

Climate Shocks, Human Capital, and Labour Informality: Evidence from India (1990–2020)

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Abstract

The informal economy remains a defining feature of India's labour market, employing a large share of the workforce while often being characterised by income insecurity, limited social protection, and low productivity. At the same time, climate-related disasters and disruptions in educational continuity have emerged as important challenges affecting labour market outcomes in developing economies. This study attempts to examine the relationship between climate-related disaster shocks, educational outcomes, and the size of the informal economy in India from 1990 to 2020. Using data sourced from the World Bank, disaster databases, and national education indicators, the paper analyses the correlation between the number of people affected by climate-related disasters, gross enrollment ratios, and the estimated size of the informal economy. The quantitative analysis reveals a strong negative relationship between educational enrollment and the size of the informal economy, suggesting the role of education in improving labour market outcomes. In contrast, the climate-related disaster variable does not show a statistically significant relationship at the national level, indicating the possibility of spatially concentrated effects. To further explore these dynamics, qualitative case studies across several Indian states highlight how climate shocks disrupt traditional livelihoods, trigger migration, and increase reliance on informal employment. Overall, the paper highlights the complex relationship between climate vulnerability, human capital formation, and labour market informality, emphasizing the need for policies that strengthen education systems and climate-resilient employment opportunities.

Keywords: Informal Economy, Climate Disasters, Education, Labour Markets, India

1. Introduction

The informal economy— comprising unregistered, unregulated and often unprotected forms of employment plays a central yet paradoxical role in economies around the globe. While it absorbs surplus labour, provides livelihoods in the absence of sufficient formal jobs and contributes

significantly to economic output, it is also characterised by income insecurity, exploitation of labour, lack of social protection and limited skill enhancement. A persistently large informal sector also limits tax revenues, lowers labour standards and slows long-term structural transformation, adversely shaping both growth trajectories and inequality outcomes.

In the case of India, the informal economy employs over 80% of the workforce and generates nearly half of the country's surging GDP. The sector has witnessed a steep growth between 1990 and 2020 but unfortunately, this growth was shaped in part by catastrophic disasters that exploited existing vulnerabilities in rural livelihoods. Alongside this, climate change and the rising frequency of natural disasters have emerged as an alarming global concern, particularly for developing countries like India. Climate-related shocks are no longer rare or isolated events—they keep on becoming more frequent, intense and economically disruptive, making this a critical moment to examine their developmental consequences. The unforeseen natural disasters wreck farming jobs and push rural workers to urban cities for unregulated work like street vending and construction. In an agrarian economy such as India, agriculture still supports about half of our labor force and relies heavily on unpredictable monsoons—making it extremely important and extremely susceptible. Events like the 1999 Odisha supercyclone that destroyed coastal farms and killed over 10,000 people, the 2008 Kosi floods in Bihar that submerged millions of acres and the harsh 2002 and 2015 droughts in parts of the Ganga basin led to significant yield losses have proved the vulnerability of the agricultural sector in India. These shocks—over 1,000 from 1990 to 2020—not only damaged produce and displaced workers on a huge scale but also disrupted schooling in affected families, who focused on survival income instead of education. As a consequence, these natural disasters are associated with persistent low-skill informality across generations and regions. What often turns these natural disasters into social and economic disasters, often too big to contain, is how they shatter communities and livelihoods beyond just the initial strike.

This connection raises major apprehensions: it threatens India's push for the UN's 2030 Sustainable Development Goals, especially SDG 4 (quality education), SDG 8 (decent work), and SDG 13 (climate action), leaving some 500 million informal workers unprotected as climate risks grow. Efforts like the 2008 National Action Plan on Climate Change and 2015 Skill India Mission helped with tougher infrastructure and training, but their impact remained limited,

inaccessible and unequal . For India, with its young population and rising climate threats, this is a pressing socio- economic concern as it risks trapping millions in low-productivity jobs, slowing overall growth and widening inequality in an already divided economy.

Our study asks: How do climate-related disaster shocks and education outcomes shape the size of India's informal economy from 1990–2020? Climate is chosen as a driver here because its shocks cause sudden, clear disruptions – unlike gradual, structural changes—making it possible to trace cause and effect with case studies and detailed qualitative analysis. Education is central to this analysis as it is a key determinant of human capital formation and one of the three core components of the Human Development Index (HDI), alongside health and income. Disruptions to education during disaster periods can have long-term effects on labour productivity and mobility while also adversely affecting employment quality. Climate disasters can disrupt rural incomes, often leading to migration without adequate skills to access formal employment, while education losses in disaster areas push families into a vicious cycle of poverty by limiting human capital. Methodologically, this study adopts a mixed approach, combining qualitative analysis with a linear regression framework to provide supporting macroeconomic evidence.

Our study finds that improvements in educational access are strongly associated with reductions in labour market informality, while the impact of climate shocks appears more localised and mediated by regional conditions. It argues for integrated policy interventions that combine climate resilience, education reform and targeted skill development to enable a transition toward more secure and formal employment.

2. Literature Review

Through the lenses of migration due to natural calamities rummaging in different states of India and its effects on educational continuity of the population native to the state, the informal sector economy has been deeply studied. The study can be divided under two headings – Effects of climate and Impact of education.

2.1 Why informality matters?

India is home to the world's largest informal economy. As per National Accounts Statistics, the informal sector contributed about 45% to the total GDP of the economy in FY 2022-23. The informal sector faces a lot of precarity due to the nature of its job and lack of formalised

recognition. The workers face significant challenges on grounds of safety, security and stability of their jobs. Moreover, natural disasters or climate related changes result in shifting of workers to other formal or informal sectors and their vulnerability to the circumstances leave them in an uncertain position in the economy. Their acceptance rate depends on a lot of factors such as educational qualifications, vocational training skills, family planning, status of livelihood, etc. Our research paper seeks to establish a relationship between the educational qualification of workers and the effect of disasters on the informal sector economy and sectoral movements.

2.2 Effects of climate

Findings by Shelley Liu and Alice Xu in 2025 suggest that marketers in Monrovia face climate-related precarity in their ability to sell and through disruptions to the supply chain. It has been found that marketing makes up an especially large proportion of the informal sector in Liberia, migrant workers are likely to take on positions as marketers into the system and further strain an already crowded space. This shows that when climate disasters strike the informal sector, it worsens income security for the already existing workers as well as for the new entries into the sector.

Research by Jonathan Colmer (2014) says that economic loss in agricultural productivity due to aggressive climate change is balanced by workers by reallocating themselves into other sectors like manufacturing units. However, the benefits of labour reallocation are attenuated by direct adverse effects of temperature on manufacturing activity. The economic benefits in the form of increased productivity and output growth from the sector these workers have shifted to become less significant because these sectors (the manufacturing sector, here) face damage and losses being hit by the same climate change.

The study by César Andrés Mendoza and Benjamin Jara (2019) on the 2016 earthquake in Ecuador shows that people living in earthquake-affected areas were more likely to move into the informal sector after the disaster. However, the overall probability of being informally employed did not change much. This suggests that many workers who were earlier in formal jobs shifted into informal work after the earthquake, while those already in informal employment remained informal. The researchers also found that men were more likely to experience changes in their level of informality due to the earthquake, but there was no significant change for women. This

indicates that women often have fewer alternatives and are already pushed into informal work, regardless of such shocks or they might drop out of the labour force completely.

Victoria Wenxin Xie (2024) concludes using data from Brazil that heat shocks lead to a higher probability of manufacturing worker layoffs and a significant 16.7% of all manufacturing workers who were laid off due to heat shocks failed to find another formal job within 36 months. This shows that the formal labour market adjustment is accompanied by increases in unemployment, as well as worker transitions to informal sectors and this causes persistent labour market impacts in the medium run. This research is strongly relevant for the heatwaves that are faced by northern India which has a significant impact on the informal sector, especially agriculture.

2.3 Impact of education

A paper by Sharma, Kumar and Meher (2002) shows that while education has increased the proportion of educated workers in India's labour market, it has simultaneously coincided with shrinking formal job opportunities and increasing casualisation even among educated workers, indicating that education has not insulated workers from informal or insecure employment. This shows that even educated workers are forced to accept underpaid jobs and join the informal economy due to shrinking job scope in the formal sector.

Albert Park and Xiaobo Qu find a significant gap in the returns to education for formal workers as compared to informal in China, and especially between those working in the formal and informal sectors. The return to a year of schooling is 11.1 per cent in the formal sector and just 4.2 per cent in the informal sector. This large difference in the returns to education suggests unexploited arbitrage opportunities and definite labour market segmentation between the two sectors.

Ann-Sofie Kolm & Birthe Larsen's work in 2016 proves that informal activities reduce the incentives to acquire higher education if informal employment opportunities mainly are available to low-educated workers and more zealous enforcement policies will in this case improve educational incentives as it reduces the attractiveness of remaining a low-educated worker.

Balwant Singh Mehta & Ishwar Chandra Awasthi's research in 2022 indicates that affirmative policy has helped the marginalised group in accessing formal sector employment, particularly highly educated individuals have benefited more than others. This suggests that education plays a significant role in bringing the informal sector towards a formalised one. The paper also states that policies guaranteeing minimum social security and social protection are inevitable to mitigate the hardships of vulnerable urban informal sector workers especially those belonging to lower income groups and with lower educational levels.

Though there are quite a significant amount of research papers focussed on determining how migration affects educational attainment and its continuity, there is a glaring lacuna in the field of how climate induced migration or migration due to natural disasters affect education of the children in both rural and urban areas. Most research studies have focused on regional vulnerability assessments, governance frameworks, and environmental impacts while not giving enough emphasis to direct consequences on education and the literacy rate. Such a gap has underlined the necessity for more targeted research, where it studies the effects that climate change-induced migration will bring about on migrant families including the marginalised communities in terms of changes in income, employment opportunities, and access to resources. Addressing this gap becomes important to determine targeted policies for a higher literacy rate and equal access to education for all. Our research paper seeks to establish a relationship between the educational qualification of workers and the effect of disasters on the informal sector economy and sectoral movements.

3. Research Methodology

The research paper study employs a mixed-methods approach to examine the relationship between climate-related disaster shocks, education outcomes, and labour market informality in India between 1990 and 2020. The analysis combines qualitative evidence with a supporting linear regression framework to capture both the economic mechanisms and the macroeconomic patterns underlying labour informality in the country.

3.1 Quantitative Methods

3.1.1 Indicators and Database Selection

The study intentionally selects the size of the Informal Economy, Climate-related Disasters and Gross Enrollment Ratio as key variables to analyse how climate stress and human capital conditions influenced the informal sector in India from 1990 to 2020.

The study has considered the informal economy as the dependent variable, measured using the World Bank's Dynamic General Equilibrium (DGE) model-based estimate of informal output. The indicator is selected because it provides a macro-level measure of informal economic activity, which is otherwise difficult to estimate using conventional official statistics. Since our research focuses on understanding how external, sudden shocks affect the informal sector, this measure allows for trend analysis across decades.

Climate-related disaster frequency and the number of people affected are used as key explanatory variables. These indicators capture not only the occurrence of climate disasters but also their human impact. Frequency reflects how often economies face climate shocks and the number of people affected shows the scale of social and economic disruption faced. Together, these variables act as a proxy for climate stress on livelihoods, which is expected to push vulnerable, susceptible populations into informal work.

Gross Enrollment Ratio is used as a stand in for access to education and formation of human capital. Education is associated with differences in skill levels, employability, and access to formal sector jobs. Lower enrollment is often associated with more limited access to formal employment opportunities and a higher likelihood of turning to informal employment. Including this variable helps us to examine whether weak human capital conditions amplify the effect of climate shocks on the informal economy of the country.

3.1.2 Model Specification

The linear regression is employed as supporting macroeconomic evidence to examine the relationship between climate-related disaster shocks, education outcomes and the size of the informal economy in India from the years 1990 to 2020. The dependent variable is the size of the informal economy, measured using Dynamic General Equilibrium (DGE) model based estimates

of informal output from the World Bank’s Informal Economy Database, which provide a consistent measure of informality over time. Climate-related shocks are captured using the frequency of disasters and the total number of people affected, sourced from the EM-DAT database and the IMF Climate Data platform. Education outcomes are measured using the Gross Enrolment Ratio to capture changes in human capital accumulation. The specification follows a reduced-form DNF-type framework, where disaster exposure and education enter jointly to explain variations in informality, with the regression interpreted as indicative macroeconomic evidence supporting the qualitative analysis.

3.2 Qualitative Methods

The qualitative component forms the primary basis of the analysis and focuses on 11 Indian states, selected to reflect regional variation in susceptibility to climate shocks, agricultural dependence and employment structure. This component draws on secondary sources including disaster reports from the central and state governments, news anecdotes, media interviews and academic research papers. The qualitative analysis traces the pathways through which climate induced shocks disrupt agricultural livelihoods, interrupt schooling and influence labour market outcomes, with closer attention to distress migration and long-term shifts toward informal employment.

4. Analysis

4.1 Regression Results

Primary Education

Variable	Coefficient	Standard Error	t-statistic	P-value
Intercept	58.95	8.66	6.81	0.000001
X1 = People affected by climate-related disasters (lagged)	-5.19×10^{-10}	7.26×10^{-9}	-0.07	0.944
X2 = Primary gross enrollment (lagged)	-0.384	0.087	-4.39	0.00025

Model Statistics:

$R^2 = 0.503$ Adjusted $R^2 = 0.456$ F-statistic = 10.63 (p = 0.00065)

Estimated regression equation:

$$Y = 58.95 - 5.19 \times 10^{-10}(X_{1t-1}) - 0.384(X_{2t-1})$$

A one-unit increase in lagged primary gross enrollment is associated with a 0.38-unit reduction in the size of the informal economy, holding climate-related disaster impacts constant. This coefficient is statistically significant at the 1% level ($p = 0.00025$). In contrast, the lagged climate-related disaster variable is statistically insignificant ($p = 0.944$), suggesting no statistically significant association with informality within this specification. The model accounts for approximately 50% of the observed variation in the informal economy.

Secondary Education

Variable	Coefficient	Standard Error	t-statistic	P-value
Intercept	34.80	0.74	47.18	< 0.0001
X1 = People affected by climate-related disasters (lagged)	-5.58×10^{-10}	1.52×10^{-9}	-0.37	0.717
X2 = Secondary gross enrollment (lagged)	-0.250	0.012	-20.06	< 0.0001

Model Statistics:

$$R^2 = 0.948 \quad \text{Adjusted } R^2 = 0.943 \quad \text{F-statistic} = 201.2 \quad (p < 0.0001)$$

Estimated regression equation:

$$Y = 34.80 - 5.58 \times 10^{-10}(X_{1t-1}) - 0.250(X_{2t-1})$$

A one-unit increase in lagged secondary enrollment is associated with a 0.25-unit reduction in the size of the informal economy, holding other factors constant. The coefficient is highly statistically significant ($p < 0.0001$), indicating a strong negative association. The lagged climate-related disaster variable remains statistically insignificant ($p = 0.717$). This model exhibits a high explanatory power, accounting for nearly 95% of the variation in informality.

Tertiary Education

Variable	Coefficient	Standard Error	t-statistic	P-value
Intercept	26.03	0.38	68.52	< 0.0001
X1 = People affected by climate-related disasters (lagged)	6.25×10^{-10}	1.82×10^{-9}	0.34	0.735
X2 = Tertiary gross enrollment (lagged)	-0.358	0.021	-17.03	< 0.0001

Model Statistics:

$R^2 = 0.933$ Adjusted $R^2 = 0.926$ F-statistic = 145.3 ($p < 0.0001$)

Estimated regression equation:

$$Y = 26.03 + 6.25 \times 10^{-10}(X1_{t-1}) - 0.358(X2_{t-1})$$

A one-unit increase in lagged tertiary enrollment is associated with a 0.36-unit reduction in the size of the informal economy, holding climate-related disaster impacts constant. The coefficient is highly statistically significant ($p < 0.0001$). The lagged climate-related disaster variable is statistically insignificant ($p = 0.735$). This model explains approximately 93% of the variation in the informal economy.

4.2 Interpreting Regression Results

The regression results across the three education levels provide consistent macro-level evidence supporting the patterns observed in the qualitative analysis. Lagged gross enrollment ratios are negatively related in all models, indicating that higher levels of educational participation in the previous period are associated with a smaller size of the informal economy in the current period, holding the impact of climate-related shocks constant.

In contrast, the lagged climate-related disaster variable remains statistically insignificant across all three models. The estimated coefficients are small and the p-values are high, suggesting that, at the aggregate level, the number of people affected by climate-related disasters does not exhibit a statistically significant association with informality. Climate disasters tend to cause localized disruptions and sector-specific displacement, which are unlikely to produce proportional changes in the overall size of the informal economy. The lack of statistical significance highlights the

limitations of macro-level regression for capturing heterogeneous and spatially concentrated effects.

Model fit statistics show high explanatory power for secondary and tertiary education, indicating that enrollment at higher levels aligns with long-term structural shifts in the labour market. These results suggest that education reflects persistent economy-wide dynamics such as skill formation, employability, and access to formal employment, while climate-related stressors operate through channels better captured by qualitative and region-specific analysis.

4.3 Qualitative Evidence on Climate-Induced Informalisation

While quantitative regression analysis is helpful in establishing macro-level associations, it often fails to capture the ground reality. Especially while dealing with something geography and society-specific such as climate and its relation to the informal economy, it is important to delve into the details of how they are correlated.

This qualitative analysis traces the causal pathways linking climate-related shocks to labour market outcomes at the ground level. Drawing on state-level reports, investigative journalism, policy documents, and academic case studies across eleven Indian states, this is an attempt to identify recurring mechanisms through which climate stressors reshape employment trajectories.

The states of Maharashtra, Karnataka, Uttarakhand, Bihar, Kerala, Tamil Nadu, Assam, Tripura, Gujarat, West Bengal, and Odisha have been selected for their diverse geographies, climatic vulnerabilities, labour market structures, and development profiles. Together, they capture India's major climate risks: droughts and heat stress (Maharashtra, Gujarat), floods and cyclones (Bihar, Assam, Odisha, West Bengal, Kerala, Tamil Nadu), landslides and glacial risks (Uttarakhand), and rising temperature stress in urban-industrial settings (Karnataka, Tripura).

Across these states, the analysis traces how climate shocks interact with pre-existing structures to generate pathways of informalisation.

4.3.1 Disruption of Subsistence Livelihoods

A common impact of climate-related shock was the erosion of subsistence-based livelihoods, forcing large chunks of the population into the labour market.

In Maharashtra, climate variability has increasingly undermined the traditional livelihoods of marginalised communities such as the Pardhi and agricultural workers. Reports document how erratic rainfall, droughts, and water scarcity have made hunting, forest-based livelihoods, and subsistence farming non-viable, compelling households to seek wage labour without the education or skills required for formal employment. As a result, entry occurs primarily into casual agricultural labour, sugarcane cutting, brick kilns, or other informal occupations, often under exploitative conditions. (ActionAid Association, 2024)

Similarly in Uttarakhand, climate-induced landslides, forest fires and extreme rainfall have destabilised the mountain agrarian systems. Case studies from Uttarkashi and other hill districts show that the decline of agriculture has pushed households into distress labour migration, engaging in informal work such as daily wage construction, road work, and tourism-related services with no contractual security. (Prakash, 2012; Sati, 2022)

In these cases, there is creation of new labour market entrants rather than reallocation of labour. Majorly from marginalised communities, this section of the population with low education and skills is not eligible to enter the formal labour force and thus gets absorbed in the informal sector.

4.3.2 Climate Induced Migration and Sectoral Movement

Disruptive climatic conditions such as floods, droughts, and cyclones create ‘environment refugees’ through distress migration. This migration often occurs abruptly, without adequate time for skill acquisition or job matching, resulting in high informal absorption.

In Bihar, repeated flooding along the Kosi and Gandak river basins has led to chronic displacement and seasonal migration. Empirical studies from East Champaran and other districts document how flood-affected households migrate to urban areas or agriculturally rich regions, often entering informal construction, brick kiln work or petty services. The sudden nature of

migration and the absence of social networks in the destination areas reinforce informality through occupational downgrading. (Kumar et al., 2016; Richa & Sen, 2024)

Home to the mighty Brahmaputra river, Assam is prone to floods and soil erosion. Rural households are displaced almost annually. Studies highlight how displaced workers transition into informal urban labour or precarious rural wage work, often cycling between migration and return depending on flood intensity. (Das, 2020; Juned, 2022)

In the coastal states of Odisha and West Bengal, cyclones and recurring coastal floods have forced agricultural workers to migrate to construction and informal industrial work. The most notable 1999 super cyclone caused widespread disruption, with its effect visible even a quarter century later. Reports explicitly note how climate stress accelerates occupational shifts away from agriculture but fails to provide pathways into formal employment, instead deepening informality. (UNICEF, 2000; Bhattacharyya, 2025)

This process-tracing evidence is consistent with the hypothesis that climate shocks act as push factors, reallocating labour across sectors while structurally favouring informal employment outcomes.

4.3.3 Loss of Formal Employment

Beyond individual livelihood disruption, climate shocks also reduce overall economic activity, directly eroding formal employment opportunities and indirectly expanding informal work.

In Tamil Nadu, the Chennai floods resulted in significant job losses in the MSME sector, with estimates of tens of thousands of workers losing formal or semi-formal employment. Media and policy reports indicate that many displaced workers subsequently shifted into informal self-employment or casual labour, as enterprises struggled to recover and rehire formally. (“Sample survey of losses sustained during Chennai floods,” 2016)

Maharashtra’s Vidarbha region presents a parallel case, where prolonged droughts and climate stress have reduced agricultural incomes and non-farm rural employment, leading to a decline in

regular wage work and an increase in daily-wage informal labour. (ActionAid Association, 2024; Vedeld et al., 2014)

In Karnataka, rising temperatures and heat stress have reduced productivity and earnings in informal and formal sectors alike, but formal employment losses have had a particularly strong spillover effect, pushing workers into app-based, casualised, or unregulated labour markets. (Balasubramanian et al., 2022; Surie & Sharma, 2019)

These cases illustrate that climate shocks may contribute to labour informalisation not only through entry mechanisms but also through formal sector exit. Moreover, the informal sector may also fail as an absorbent sector, increasing unemployment.

4.3.4 The Unequal Gendered Burden of Distress

Across almost all states, climate-induced labour informalisation is deeply gendered.

In Maharashtra, Karnataka, Bihar, Assam, and West Bengal, reports consistently show that women face heightened vulnerability following climate shocks. While men often migrate in search of work, women are frequently left behind in affected areas, bearing increased unpaid care burdens while also losing agricultural or allied employment opportunities. (ActionAid Association, 2024; Balasubramanian et al., 2022; Kumar et al., 2016; Das, 2020; Bhattacharyya, 2025)

In flood and cyclone-prone regions, women's limited mobility, lower access to education, and concentration in informal agricultural and home-based work restrict their ability to transition into alternative employment. Several sources also document increased incidences of gender-based violence and economic insecurity following disasters, further constraining women's labour market participation.

These findings indicate that climate shocks not only expand informality overall but also intensify existing gender inequalities within informal labour markets.

4.3.5 Policy Implications and Divergent Outcomes

While the dominant pattern points toward informalisation, the qualitative evidence also identifies important deviations, which are analytically valuable.

Kerala stands out as a case where post-disaster contexts, particularly after the 2018 floods, were associated with rising informal wages in certain sectors. Studies document increased demand for construction and reconstruction labour, leading to short-term wage gains for informal workers, including migrants. While these gains did not correspond to increased formalisation, they reflect demand-driven improvements within informality. A key reason behind this improvement was a decreased informal labour supply due to MGNREGA. (Beyer et al., 2022)

Similarly, in other regions with effective implementation of MGNREGA, climate shocks did not uniformly translate into informal labour market entry. Evidence from Maharashtra, Odisha, and parts of Bihar indicates that guaranteed public employment acted as a buffer, absorbing climate-affected workers and preventing distress migration into informal urban labour markets. This suggests that institutional factors can mediate the climate–informality relationship.

	Mechanism	States	Indicative Evidence
Subsistence Disruption	Collapse of traditional livelihoods	Maharashtra, Uttarakhand, Odisha	Forest-based and agrarian livelihoods rendered non-viable by droughts, floods, landslides
Labour Market Entry	Low education leading to informal entry	Maharashtra, Bihar, Assam	New labour entrants absorbed into casual wage work
Distress Migration	Rural–urban migration	Bihar, Assam, Odisha, Bengal	Flood-induced migration into construction and services
Sectoral Shift	Agriculture to construction	Bihar, Odisha, Tamil Nadu	Climate shocks accelerate occupational shifts
Formal Job Loss	Economic contraction	Tamil Nadu, Maharashtra, Karnataka	MSME shutdowns, loss of regular wage employment

	Mechanism	States	Indicative Evidence
Informal Wage Dynamics	Post-disaster labour demand	Kerala	Reconstruction raises informal wages without formalisation
Policy Buffer	Public employment	Maharashtra, Odisha, Bihar	MGNREGA absorbs climate-affected workers
Gendered Impact	Women's job loss and immobility	All states	Heightened care burden, violence, exclusion from migration

4.3.6 Synthesis

The qualitative evidence across the eleven states indicates that climate-related shocks play a substantive role in shaping labour market outcomes in India, particularly by reinforcing pathways into informal and precarious employment. These impacts do not operate through a single, uniform channel but instead emerge through multiple, interlinked processes that unfold at the local and sectoral levels.

Across diverse geographic contexts, climate shocks undermine subsistence livelihoods, trigger distress migration, and reduce local economic activity, thereby narrowing access to stable and formal employment. Workers affected by droughts, floods, cyclones, and heat stress often enter the labour market suddenly, without the education, skills, or networks required for formal work, resulting in absorption into informal sectors such as construction, casual agriculture, and petty services. These processes are especially pronounced in regions with high dependence on climate-sensitive livelihoods and limited employment diversification.

At the same time, the analysis highlights that the labour market consequences of climate shocks are strongly shaped by institutional and policy environments. In areas where public employment programmes and social protection mechanisms were accessible, most notably through MGNREGA, climate-induced displacement and livelihood loss did not translate as directly into informal labour market entry. Such interventions acted as stabilising mechanisms, absorbing labour during periods of climatic stress and reducing reliance on distress migration and precarious work. Conversely, where these institutional buffers were weak or unevenly implemented, informalisation pressures were more acute.

The case of Kerala further illustrates that climate shocks do not uniformly worsen labour outcomes, even within the informal sector. Post-disaster reconstruction created short-term demand for labour and, in some instances, raised informal wages. However, the persistence of informal employment in these contexts underscores that recovery-led labour absorption, while beneficial, does not automatically lead to formalisation in the absence of sustained labour market reforms.

A cross-cutting finding concerns the gendered nature of climate-induced labour transitions. Women consistently face disproportionate burdens following climate shocks, including loss of livelihood, increased unpaid care responsibilities, restricted mobility, and heightened exposure to violence. These factors constrain women's ability to engage in alternative employment and often push them into more insecure and invisible forms of informal work. The absence of gender-responsive labour and disaster policies therefore deepens existing inequalities within informal labour markets.

Taken together, these findings suggest that the impact of climate change on labour informalisation is real but uneven, indirect, and institutionally mediated. Climate shocks expose structural vulnerabilities within labour markets rather than acting as isolated drivers of informality. As a result, their aggregate effects may appear muted when measured through broad macro indicators, even as their consequences are strongly felt at the ground level.

4.4 Qualitative Evidence on Impact of Education on Informalisation

While studying education and its impact on the size of the informal economy, several challenges are faced on a macro level study including lack of accurate data and the high degree of diversity in a country like India. In these cases, a qualitative study can provide more insight into the dynamics and help us in understanding it better.

To fulfill this objective, a qualitative analysis of education levels and quality, vocational training and informal sector of 8 states and the North Eastern region has been conducted. The states have been chosen as such to cover the varying levels of literacy rates and economic development in the country. The analysed states are Maharashtra, Karnataka, Uttarakhand, Bihar, Tamil Nadu, Gujarat and West Bengal, Kerala and the North East. Academic research of both quantitative and

qualitative analysis has been used including secondary data analysis, primary survey based papers, descriptive and theoretical papers.

4.4.1 The Educational Pipeline into Informality

In a study (Rode, 2015) conducted in the Mumbai district of Maharashtra using household data from 8 slums, it was found that men and women who had acquired secondary and tertiary education were more likely to be working in regular jobs while workers who only had a high school education were mostly working casual jobs. According to the survey, only 12.85% of illiterate men are working regular jobs, while 76.07% are employed in casual jobs. For women, the ratios are more balanced at 46.23% illiterate women in regular jobs and 43.40% in casual jobs. It is also observed from the surveyed sample that 66.67% of college educated men are employed in regular work while only 16.67% are employed in casual work. Additionally, the percentage of workers employed in regular work increases with every additional level of education. The majority of the workers in the area possess traditional skills passed down through families, neighbours and friends. Most workers have little formal education or training.

In West Bengal's district, Hooghly, a primary survey was conducted of 13 corporations/municipalities and 28 village blocks. The study (Banerjee & Kundu, 2020) discovered that the percentage of regular wage earners was high in the least and highly educated workers but for different reasons. People having acquired 1-4 years of education, opted for low wage regular jobs that did not provide income but gave stability. People having acquired secondary education, mostly opted for self employment and entrepreneurship and workers with more than 10 years of education opted for regular work but with higher wages. This study explores how people with low education qualification who obtain regular jobs, don't get financial stability and are usually at the bottom of the formal sector hierarchy.

Another study (Ghosh, 2001) in West Bengal studies women's work in the informal sector, primarily studying rice mills and nursing homes. They conclude that the education level of most of these workers is extremely low with very few who have studied past class VIII. From the sample, 50% of the employees are illiterate and only 6% have studied till class IXth-Xth.

A 2002 survey in Gujarat (Unni & Rani, 2002) state with a sample size of 1,236 workers put forth that in their household survey, a majority of the casual workers were illiterate (51%) and they also faced more irregular work. At the same time 86% of the regular workers were literate and barely any of them faced irregular work.

A study conducted in North East India (Devi & Upadhyay, 2016) explains how the majority of the workforce in the informal sector are women, elderly people and youngsters. Assam has 90% of its workforce in the informal sector and a disproportionate share of it is uneducated women.

A state that stands in contrast to the evidence so far, is Kerala. Kerala has the highest literacy rates in the country, however it also has major unemployment problems. A majority of these educated and unemployed people tend to shift into unorganised and unregistered sectors in Kerala. A study (Deepa, 2018) also found that even though most of the people were literate, very few people in the informal sector had technical degrees/skills. However, interestingly, this study finds that unemployment in Kerala is higher in the educated population, rather than the uneducated ones. This has been attributed to the fact that the educated population is averse to jobs that require manual labour and therefore not inclined to take them up if offered. However, a bigger reason for this phenomenon is cited as the inability of the government to create productive job opportunities in the formal sector that can hire these workers. This brings forth another dimension of the informal sector, implying that mere education is not enough to decrease the size of the informal economy but instead there needs to be equal, if not more focus on creating jobs in the formal sector in the first place.

4.4.2 The Broken Bridge: Education Quality and Skill Relevance

When talking about the impact of education and skill training on employability, it's important to analyse the quality and accessibility of education in India.

According to a survey conducted in Dehradun, Uttarakhand, among 316 college students, it was concluded that the present state of traditional higher education does not improve skills or increase employability of the students. The paper argues that the education is not even equipping the students with basic marketable skills like their domain knowledge.

Another 2020 study in Uttarakhand (Bhatt, 2020) analyses how even though the number of government schools have increased, there has been a decrease in enrollment rates in government schools. Some of this change can be attributed to movement of students from government to private schools but that doesn't fully explain the change. Additionally, there is a lack of higher education institutions in hilly areas. In the established institutions, it is observed that education doesn't focus on key job providing sectors which supports the previous study in explaining the inability of education in skill enhancement.

A 2002 survey in Gujarat (Unni & Rani, 2002) state with a sample size of 1,236 workers identified that most informal sector workers were unskilled or had very low level of skill. Their source of skill attainment was recorded and the paper concluded that there was heavy dependence on informal sources of skill acquisition or upgradation. Only about 7% of the workers acquired their skills from formal sources while around 30% did from friends, family and 66% while being on their job.

A study based in North East India (Sarkar, 2020) finds that formal vocational education programs don't make a noticeable difference in earnings in the informal sector. The paper connects this to poor quality of education, outdated curriculum and lack of strong teachers. This further elucidates how simply having more educational institutions and programs doesn't work unless their quality is maintained.

4.4.3 Barriers to Exit: Why the Cycle Persists

In order to understand the connection between these two factors and the long term implications, we analyse the state of education and the rationale behind engaging in work instead of education at a young age.

In Karnataka (Chandrashekhar & Arpitha, 2022) , the drop out rates of educational institutions was estimated to be around 63% for students aged 5-14 and 88% after 15 years of age. At the same time, workforce participation rate increases intensely after 14 years of age. Both of these together produce a semi-skilled workforce that is usually pushed into the informal sector or in low paying jobs in the formal sector. The study also identified that in some cities of Karnataka,

there are high dropout rates due to transportation costs, lack of accessibility to the marginalised sector and due to the opportunity cost of work. These dropout rates increase even further for female students due to gender bias still prevailing in households. The study also explains that around 90% of the workforce in Karnataka is engaged in the informal sector.

On top of that, only 2.5% of the workers in the informal sector receive formal skill training, compared to 11% in the formal sector. This implies that around 85% of the workers in the unorganized sector lack proper training or skill development.

According to a secondary data analysis (Karim, 2022) conducted on the state of Bihar in 2022, it was concluded that school enrollment of both men and women decreased as they moved from primary to secondary education. Additionally, Bihar's Gross Enrollment Ratio was at 58% which is lower than the GER of India (77%). The state also has a higher than average dropout rate (27%).

Analysis conducted in Gujarat's Ahmedabad (Unni & Rani, 2001) shows that despite a primary school being available in the neighbourhood, 24% of the households did not send their children to school. Several reasons have been sighted for this including students taking part in income generating activities to assist in finances of the household. Even out of the students attending school, 4% were engaged in income generating activities after school timings.

The 2001 study conducted in Bengal (Ghosh, 2001) also noticed how the majority of the women employed in the informal sector had a poor educational background due to lack of resources in the family, gender bias and low education level of the parents. The paper also expressed how for most of these families it was common to get their children to engage in income generating activities or househelp. Furthermore, this tendency is even higher for girl children.

4.4.4 The Vicious Cycle: Intergenerational Lock-in

It has been observed that the lack of education in the workers and financial constraints in households not only impact current income but also continue this cycle of illiteracy and informal employment into the next generation.

A study in Bihar (Singh & Narayan, 2023) among brick kiln workers revealed that due to the parents being unable to provide proper arrangements to their children, the children were also not inclined to study and neither got the opportunity to do so.

In a study conducted in the Mumbai district of Maharashtra (Rode, 2015) using household data from 8 slums, it was observed that the income of the regular worker is higher as compared to the casual workers and self-employed.

Additionally, as discussed above in the cases of Bengal, Bihar and Gujarat, this financial constraint pushes the next generation out of schools into employment generation activities at a young age. Because of these dropouts from the educational process and lack of formal skill development programs, the children of a majority of these informal workers are also unable to procure jobs in the organised sector.

4.4.5 Policy Interventions and their Limitations

The government of India has undertaken several skill enhancement programmes for the workers in the informal sector. Two of the most widely implemented schemes are the Pradhan Mantri Kaushal Vikas Yojana (PMKVY) and Skill India mission (2015).

PMKVY is a flagship training scheme of the new Ministry of Skill Development & Entrepreneurship (MSDE). It is an outcome based scheme where financial reward is provided to trainees who are able to successfully complete the training and gain skill. The aim is to enable a large proportion of the Indian youth to gain skill training and become employable, in turn boosting the productivity and economic growth of the country.

A 2022 primary survey based study (Nehru, 2022) was conducted in Haryana which has the highest unemployment rate in the country. The study found that out of the participating candidates, 90% did not get job opportunities relevant to their skill training. Only 15% candidates could secure employment after the program and from those employed, 44% were working in jobs irrelevant to their area of expertise.

Another extensive study conducted in Madhya Pradesh (Shinde & Gupta, 2022) among tractor operator trainees and harvester operator trainees concluded that post the PMKVY, majority of the tractor operator trainees (46%) and harvester operator trainees (51.33%) had acquired a high level of skill.

National Skill Development & Entrepreneurship Policy (2015) was an umbrella policy to cover all skill training activities being performed in the country. Their aim is to provide skill training at a large scale, at speed and with standards. It uses incentives like certification, accumulation of credits to encourage skilling and entrepreneurship.

The initiative's pace has remained very slow and they have not been able to achieve their target of skilling 400 million workers by 2022. Despite the slow pace of the program, the workers who're skilled under it are not able to find relevant jobs due to demand-supply gaps in the labour market. However, India Skill Report 2018 shows that the scheme has made progress since there has been a rise in employability from 33% (2014) to 45% (2018).

Another paper studying Skill India's agricultural initiatives analyses how for increased enrollment and completion of goals, the trainers, institutions and other stakeholders involved are fostering elevated expectations in the trainees. They're made to believe that the certificate from the scheme will lead to easier financial assistance from the banks and other institutions. However, when these expectations are not met, it leads to distress and adverse consequences for the trainees including financial loss for some. (Sharma & Nagendra, 2016)

This is not to suggest that existing government initiatives have been ineffective. However, there is a great deal of refinement and careful execution that is required for them to benefit on the grassroots level.

4.4.6 Synthesis

Through the analysis of the 8 states and North East India, it can be observed that not only education and informal sector have high correlation but they also feed into each other thereby producing negative long run impacts on the families involved. Lack of education and skills

doesn't allow workers to join the formal sector and instead they have to opt for the informal sector for subsistence. Informal workers are paid less than regular workers. This leads to financial despair and due to these constraints most families aren't able to provide appropriate education to their children. For the poorest sections, the children usually drop out of school to take up income earning activities to supplement the lack of financial resources. Due to their education being left incomplete, they're further pushed into the informal sector. This cycle traps families into the informal sector and into poverty.

In addition to that, education in India in several regions falls short of being able to imbibe employable skills in their students. The effectiveness and accessibility of vocational education and skill training courses is questionable and not impactful in producing major improvements.

In order to absorb employees into the formal sector, not only does the government need to focus education and skill training but also on increasing job opportunities in the formal sector itself so it is able to absorb labour that has shifted from the traditional sector into the modern economy.

5. Limitations

This paper uses time series regression with Autoregressive Distributive Lag (ARDL) along with comparative qualitative case studies of climate change induced natural disasters on different geographical regions of India. Secondary data is used for measuring the size of the informal economy, impact of natural disasters and educational continuity. The study uses a relatively small sample size of 33 observations. This can lead to high sample errors and the model might not be able to detect small changes in the variables. The data is recorded on a yearly basis for the whole country. This provides macro insight but is likely to miss out on important nuances within the country and time periods. Lack of long term data limits the analysis of long term impacts of education and climate change on the informal economy.

Since country level data is taken, it masks over state level or regional differences which becomes a notable limitation for a diverse economy like India. We have attempted to compensate for this limitation by including case studies of the major disasters in recent years, categorized on the basis of geographical characteristics, however the limitation isn't completely overcome. For data

on the informal sector, the World Bank has used informal sector output as an estimation for the size of the sector. The variable might not accurately represent the level of employment in the sector. Secondly, there is a lack of detail due to all informal activities clubbed under a single variable of informal economy. The impact of education and climate change can show up in varying ways on different sectors of the informal economy. Additionally, the Gross Enrollment Variable used for education is not sufficient to portray the quality of education and continuity within a year.

The model takes both the educational and natural disaster variables with a lag of 1 year, however, the impact of these variables on the size of the informal sector can span over several years and can vary depending on the region/sector being studied. The model suffers from a high omitted variable bias since important factors impacting informal economy like GDP growth of the country, unemployment rates, urbanisation and important government policies, among others are not included in the model. There is a possibility of reverse causality between the informal sector and education which makes the direction and magnitude of impact unclear.

The qualitative analysis studies regional influences of climate change and education on the size of the informal sector for 8-11 states. Even though the analysis allows a closer look into the phenomenon, due to the limited area of study, the results cannot be generalized to the whole country. The nature and extent of the analysis also poses limitations to drawing a clear causal relationship between the variables. Additionally, due to the diversity in geographical and economic structures, identification of important causal chains and factors is difficult. It could also lead to neglect of important factors due to lack of regional studies and databases or due to the limited scope of the study.

The period from 1990-2020 went through several major policy changes and crises including the reforms of 1991, the global financial crisis of 2008, demonetisation (2016), GST implementation(2017) and COVID-19 in 2020. These economic changes have nationwide impact on all economic variables which in turn impacts the parameters of the model, therefore, in reality the parameters might not be constant as predicted by the model. The lack of accurate data on the informal economy also poses challenges to make estimations.

Despite these limitations, our model provides important insights into the impact of educational continuity and natural disasters on the size of the informal sector in India. Some of these limitations can be mitigated through advanced econometric methods and others like regional analysis require deeper study and focus on the subject which can be a topic of future research.

6. Way Forward

The analysis suggests that climate shocks not only disrupt livelihoods but also push vulnerable populations into precarious and informal employment arrangements. At the same time, structural gaps in education and skill formation limit the ability of individuals to transition into more stable and resilient forms of employment. These interconnected challenges underline the need for policy interventions that simultaneously address climate resilience, labour market inclusion, and human capital development. The following recommendations outline possible directions through which policy can mitigate the impact of climate shocks while strengthening employment opportunities and long-term economic security.

1. Climate-Responsive Employment Guarantee

The qualitative evidence on climate shows that places with implementation of MGNREGA recorded low informality. Implemented to address rural unemployment, MGNREGA shows how employment security is not only beneficial but crucial during times of crisis. There is scope to design policies targeted at regions with high climatic vulnerability.

Proposed features-

- **Tiered Climate Vulnerability Classification:** Regions can be categorised depending on the type of climate shock they face. These categories can be on the basis of impact and immediacy, for example, acute climate shocks such as floods, cyclones and earthquakes, and slow onset climate stress such as heat waves and rising sea levels. This distinction will help devise region specific state assistance.
- **Inclusion of Skilled Labour:** Most employment guarantee schemes focus on unskilled, semi skilled and uneducated workers. However, climatic shocks affect skilled and unskilled workers alike. Thus, this scheme should make provisions to include skilled and educated labour.

- Alignment with Climate Adaptation and Risk Reduction: Employment generated under the scheme could be tied to long-term climate adaptation objectives, including flood control, water conservation, heat mitigation, coastal protection, and disaster preparedness. This would allow employment guarantees to function not only as short-term income support but also as investments in local climate resilience.

2. Modernising Traditional Livelihood Methods

A significant entrant of the informal labour market was the population forced into the labour market due to failure of their traditional subsistence based livelihood. These subsistence based methods are often deeply ingrained in the community's culture and history.

Proposed Features-

- Identification of the cultural capital allied to subsistence practices
- Incorporating modern techniques while keeping the traditional culture intact
- Link traditional occupations to formal value chains and market access without undermining community autonomy

3. Extending Women Specific Schemes

There already exist many women centric schemes. The Government of India's NAVYA (Nurturing Aspirations through Vocational training for Young Adolescent Girls) initiative aims to equip adolescent girls with demand-driven vocational skills and life-skills training, thereby enhancing employability and economic independence in underserved areas. Likewise, the "Namo Drone Didi" scheme empowers women-led Self-Help Groups (SHGs) by providing subsidised access to drone technology, training, and opportunities to offer agricultural services, which expands women's participation in technology-linked rural livelihoods. These schemes can be extended to include climate vulnerability and sustainable practices.

Proposed features-

- Skill modules can be extended to incorporate climate-resilient practices, disaster preparedness, sustainable resource management, and environmentally adaptive technologies, aligning women's skill acquisition with emerging climate-linked labour demand.

- Women-led groups and Self-Help Groups may be incorporated as contracting entities in reconstruction and recovery work following climate shocks, allowing collective participation in publicly supported employment.

4. Accessibility and Quality of Education

A significant number of students in primary school drop out due to lack of facilities like sanitation and basic hygiene. This problem is worsened for girl children.

Proposed features-

- Improve sanitation facilities and ensure access to essential hygiene resources, including affordable or free menstrual products
- Revise teaching methods in accordance with the socio-economic background of students

5. Vocational training

As shown in the above analysis, traditional education alone is not enough to impart required skills, especially to the informal sector workers. For this, we need skill training programs that are catered to the skillset needed in their industry.

Proposed features-

- State-level educational and training institutions can design programmes that reflect the dominant economic activities and skill demands of their respective regions.
- Vocational training should be accorded the same importance as academic education, with formal certification and pathways that enable workers to transition across sectors.

6. Data Collection

This study also highlights the problem of uneven data collection patterns, which limits the ability to accurately assess labour market trends and the impact of climate shocks on employment outcomes.

Proposed features-

- Integrated Multi-Level Data Systems: Coordinated data collection practices across local, state, and national levels can help improve consistency and reliability of labour market statistics.

- **Cross-Verification Mechanisms:** Data collected at different administrative levels can be used as cross-checking mechanisms, improving transparency and reducing discrepancies in reporting.

Addressing the intersection of climate vulnerability, labour market informality, and educational access requires a multidimensional policy approach. Strengthening employment guarantees, supporting traditional livelihoods, expanding women-focused initiatives, improving educational access, and enhancing vocational training can collectively contribute to building more resilient labour markets. At the same time, improved data collection systems are necessary to ensure that policy interventions are effectively targeted and continuously evaluated. Together, these measures can help mitigate the disruptive effects of climate shocks while promoting inclusive and sustainable pathways for employment and human development.

7. Conclusion

The persistence of a large informal economy remains a significant challenge for achieving inclusive and sustainable economic development in India, particularly in the context of rising climate vulnerabilities and structural gaps in education. Climate-related disasters disrupt livelihoods, displace communities, and create labour market pressures that may push vulnerable populations into informal employment. At the same time, limitations in educational access and skill development restrict the ability of workers to transition into stable and formal forms of employment. These dynamics pose important challenges for India's progress toward the United Nations Sustainable Development Goals, particularly SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action).

Using data from international databases and national education indicators, the quantitative analysis of this study finds a strong negative relationship between gross enrollment ratios and the size of the informal economy, indicating that improvements in educational participation are associated with reductions in labour market informality. In contrast, the climate-related disaster variable does not show a statistically significant relationship with the size of the informal economy at the aggregate level. This suggests that while climate shocks affect livelihoods and

employment outcomes, their impacts may be localised and mediated by regional economic structures and institutional responses.

The qualitative analysis across several Indian states provides further insight into these dynamics by illustrating how climate shocks disrupt subsistence livelihoods, trigger distress migration, reduce formal employment opportunities, and reinforce reliance on informal labour markets. These processes are often accompanied by barriers in education, skill development, and access to formal employment, which together create a cycle of vulnerability and intergenerational persistence of informal work. The findings highlight that the relationship between climate change, education, and labour market outcomes is complex and shaped by regional socio-economic conditions and institutional capacities.

Overall, the study highlights the need for integrated policy responses that simultaneously strengthen climate resilience, improve educational access and quality, and expand skill development opportunities. Such measures can help reduce structural dependence on informal employment while supporting more resilient and inclusive labour markets. Effective implementation of these policies will be essential for improving the livelihoods and economic security of millions of workers in India who remain vulnerable to both climate risks and labour market instability.

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