation(in %) | 57.56% | 73.91% |
| % Area Under Wetlands | 0.31% | 1.38% |
| % of available ground water used for irrigation Purpose | 55.85% | 69.0% |
| %of HH that has an improved sanitation facilities | 59.8% | 72.6% |
| % of ODF plus village to total villages | 73.45% | 82% |

From the Table above, it is observed that the district exhibits commendable access to improved drinking water sources, with 97.4% of households enjoying this privilege, though this is slightly lower than the state's 98.6%. However, the district's groundwater utilization rate stands at 57.56%, significantly below the state's 73.91%, indicating potential disparities in water use practices. Similarly, while the district claims 0.31% of its area under wetlands, this figure falls short of the state average of 1.38%, suggesting differing ecological characteristics or land use patterns. Moreover, the district utilizes 55.85% of its available groundwater for irrigation purposes, trailing behind the state's 69.0%, reflecting potential inefficiencies in agricultural practices or water management strategies. Additionally, the district records a lower percentage of households with improved sanitation facilities at 59.8% compared to the state's 72.6%. Despite these disparities, the district demonstrates progress in sanitation initiatives, with 73.45% of villages achieving Open Defecation Free Plus status, albeit lower than the state's 82%.

Chart 9




In assessing the water and sanitation sector vulnerability, several key drivers and indicators emerge, highlighting areas of vulnerability within the district **(Chart 9)**. The district's excessive utilization of available groundwater for irrigation purposes, reflected in its high score of 3.11, poses a significant vulnerability, potentially leading to groundwater depletion. Furthermore, the district's slow progress in achieving Open Defecation Free Plus status contributes to enhance vulnerability by addressing sanitation-related risks.

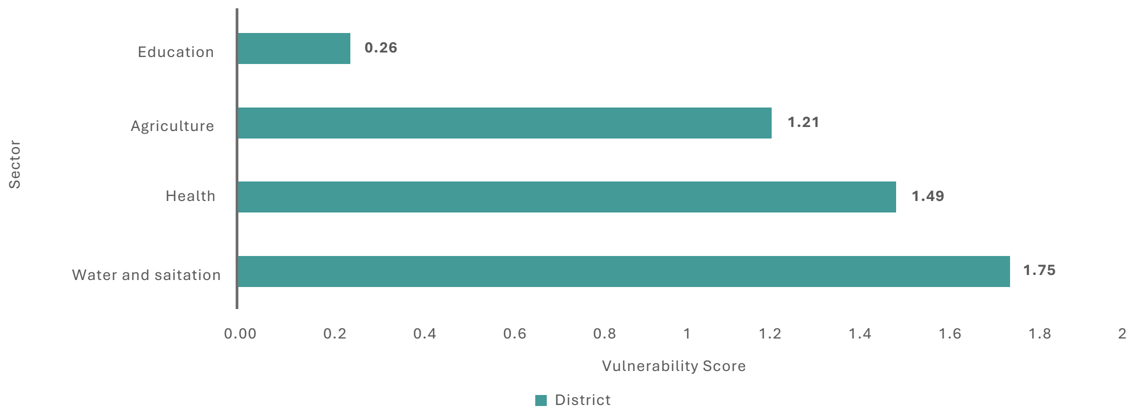
Moreover, the district's small proportion of area under the wetland coverage, in contrast to the state's coverage, emphasizes the importance of preserving existing wetlands for sustainable water resource management. Access to improved drinking water sources emerges as another critical driver of vulnerability, with the district's high score indicating risk of waterborne diseases and related health risks. Addressing these vulnerabilities through targeted interventions and sustainable management practices is essential to enhance resilience and sustainability in the water and sanitation sector at district levels.

## Composite level of sectoral Vulnerability and ranking of indicators

The Composite vulnerability scores provide insight into the status of various sectors within the district and state, highlighting areas of concern and resilience**. (Chart 10)**

- In the water and sanitation sector, the district demonstrates a higher vulnerability score of 1.75. This suggests that the district faces greater challenges in ensuring access to clean water and sanitation facilities, potentially leading to health risks and environmental concerns. Addressing issues such as groundwater depletion, inadequate sanitation infrastructure, and waterborne diseases is crucial to improve the sector's resilience in the district.
- Similarly, in the health sector, the district's vulnerability score of 1.49 indicates significant challenges. This suggests that the district possesses potential gaps in healthcare access, infrastructure, and service delivery with reference to the state, highlighting the need for targeted interventions to improve healthcare outcomes and reduce vulnerabilities.
- Agriculture sector is the third most vulnerable sector. The district shows a moderate vulnerability score of 1.21. This gives an indication that while there are challenges such as climate risks, water scarcity, and land degradation affecting agricultural productivity, efforts are also being made to enhance resilience through sustainable farming practices, irrigation management, and crop diversification.
- Education sector in the district appears to be relatively less vulnerable compared to other sectors, with reference to the state. However, there is still room for improvement in ensuring access to quality education, reducing dropout rates, and addressing infrastructure gaps to enhance educational resilience and promote human development in the district.

**Chart 10**

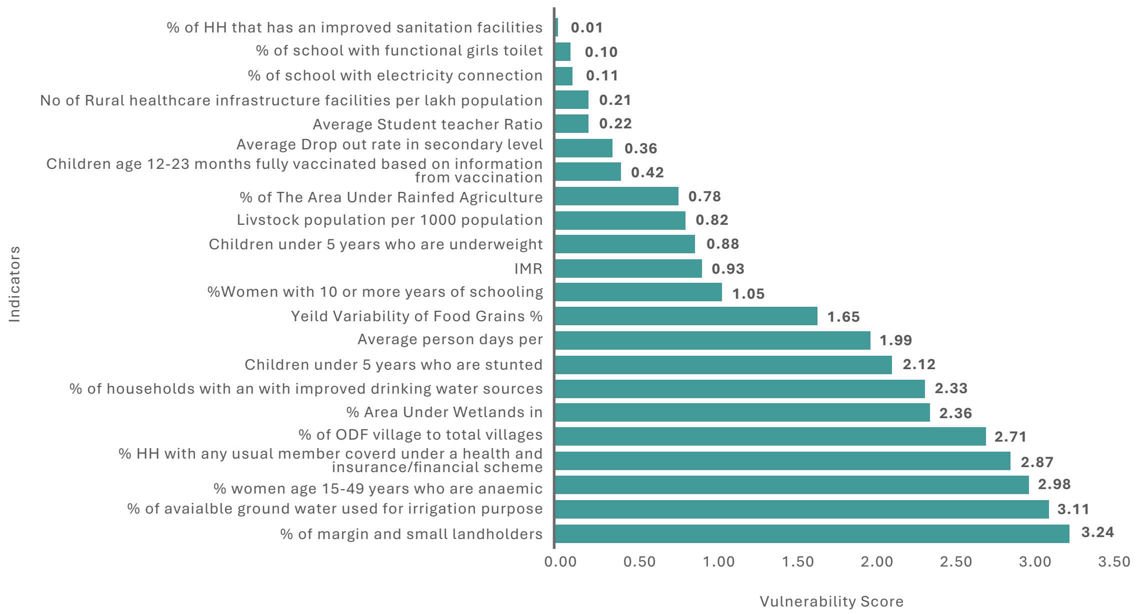


# Area of concern

The vulnerability assessment of the district reveals critical areas of concern across multiple sectors. Among the top 10 key indicators, the high percentage of marginal and small landholders' underscores challenges in agricultural productivity, income stability, and livelihood security, indicating vulnerability in the agricultural sector. **(Chart 11)**

Excessive utilization of groundwater for irrigation purposes highlights vulnerability to water scarcity, posing risks to water resources sustainability. Moreover, the prevalence of anaemia among women of reproductive age points to vulnerability in maternal health and nutritional deficiencies. Low coverage of health insurance or financial schemes signifies vulnerability to healthcare costs and limited access to services. While progress in achieving Open Defecation Free Plus status indicates strides in sanitation, disparities persist, reflecting vulnerability in public health and environmental hygiene.

**Chart 11**




Additionally, the extent of wetlands and access to improved drinking water sources play crucial roles in water conservation and public health, reflecting vulnerabilities to environmental degradation and waterborne diseases. High prevalence of stunting among children highlights vulnerability to malnutrition and long-term health consequences, while higher employment under MGNREGA signifies vulnerability to livelihood insecurity and poverty. Finally, variability in food grain yields signals vulnerability to climate change impacts, affecting food security and agricultural livelihoods.

## Key insights for further investigation

Addressing these vulnerabilities requires a holistic approach encompassing socio-economic development, environmental conservation, and public health interventions to enhance resilience and promote sustainable development in the district.

- In agriculture, the variability in rainfall patterns and increasing temperatures can disrupt crop cycles, leading to reduced yields and economic losses for farmers. Excessive rainfall or drought conditions can exacerbate soil erosion, waterlogging, and crop failures, impacting food security and livelihoods. Additionally, changes in temperature and precipitation patterns may favour the spread of pests and diseases, further compromising agricultural productivity.

- Health outcomes are also influenced by climate-induced risks. Rising temperatures can increase the incidence of heat-related illnesses, vector-borne diseases, and respiratory ailments. Inadequate access to clean water and sanitation facilities, exacerbated by erratic rainfall patterns, can contribute to waterborne diseases and hygiene-related health issues. Vulnerable populations, including children, the elderly, and those with pre-existing health conditions, are particularly at risk.

- The education sector may face disruptions due to extreme weather events, such as floods or cyclones, which can damage school infrastructure and disrupt learning activities. Additionally, heatwaves and poor air quality may impact students' ability to concentrate and participate in educational activities, affecting academic performance and their overall well-being.

- Water and sanitation services are vulnerable to climate-induced risks, with changes in precipitation patterns affecting water availability and quality. Drought conditions can lead to water scarcity, hindering access to safe drinking water and sanitation facilities. Flooding events can contaminate water sources and damage sanitation infrastructure, increasing the risk of waterborne diseases and environmental pollution.

Hence, addressing climate-induced risks in Virdhunagar district requires comprehensive adaptation and mitigation strategies across sectors. This includes implementing climate-resilient agricultural practices, enhancing healthcare infrastructure and services, strengthening disaster preparedness and response mechanisms in education, and investing in sustainable water and sanitation solutions. Collaborative efforts involving government agencies, civil society organizations, and local communities are essential to build resilience and mitigate the impacts of climate change on vulnerable sectors in the district.

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