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Dear Professors Flammer and Giglio,
I am writing to apply for the PhD Student Workshop on Climate Finance, to be held on October 9 and 10, 2025, convened by the National Bureau of Economic Research (NBER). I am a doctoral student at the Bennett Institute for Innovation and Policy Acceleration in the Science Policy Research Unit (SPRU) of the University of Sussex Business School. My research focuses on climate finance, financial inclusion, and institutional climate resilience in developing and emerging economies. I plan to present my paper, co-authored with my supervisors (Prof. Chirantan Chatterjee and Prof. Benjamin K. Sovacool), *Warming Economies, Shrinking Credit: Climate Change and Gendered Impacts on Microfinance in BASIC Countries, 2000-2018,* which is currently under journal review and open to feedback.

My PhD dissertation explores how climate change affects microfinance institutions (MFIs) and reshapes access to credit and other financial services in low- and middle-income countries, positioning MFIs as both vulnerable actors and potential vehicles for climate adaptation. One strand of this research systematically reviews 42 studies spanning diverse geographies, climate hazards, and program models to map how microfinance intersects with climate resilience, revealing both positive adaptation outcomes and structural limitations—including institutional fragility, design flaws, and gendered access barriers. A second strand uses cross-national panel data to examine how rising temperatures affect MFI viability and borrower inclusion. Together, this work lays the foundation for subsequent papers that will empirically examine how MFIs foster household-level climate resilience and how the broader microfinance ecosystem is itself vulnerable to escalating climate risks. My broader aim is to contribute to the design of climate-aligned, equitable financial architectures that can support climate adaptation, reduce exclusion, and withstand environmental stress.

The paper I am submitting—*Warming Economies, Shrinking Credit: Climate Change and Gendered Impacts on Microfinance in BASIC Countries, 2000-2018*—examines how rising temperatures driven by global warming affect microfinance ecosystems and credit access in Brazil, South Africa, India, and China (BASIC countries). Using a triple-difference estimation strategy on panel data from 123 countries (2000–2018), the paper finds that a 1°C increase in annual temperature is associated with a statistically significant decline of approximately 24 MFIs and 156,841 active borrowers per year in BASIC countries following the 2009 Copenhagen Accord. Female borrowers alone account for over 62% of this decline, while no statistically significant effects are found for male borrowers, underscoring a gender-specific vulnerability. These findings point to an emerging climate–finance–gender trilemma, where rising temperatures threaten both institutional viability and equitable credit access. This paper aims to contribute to the climate finance literature by documenting how climate shocks reshape access to credit in developing economies, with gender-differentiated impacts.

My PhD dissertation is co-supervised by Prof. Chirantan Chatterjee (Professor of Development Economics, Innovation, and Global Health at the University of Sussex Business School's Department of Economics: C.Chatterjee@sussex.ac.uk) and Professor Benjamin K. Sovacool (Professor of Energy Policy at the Science Policy Research Unit at the University of Sussex Business School: B.Sovacool@sussex.ac.uk). Given the current progress, I expect to complete the program in September 2027.

Thank you for considering my application. I look forward to the opportunity to engage with peers and leading scholars at the workshop.

Sincerely,
Indrajit Adhikari

Warming Economies, Shrinking Credit: Climate Change and Gendered Impacts on Microfinance in BASIC Countries, 2000-2018**

Indrajit Adhikari, Benjamin K. Sovacool, Chirantan Chatterjee

Abstract

This paper examines the impact of climate change given rising temperatures on microfinance institutions (MFIs) and borrower dynamics in BASIC countries (Brazil, South Africa, India, and China) following the 2009 Copenhagen Accord. Using panel data from 123 countries between 2000 and 2018, we implement a triple-differences estimation strategy to isolate the causal effects of temperature shocks on diffusion of microfinance, while accounting for country and time-specific unobserved heterogeneity and GDP per capita. We find that a 1°C increase in annual temperature is associated with a statistically significant decline of approximately 24 MFIs and 156,841 active borrowers per year in BASIC countries post-2009. The results are strongly gendered, female borrowers alone account for over 62% of this decline, with a 1°C increase leading to an average reduction of 97,093 active female borrowers annually. No statistically significant effects are found for male borrowers, underscoring a gender-specific vulnerability. These results are robust across OLS and Poisson specifications, placebo tests, and alternate treatment year assumptions. Our findings highlight the compounded effects of climate change, gender inequality and a "climate-finance-gender trilemma." We conclude calling for climate-resilient, gender-sensitive microfinance strategies to protect access to credit and strengthen adaptive capacity in the most climate-vulnerable communities.

Keywords: Microfinance; Microcredit; Global warming; BASIC countries; Women's empowerment; Climate justice.

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1. Introduction

"Men argue. Nature Acts." – Voltaire.

Microfinance has long been heralded as a transformative tool for economic development, particularly for the world's most vulnerable populations (Morduch, 1999; World Bank Report: 2017). The premise is simple, and powerful: by providing access to small loans, savings accounts, and other financial services, microfinance enables and empowers individuals to start or expand businesses, improves their living standards, and builds resilience to economic shocks (Yunus et al., 2007; Yunus, 2007; Cull et al., 2007). But with the world symbolically and literally on fire, given natural disasters and increasing temperature changes globally (WMO, 2025), is microfinance and hence the poor suffering? Are these effects particularly impacting women and especially in certain regions of the world relative to others? Standing on the cusp of the highest ever temperature rises globally in 2024 and with the US new administration now pulling out of the 2015 Paris agreement, we try to answer these questions in this study.

Specifically, using novel data, we examine the intricate relationship between temperature changes worldwide and evolution of microfinance institutions (MFIs) and associated dynamics in the average number of borrowers in aggregate and in female and male borrowers. We do this by bringing together unique data from the World Bank MIX (Microfinance Information Exchange) Market dataset used in prior work and merge it with temperature change data from FAOSTAT and macroeconomic financial information from the International Monetary Fund (IMF). Our sample consists of 123 countries for the period 2000 to 2018, where we investigate, in particular if the formation of the BASIC bloc of countries in the lead up to the 2009 Copenhagen Accord shifted dynamics in global microfinance ecosystem, especially in those four countries.

The Copenhagen Accord was particularly interesting because this was the first time that temperature change formed an anchoring point in policy discourse internationally with prima-facie international acceptance to limit global temperature changes rise to 2 degrees Celsius above pre-industrial levels. Additionally, the four highly populated and fast emerging economies of the world: Brazil, South Africa, China and India (BASIC) came together all through 2009 to chart their own discussions around the climate change journey towards financing, transitioning, innovating and coordinating globally with explicit emission pledges

for a net-zero society in the long run.[1] We use these observations to explicitly examine for the first time if post 2009 in these BASIC countries, temperature changes impacted the growth of MFIs, and where in this, there was a negative impact of climate change on average number of borrowers, females in particular.

Our analysis controls for country level and yearly unobserved heterogeneity. We also control for GDP per capita and find broadly that global temperature changes in BASIC countries negatively impacted the growth of MFIs relative to rest of the world. Rising temperatures globally also reduced the average number of borrowers in our sample controlling for all else, particularly female borrowers. Interestingly, we did not find any significant impact on average number of male borrowers. The results were robust to some associated sensitivity checks.

Overall, we contribute to the growing, albeit if limited, body of literature on the interplay of climate change and microfinance and related gendered dimensions around it. Our empirical analyses provide evidence on the climate-microfinance journey of BASIC countries post 2009 Copenhagen Accord and highlight the gendered dimensions of this journey. In doing so, we examine how climate change is associated with adverse effects on social vulnerabilities and gender empowerment. We conclude in the end with some policy recommendations to strengthen the resilience of microfinance systems in the face of climate change.

The paper proceeds as follows. In the next section we provide a brief literature review and discuss relevant hypotheses. The section that follows describes our data and methods. We subsequently report our findings. We finally conclude with policy implications, suggestions for future work and limitations.

2. Literature Review & Hypotheses

2.1 Microfinance and Development

Microfinance has emerged as a critical strategy for alleviating poverty and promoting economic development, particularly in developing economies (Hulme et al., 1996; Fischer et al., 2011; Banerjee et al., 2013). The core principle here has been to provide financial services to low-income individuals and marginalized communities who are often excluded from formal banking systems (Morduch, 2000; Yunus et al., 2010). These services typically include microcredit (small loans to support income-generating activities (Yunus, 2007; Yunus et al.,

[1] See for a nice discussion on the evolution of the 2009 BASIC bloc of countries: sei-basic-preview-jun2011.pdf

2010; World Bank Report: 2017)); savings accounts in regulated or permitted microfinance institutions or microfinance banks (safe mechanisms for people to save money (Wright et al., 2001; Vonderlack et al., 2002)); microinsurance (access to insurance products that protect against risks (Ashta et al., 2014; Akotey et al., 2016)) and financial literacy training (programs that enhance people's ability to manage their finances (Shankar, 2015; Bylander et al., 2021)).

The success of microfinance is attributed to its ability to empower individuals, particularly women, by enabling them to start or expand small businesses (Alawattage et al., 2019), generate income (Khandker et al., 2016), and improve their livelihoods (McIntosh et al., 2011). At the same time, there has also been a vigorous debate that microfinance is not a *magic bullet* for women's empowerment with scholars arguing that there is a complementary role of context, commitment and capacity for sustainable pathways in women's empowerment (Kabeer 2001, Kabeer 2005, Quisumbing et al. 2010 among many others).

Microfinance programs have also been argued to show great promise in fostering inclusive economic growth (Corrado et al., 2017; Cobb et al., 2016). MFIs and related financial service providers began to gain importance in development from the 1970s, especially after the establishment of the Grameen Bank by Muhammad Yunus in Bangladesh, winner of the 2006 Nobel Peace Prize, who championed its success in the following decades. Critics however raise concerns about mission drift, commercialization (Lønborg et al., 2014; Epstein et al., 2010), and financialization (Cull et al., 2018; Aitken, 2013), while others have warned that it could exacerbate vulnerabilities (Banerjee et al., 2017; Ghosh, 2013).

Amidst these debates, a particular rising concern in microfinance has been how climate change has posed significant threats to human health and societies particularly in developing countries to vulnerable populations. Be that through rising temperatures (inducing heat stress, drought or reduced agricultural productivity), erratic precipitations (causing floods and disruptions in agricultural cycles), extreme weather events (resulting in large scale economic and human losses through cyclones, wildfires or hurricanes) or sea-level rises (impacting small island economies and coastal communities resulting in climate induced migration), the dimensions are many in the channels through which climate vulnerabilities are being exacerbated globally.

These adverse effects are already jeopardizing progress towards the UN Sustainable Development Goals (SDGs) (Sachs, 2015; Hubacek et al., 2017); for instance, Sub-Saharan Africa is staring at the grim possibility of an evaporation of all components of food security

(Kotir, 2011) and a potential 12% decline in the Human Development Index due to the impacts of climate change (Chirambo, 2016).

2.2 The Interplay Between Microfinance and Climate Change

The interaction between microfinance and climate change is multifaceted. On one hand, microfinance has the potential to support adaptation to climate change (Dowla, 2018; Below et al., 2012) by raising agricultural productivity, especially food production (Khandker, 2016), livelihood adaptation (Fenton et al., 2017; Osbahr et al., 2008) or enabling income diversification (Asfaw et al., 2017). The last one could happen by providing access to credit that allows farmers and rural communities to diversify their income sources, thus building resilience to climate shocks (Paprocki, 2019). It could also facilitate investment in climate-resilient technologies like water-saving irrigation systems, drought-resistant crops, and other climate-smart agriculture practices (Bakare et al., 2023; Amare et al., 2017). MFIs could also aid in supporting disaster preparedness by providing financial tools to help communities prepare for and recover from extreme weather events (Calis et al., 2017). In addition, MFIs can also offer micro-insurance to vulnerable populations facing climate-related disasters (Janzen et al., 2019).

That said, climate change also poses significant challenges to the microfinance sector itself (Dowla, 2018), including, in survival of these MFIs, due to increased credit risk, with climate disruptions reducing borrowers' ability to repay (Moser et al., 2015). This could lead to higher default rates and increasing risk aversion of lenders (Möllmann et al., 2020; Timu *et al.*, 2024). In addition, there could be operational challenges since MFIs in climate-sensitive regions may face increased operational costs and logistical difficulties due to extreme weather events (Johnson et al., 2019). Overall, climate change could shrink the MFI ecosystem due to a decrease in economic activity causing a reduced demand for microfinance services particularly for vulnerable sections of the population. Ultimately, this could also result in mission drift in the sense that to manage higher risks and in lure of higher profit, MFIs could start shifting their focus away from the most vulnerable clients and regions (Datar et al., 2010; Epstein et al., 2010).

All that said, there seems to be no systematic global study that empirically investigates how climate change may have impacted MFIs, and how average borrowing may have shifted with temperature changes worldwide. We contribute to this gap in the literature.

2.3 The BASIC Countries and the Post-Copenhagen Context

The BASIC group of countries—Brazil, South Africa, India, and China—represent a critical economic context for examining the interplay of climate change and microfinance. With a combined total population of more than 3 billion in the lead up to the 2009 Copenhagen Accord, they accounted for about 40% of the global population. These countries have also grown rapidly in the last two decades resulting in improvements of living standards but at the same time with costs inflicted on the climate. One can see the effects of this in Amazonian rain forests in Brazil (Grau et al., 2008), drought in coastal towns of Cape Town, South Africa (Bond, 2019), impact of air pollution in Northern Indian plains or cyclones in coastal India (Dash et al., 2007) or the emergence of vulnerable regions like Jiangsu in Northern and North-Eastern China (Chen et al., 2016).

These vulnerabilities to climate changes in these countries have been on the rise over the last couple of decades. Particularly given their geography, population density, economic dependence on agriculture and fossil fuels, and existing levels of poverty. We thus witnessed in the lead up to the 2009 Accord, active participation by these four countries (Brazil, South Africa, India and China) in global climate negotiations in different platforms like in BASIC group meetings, USA-India-China or UIC group meetings, India-Brazil-South Africa or IBSA dialogue forum. Herein, they forged a formidable force in the negotiation-table and more proactively committed to address climate change through mitigation and adaptation measures (Nhamo, 2010). The ambition here seemed to be that one did not need to rush through legally binding treaties given their socio-economic-political compulsions back in their home countries, especially since this was occurring at a time when the world was witnessing the fallout of the 2008 global recession.

The origin of the BASIC cooperation regarding climate change dates back at least to the mid-2000s, however. This is when the four countries started to meet separately within the G77 platform for climate negotiations. Tagged as indisputable regional leaders, with higher average growth rates than USA, EU and the rest of the world and collectively accounting for 12% of global GDP with substantial contribution to global trade, the BASIC countries brought in serious negotiation powers to the table after forming the group formally in November 2009 (Hallding et al., 2011; Qi, 2011).

But these four nations could also feel international pressure as they in aggregate accounted for nearly 29% of total global emissions, of which China alone was responsible for almost 17%. Given these compulsions, and yet the realization of the urgency to address the

climate-issue with alternative growth pathways (Hallding et al., 2018), the BASIC countries voluntarily pledged to reduce their emissions per unit of GDP relative to 2005 or a pre-determined baseline in the long run to adhere to the goal of temperature rise-cap for the planet (den Elzen et al., 2011). Some of them also promised other measures like increasing the share of non-fossil fuels and renewable energy, improving agricultural techniques, spiking forest coverage etc.

It is worth reminding here too that the Copenhagen Accord, often criticised for not being legally binding (Christoff, 2010), marked a turning point in global climate policy by setting a goal to limit global warming to below 2°C above pre-industrial levels (Held et al., 2018; Houser, 2010). This would require substantial reduction in global greenhouse gas emissions (Saveyn et al., 2012). While some global discussions in the past had mentioned about temperature changes (for example, the root of the temperature target can be traced back to the heuristics of the scientists and economists from the 1970s. The European Union (EU) even proposed the 2 degrees Celsius temperature-cap target in 1996 (Randalls, 2010)), Copenhagen Accord for the first time raised awareness of the urgent need for climate action in this regard, spurring both international and domestic policy changes. It not only delivered a Kyoto Protocol (greenhouse gas reduction)-like verifiable and monitorable (at least theoretically) quantitative target but also embraced the 'bottom up' approach rather than the 'top down', where countries voluntarily pledged their own actions and developing countries voiced their own terms reflecting the ascending power of several emerging economies and the uneven impact of the global financial crisis of 2008 (Held et al., 2018). For microfinance, this likely translated into an increased focus on climate resilience and adaptation, a hypothesis we investigate in this study. The post-Copenhagen context thus presents a new set of challenges and opportunities for microfinance institutions operating in the BASIC countries which we explicitly for the first time investigate in this study.

2.4. Gender Dimensions

The impacts of climate change, simply put, are sexist. Those identifying as women are much more likely to suffer death or injury from severe climate change events, and they are far more vulnerable to malnourishment and poverty when climate changes threaten food and water security (Alston, 2011; Awiti, 2022). During droughts, it is women that are the most likely to starve—intentionally or unintentionally—when food insecurity becomes severe (Patel et al., 2020). Women are known to have poorer resistance to changing disease vectors and disease

outbreaks compared to men, especially when combined with poorer access to medical care and health services (Nelson et al., 2002).

Women are also more prone to the impacts of extreme heat, given that they differ from men in their physiologic compensation to elevated temperatures, and that women dissipate less heat by sweating, have higher working metabolic rates, and have other biological vulnerabilities to heat (Sorensen et al., 2018). These vulnerabilities to heat become even more pronounced when women are pregnant, and prolonged exposure to high temperatures are even associated with a greater risk of menarche, still birth, congenital birth defects, and preterm delivery—regardless of maternal ethnicity or age, with younger mothers having an even higher risk of negative outcomes (Canelon et al., 2020; Sorensen et al., 2018; Spencer et al., 2022).

More generally, women are disproportionately affected by water scarcity as well and tend to be more gravely impacted by water mismanagement, yet they face greater difficulties than men in participating in water governance bodies (Figueiredo & Perkins, 2013). An investigation into recovery efforts following the 2010 Pakistani floods revealed that not only were a majority of the victims women, but also that women systematically "were either overlooked in the distribution of relief or were unable to reach places of relief distribution due to social norms that restricted their mobility (Sikka, 2018)." Climate change impacts even have a greater negative impact on the mental health of women, given that it is generally women who have caregiving responsibilities and must clean, cook, and ensure family wellbeing during disasters or floods, leading to significant mental trauma and stress (Stone et al., 2022). Evidence has even revealed that climate disasters have led to increased cases of depression and suicides among women in the Maldives due to displacement and destitution (Patel et al., 2020).

For perhaps reasons such as these, many have now highlighted (Parvin et al., 2014) that it is critical to examine the gender dimensions of climate change and microfinance, as women are often disproportionately affected by both resulting in a double jeopardy (Timu et al., 2024). Particularly in developing countries these impacts are acute given women's roles in agriculture, household food security, and water collection (Phuong et al., 2024).

Prior work has additionally found that the positive effect of microcredit is larger on the households' behaviour when women are the program participants (Pitt et al., 1998), access to the microfinance contributes to poverty reduction of the female participants (Khandker, 2005) and in many parts of the world, microcredits are predominantly lent to female clients from the

poor households as that generally results into lower portfolio risk and fewer write-offs (D'Espallier et al., 2011).

Yet, climate change can exacerbate existing gender inequalities by reducing women's access to resources, affecting their income and livelihoods. The impact on workloads could also be severe since women are often responsible for securing water and food for the household, increasing unpaid labour and reduce the time available for income-generating activities. The adverse impacts could also manifest through limitations in access to finance due to social norms, lack of collateral, excruciating social stigma of non-repayment, excessive indebtedness or mobility constraints conditioned by climate shocks (Naz et al., 2022; Banerjee et al., 2017).

Overall, understanding how climate change and gender intersect is thus crucial for designing microfinance interventions normatively such that it can foster women's climate resilience and empowerment (Coppock et al., 2013; Ray-Bennett, 2010; Pitt et al., 2006), can shield them from gender-based violence (Allen et al., 2024) and ensure climate justice (Vitellozzi et al., 2024). We offer in this study what is likely the first such global empirical evidence with a systematic analysis across 123 countries between 2000 and 2018.

2.5 Testable Hypotheses

Based on the discussion above we propose the following hypotheses:

> *H1: Climate change, specifically rising temperatures, will have a negative impact on the diffusion of microfinance services in the BASIC countries post-Copenhagen 2009.*

We will test this hypothesis in two margins in our data. First, we will unpack what might have happened to the flow of number of MFIs globally over time in particularly BASIC countries post 2009 relative to the rest of the world. In addition, we will also explore if MFIs are able to recruit borrowers by testing whether average number of borrowers in BASIC countries are declining with rising temperatures globally over time controlling for all else. The rationale behind this hypothesis lies in the fact that increased temperatures directly impact agricultural productivity, livelihoods and economic growth of the developing economies (Battisti et al., 2009; Dell et al., 2012), thus impacting the borrowing and repayment capacity, hence shifting risk profiles of MFIs, leading to a more cautious approach to lending and potentially impact on the industry ecosystem as well (von Negenborn et al., 2018).

> *H2: Female microfinance borrowers in the BASIC countries are more negatively affected by climate change impacts than their male counterparts.*

We will test this hypothesis by examining if the average number of female borrowers decline in BASIC countries after 2009 relative to the rest of the world and establish these findings also causally by examining what is happening to average number of male borrowers in some other sensitivity checks. The rationale for this hypothesis is based on the fact that women, who often have disproportionately higher burdens in household work and considerable contributions to agricultural activities are also more socially and economically vulnerable than men. They are therefore less resilient to climate shocks, reducing their capacity to borrow and manage loans effectively, and therefore affecting their access to microfinance as we have elaborated in Section 2.4.

3. Data and Methods

We primarily work with three data sources for our analysis. Ultimately, we create a panel dataset constructed from these data sources to capture the operations of MFIs and climate change variables. For microfinance data we use information from the World Bank MIX database and collected the variables, number of microfinance institutions (MFIs), active borrowers, active male borrowers, and active female borrowers by country-year for our analysis. We could also classify here the BASIC countries and had information on other operational variables on MFIs in various countries, except the United Kingdom which doesn't show up in the MIX dataset.

Climate data specifically on temperature change was collected from FAOSTAT, the statistical database of the Food and Agriculture Organization of the United Nations which has been also used in prior work (Mannell et al.,2024; Tubiello et al.,2013). The temperature change variable measure at the end of the year in this database calculates average temperature change in every country-year pair in our sample. We controlled for economic information using Gross Domestic Product (GDP) per capita data, measured in current USD, which was obtained from the International Monetary Fund (IMF). We use this to control for economic health of countries in our sample.

Note that in merging these three datasets, there were observations that showed up in one dataset but not the other or even within a particular dataset. Herein, for the latter we used a nearest neighbour approximation (for example if MFI information for Afghanistan is not available in 2002 and 2003, we assume that they may be at the same level as 2000 and 2001) and adopt this approach for all our variables in our analysis. If we change this approximation approach in our data processing to an averages-algorithm (Afghanistan's missing 2002 and

2003 data imputed with the average from the years when it has data) our results remain generally robust and results are available with authors on request.[2]

The dataset spanned yearly from 2000 to 2018, allowing for an analysis of microfinance trends before and after the 2009 Copenhagen Accord in 123 countries, with the 4 BASIC countries as our treated set of countries, rest of the countries as our control countries and the treatment period being 2009 and beyond.

To test our hypotheses, we use a simple ordinary least square regression framework wherein the dependent variable was the number of MFIs, average number of borrowers, average number of female borrowers and average number of male borrowers. Our econometric specification took the following form:

$$
\begin{aligned}
Y_{i,t} = \alpha + \beta_1(BasicCountries_i) + \beta_2\left(TemperatureChange_{i,t}\right) + \beta_3(Dummy2009_t) \\
+ \beta_4(BasicCountries_t) * \left(TemperatureChange_{i,t}\right) + \beta_5(BasicCountries_i) \\
* (Dummy2009_t) + \beta_6\left(TemperatureChange_{i,t}\right) * (Dummy2009_t) \\
+ \boldsymbol{\beta_7(BasicCountries_i) * \left(TemperatureChange_{i,t}\right) * (Dummy2009_t)} \\
+ \gamma\left(GDP\ Per\ Capita_{i,t}\right) + \mu_i + \delta_t + \epsilon_{i,t} \quad - Equation\ (1)
\end{aligned}
$$

Equation (1) is estimated using a dependent variable $Y_{i,t}$ as mentioned above to capture the impact on diffusion of microfinance, specifically on number of MFIs for every country *i* in year *t.* These models borrow from earlier work on time-series cross sectional models and despite limitations offer a starting pathway for understanding some of our associations we are trying to investigate (Beck 2001). n *some other specifications, we examine with alternative depen*dent variables like average number of borrowers, also average number of female and male borrowers. On the right-hand side, the equation adopts the spirit of a triple differences in differences specification. In our treated group of BASIC countries ($BasicCountries_{i,t}$ is a dummy which switches as 1 for Brazil, South Africa, India and China, remains 0 for all other countries), after 2009 as our treatment year ($Dummy2009_t$ is 1 from 2009 onwards to 2018, 0 before), we explore how temperature changes ($TemperatureChange_{i,t}$ measures for every country every year, temperature changes from the FAOSTAT data), impact our outcome variables of interest. We do this while controlling for other double interaction effects, also GDP per capita by country-year and unobserved heterogeneity by using in a panel data, country *i* (μ_i) and year *t* (δ_t) fixed effects. The country and year level fixed effects along with GDP per

[2] See the Annexure I for more details on our data collection process, thank you to Shubh Gupta for helping us out on this with his research assistance.

capita by country-year are important since post 2008, the world was also dealing with the deleterious effects from the global financial crises, and we would need to control for that in our analyses.

The coefficient of primary interest is the coefficient β_7 in Equation 1 above. It measures the triple-difference effect -- of temperature changes in BASIC countries after 2009 controlling for all else. Herein the first difference is the treatment period pre and post 2009-Copenhagen Accord, the second difference comes from the treatment countries, the BASIC countries and all else and a third difference comes from the impact of temperature changes. If our H1 is supported, we should see β_7 both economically and statistically negative and significant. Similar should be the direction of the coefficient economically and statistically if we want to test H2. Furthermore, it should not be showing economic and statistical significance when we test for male borrowers and should go through alternative models, like count data models using Poisson regressions. The results should also hold if we change the treatment from 2009 to 2010. As we will discuss below, all these statements are actually supported in our findings.

4. Results

4.1 Descriptive Statistics

Table 1-3 and Figure 1-3 provide some descriptive statistics for our analyses. First, we note that the average number of MFIs globally is 9.24, with a minimum of 1, and a maximum of 128. This suggests that, while some areas have few MFIs, others have many. The standard deviation is quite high at 14.66, indicating variation in the number of MFIs across the dataset. The mean number of active borrowers is 37,751 while the total number varies from a minimum of 2 to a maximum of 842818, and the standard deviation of 81,608 is very high, suggesting dispersion in the scale of operations of MFIs around the world. The mean number of active male borrowers is 12,850, with a minimum of 0 and a maximum of 886,029. The standard deviation is again high, 38465, indicating variation in the number of male borrowers across different MFIs. The mean number of active female borrowers is 26,961 with a minimum of 0 and a maximum of 1,021,524. The standard deviation is 77726, showing again substantial variation globally across MFIs.

The average temperature change in our sample is 0.94 degrees Celsius, with a minimum of -0.45 and a maximum of 2.77 degrees Celsius. The standard deviation is 0.47, which suggests temperature change is fairly consistent across the dataset. The mean GDP per capita is 4,190 USD, with a minimum of 108 USD and a maximum of 63,165 USD. The standard

deviation is 6,238 indicating wide variation in economic development among the countries considered in our sample.

Table 2 provides a comparison of these statistics for BASIC (Brazil, South Africa, India, and China) and non-BASIC countries. Non-BASIC countries have a much lower average number of MFIs (8.47) compared to BASIC countries (32.13). Non-BASIC countries on an average annually had 35,032 active borrowers, while BASIC countries had 116,594. Non-BASIC countries on an average annually had 12,218 active male borrowers, and BASIC countries on an average annually had about 2.5x, 30,388 borrowers. In terms of female borrowers by country-year, non-BASIC countries have an average of 25,013 active female borrowers while BASIC countries average more than 3x here annually, around 82,469. The average annual temperature change is similar between non-BASIC and BASIC countries, 0.94 and 0.92 degree Celsius during our 2000-2018 time period respectively. Finally, the average GDP per capita in non-BASIC countries is $4,161 and $4,915 in BASIC countries reflective of more economic activity in the latter as discussed and particularly so in recent years.

Overall, the mean values show that there is considerable variation in the dataset. For example, there are significant differences in the number of MFIs and active borrowers between BASIC and non-BASIC countries. The average temperature change across all regions is close to one degree Celsius, which indicates the existence of warming trends secularly worldwide. Table 3 shows some initial evidence on a negative correlation between temperature changes and number of MFIs, average annual number of borrowers and average annual number of female borrowers. Interestingly, the correlation is positive for average annual number of male borrowers which we formally test later in our regression models.

We also plot in our figures (Figure 1-3) the global evolution of the average number of MFIs and average number of active borrowers from 2000 to 2018. BASIC countries descriptively show a steeper fall in number of MFIs in Figure 1 compared to non-BASIC countries after 2009. In Figure 2, we see a dip in average annual number of borrowers also for BASIC countries in a staggered fashion after 2009, particularly for later years. But for non-BASIC countries there seems to be a secular increase here. A similar trend if observed in Figure 3 for average number of female borrowers in our sample.

These general trends are however suggestive and need to be formally tested in econometric models as we later do in the regressions. That said, visual inspections suggest that there may be a difference in the trends for number of MFIs, average number of borrowers,

average number of female active borrowers between BASIC and non-BASIC countries after 2009 suggestive of support for our hypotheses H1 and H2 which we will next investigate more formally in our regression findings.

4.2 Regression Results

Our regression results are reported in Tables 4-8. We explore herein systematically the impact of temperature changes and the 2009 Copenhagen Accord on MFIs and their borrowers, particularly focusing on BASIC countries (Brazil, South Africa, India, and China) compared to the rest of the world. The analyses controls for unobserved heterogeneity using country and year fixed effects. We also control for GDP per capita in some models, which is important to isolate the effects of climate change.

Table 4 examines the impact of temperature change and the 2009 Copenhagen Accord on the number of MFIs in BASIC countries. Model (4) is the most conservative including both country and year specific fixed effects and it shows a negative but statistically significant coefficient for the triple interaction term basicXdum2009Xtempchg (also across all models). The size of the coefficient indicates that the number of MFIs on an average in BASIC Countries after 2009 decreased by about 24 with every 1-degree Celsius rise in temperature relative to rest of the world. This is an important result because it shows for the first time, how there may be a general decompression effect on the global microfinance ecosystem given climate change as we hypothesize in H1. This result shows that there may actually be profound welfare consequences for poverty, economic development and sustainable development goals for the planet tomorrow and climate policy makers need to pay urgent attention to these overall results on detrimental impact on MFIs given global warming that we are able to bring to the conversation. Note also as an aside that generally across models, dummy variable for BASIC countries shows a positive and significant effect on the number of MFIs, which shows that on average BASIC countries have more MFIs than non-BASIC countries and hence are worthy of examination of the climate change effects as we have highlighted earlier.

Table 5 analyses the impact of temperature changes and the 2009 Copenhagen Accord on the number of active borrowers in BASIC countries. Again, in order to test H1, we examine the coefficient estimates of the triple interaction term basicXdum2009Xtempchg in our most conservative model specification, that is in Model 4. The coefficient on basicXdum2009Xtempchg is -156,841 and strongly statistically significant. The negative coefficient suggests that for BASIC countries after 2009, a one-degree Celsius increase in

temperature is associated with a decrease of approximately 0.15 million active borrowers, after controlling for other factors such as GDP per capita, country and year level unobserved heterogeneities. The result is both economically and statistically significant and supports H1 and is consistent with the extensive margin negative effect on number of MFIs we report above.

Table 6 explores the situation for female borrowers in our setting to unpack H2. Again, using Model 4, the coefficient on the triple interaction term is negative and statistically significant at the 5% level, suggesting that temperature changes after 2009 had a negative effect on the number of female borrowers in BASIC countries. The magnitude of the coefficient is relatively large and economically relevant. A one-degree Celsius increase in temperature change is associated with 97,093 fewer female borrowers after 2009 in BASIC countries, once we control for unobserved heterogeneity with country and year fixed effects and also after controlling for GDP per capita in the regressions. The findings support Hypothesis 2, which states that, temperature changes affect female borrowers more than male borrowers. Our primary premise for the paper that there are strong gendered effects of climate change on MFIs borrowers is thus established. It is additionally augmented when we turn to Table 7 and see that across all specifications there are simply no economically or statistically significant effects on male borrowers (as a placebo test) especially when one controls for GDP per capita and country and year level unobserved heterogeneities.

Table 8 and 9 finally conduct some robustness checks by experimenting with the treatment period. Table 8 shows the results of the regressions with a 2010 dummy variable instead of the 2009 dummy. The results are directionally similar and statistically significant, which suggests that the main findings are robust to the timing of the treatment dummy. Table 9 presents the results with Poisson count data models. The findings are again consistent and directionally similar, suggesting that the use of a different model does not change the qualitative conclusions.[3]

To summarize these findings overall, H1 is strongly supported since we find that temperature changes reduce the average number of MFIs in BASIC countries after the 2009

[3] We should add that we use robust standard errors across all models. When we cluster for standard errors at the country level or use wild cluster bootstrap standard errors (Roodman et al. 2019), the results somewhat weaken (results available with authors on request). It also suggests that the underlying mechanisms at play in this context maybe not just at a country-year level but at a country-household-year level given disparities in economically resilient versus less-resilient households around the world.

Copenhagen Accord, the effects are also similar for average number of borrowers. H2, the hypothesized detrimental effect on female borrowers is also supported in Table 6.

Overall, our results suggest that climate change impacts the microfinance sector globally, particularly in BASIC countries and more so since 2009 once temperature conversations became more mainstream since Copenhagen Accord in the global climate debate. Our findings should motivate policymakers to consider strategies to promote financial inclusion that are supportive of vulnerable populations, particularly women.[4]

5. Discussion and Conclusion

Our study investigates the intricate relationships between climate change, microfinance, and gender dynamics, specifically within the context of the BASIC countries after the 2009 Copenhagen Accord. It provides for the first time, empirical evidence that rising temperatures negatively impact the microfinance ecosystem, with a particularly pronounced effect on female borrowers in these rapidly developing economies. By combining macro-level analysis with a focus on gendered impacts, the research enhances our understanding of the challenges faced by vulnerable populations in a changing climate, adding a critical layer to the existing literature on climate change, poverty, and development.

The central findings can be summarized as follows. We find a negative relationship between temperature changes and the microfinance sector in BASIC countries following the 2009 Copenhagen Accord. Specifically, rising temperatures are associated with a decrease in the number of microfinance institutions (MFIs) and average number of active borrowers and particularly female borrowers operating in these regions relative to rest of the world. Our results are robust to different specifications. The analysis controls for country and year fixed effects and includes GDP per capita in some models to isolate the effect of climate change.

We are likely offering several significant contributions to the gender, climate and microfinance literature. Ours is perhaps the first robust empirical evidence of a direct link between climate change, specifically temperature increases, and the decline of microfinance activities in vulnerable regions. This finding is important because, while microfinance has been

[4] We are off course limited here by data at the household level which we plan to return in future work. Also noteworthy is the fact that while we can unearth effects on MFIs and borrower levels, in unreported results, there seem to be little effect on other outcome variables related to MFIs, such as write-offs and cost per loan in BASIC countries after 2009 with temperature changes relative to rest of the world.

described as a powerful device for poverty alleviation and women's empowerment, this paper highlights how climate change can hinder access to financial services. We are also among the first to underscore the importance of gendered dimensions in climate change research. By demonstrating that women are disproportionately affected by the negative impacts of climate change on microfinance, we highlight the need for gender-focused programs and policies.

The analysis also makes a clear argument that because of patriarchal structures that exist in many developing countries, women's access to microfinance is more vulnerable in the face of climate change. This finding is consistent with prior work (Goetz et al., 1996; Hunt et al., 2001) that examine how gender and microcredit access between partners determines women's access to and use of credit.

Our study is also among only a few which focuses on the BASIC group of countries, which are major players in the global economy and at the same time they are significant contributors to greenhouse gas emissions. This specific focus makes the research particularly relevant to understanding how climate change will impact financial inclusion in key emerging economies. The paper's examination of microfinance trends before and after the 2009 Copenhagen Accord provides valuable insights into the impact of international climate agreements on the ground. It demonstrates how, in spite of global agreements, the negative impacts of climate change are already being felt and are undermining the development goals.

Our findings have several important policy implications. First, we want to draw attention of governments to climate-resilient microfinance programs. Governments and MFIs need to implement such programs, particularly in regions vulnerable to climate change. This would include providing financial services that help borrowers adapt to climate shocks such as droughts or floods. For example, weather index insurance can reduce the credit risk of farmers. There is also a clear need for gender-focused interventions to ensure that women are not disproportionately affected by the negative impact of climate change on microfinance. These interventions should also consider the existing patriarchal structures that impede women's access to financial services. One idea maybe through community savings clubs and women-managed microfinance groups.

Our findings highlight very critically an emerging *climate–finance–gender trilemma*, wherein rising temperatures simultaneously weaken financial infrastructure, restrict credit access, and disproportionately disempower women. Addressing this interlinked challenge

requires policy frameworks that integrate climate adaptation, financial inclusion, and gender equity as mutually reinforcing priorities rather than siloed development goals.

Relatedly, our findings suggest that **c**limate change adaptation must be integrated into poverty alleviation and economic development strategies. This requires a cross-sectoral approach and a more holistic theory of change -- that recognizes the interdependencies between climate, finance, and gender. Policymakers should work to expand financial inclusion in climate vulnerable areas. This might include promoting digital financial services, making micro-savings more available, and providing access to credit. International cooperation herein will be important. The global community should support developing countries in their efforts to build climate resilience, particularly in the microfinance sector. This could involve financial and technical assistance, as well as capacity-building initiatives.

There are several avenues for future research from our findings. First, future research could use household-level data to examine the underlying micro-mechanisms through which climate change impacts the microfinance ecosystem. This will help in getting more precise inferences and mechanism unpacking as to how climate change impacts the MFI ecosystem. Another avenue of research maybe investigation of specific climate hazards, such as floods, droughts, and heatwaves on MFIs and their borrowers. This would allow for a more nuanced and comparative understanding of the risks and vulnerabilities associated with different types of climate shocks. Furthermore, more work is needed on effective strategies for microfinance adaptation in climate-vulnerable areas and especially for women. This could involve the role of microinsurance, diversified livelihood programs, and resilient infrastructures along with related innovations.

Finally, our study has some important limitations. First, we are limited by the availability of data, particularly at the household level. The data only covers the period up to 2018. Second, we find a correlation between temperature increases and declines in microfinance activities, but there is more to be done on examining the impact of other climate shocks particularly for women and relatedly to claim causality is a complex issue. There may also be other confounding factors that were not accounted for in the analysis. In summary, much more remains to be done.

References

Aitken, R. (2013). The Financialization of Micro-Credit. *Development and Change, 44*(3), 473–499.

Akotey, J. O., & Adjasi, C. K. (2016). Does microcredit increase household welfare in the absence of microinsurance? *World Development*, *77*, 380-394.

Alawattage, C., Graham, C., & Wickramasinghe, D. (2019). Microaccountability and biopolitics: Microfinance in a Sri Lankan village. *Accounting, Organizations and Society, 72*, 38-60.

Allen, E.M., Munala, L. & Ward-Rannow, J. (2024). Do Gender-Based Violence Interventions Consider the Impacts of Climate Change? A Systematic Review. *Trauma, Violence & Abuse, 25*(3), 2421–2435.

Alston, M. (2011). Gender and climate change in Australia. *Journal of Sociology*, *47*(1), 53-70.

Amare, A. & Simane, B. (2017). Determinants of smallholder farmers' decision to adopt adaptation options to climate change and variability in the Muger Sub basin of the Upper Blue Nile basin of Ethiopia. *Agriculture & Food Security, 6*, 1-20.

Asfaw, A. et al. (2017). Determinants of non-farm livelihood diversification: evidence from rainfed-dependent smallholder farmers in northcentral Ethiopia (Woleka sub-basin). *Development Studies Research, 4*(1), 22–36.

Ashta, A., Couchoro, M., & Musa, A.S. (2014). Dialectic evolution through the social innovation process: from microcredit to microfinance. *Journal of Innovation and Entrepreneurship, 3*(1).

Awiti, A. O. (2022). Climate change and gender in Africa: A review of impact and gender-responsive solutions. *Frontiers in Climate*, *4*, 895950.

Bakare, A.Y., Ogunleye, A.S., & Kehinde, A.D. (2023). Impacts of microcredit access on climate change adaptation strategies adoption and rice yield in Kwara State, Nigeria. *World Development Sustainability, 2*.

Beck, N. (2001). Time-series–cross-section data: What have we learned in the past few years? Annual Review of Political Science, 4(1), 271-293.

Banerjee, A., Chandrasekhar, A.G., Duflo, E., & Jackson, M.O. (2013). The diffusion of microfinance. *Science, 341*(6144), 1236498.

Banerjee, S.B. & Jackson, L. (2017). Microfinance and the business of poverty reduction: Critical perspectives from rural Bangladesh. *Human Relations, 70*(1), 63-91.

Battisti, D.S., & Naylor, R.L. (2009). Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat. *Science, 323*(5911), 240–244.

Below, T.B. et al. (2012). Can farmers' adaptation to climate change be explained by socio-economic household-level variables? *Global Environmental Change, 22*(1), 223–235.

Bond, P. (2019). Blue Economy threats, contradictions and resistances seen from South Africa. *Journal of Political Ecology, 26*(1), 341–362.

Bylander, M. & Res, P. (2021). "If You Fall, Stand Up Again": The Moral Nature of Financial Literacy in the Global South. *Development and Change, 52*(1), 26–53.

Calis, T. et al. (2017). Does Microfinance Make Households More Resilient to Shocks? Evidence From the Cyclone Phailin in India. *Journal of International Development, 29*(7), 1011–1015.

Canelón, S. P., & Boland, M. R. (2020). A systematic literature review of factors affecting the timing of menarche: the potential for climate change to impact women's health. *International Journal of Environmental Research and Public Health*, *17*(5), 1703.

Chen, K. et al. (2016). Urbanization Level and Vulnerability to Heat-Related Mortality in Jiangsu Province, China. *Environmental Health Perspectives, 124*(12), 1863–1869.

Chirambo, D. (2016). Moving past the rhetoric: Policy considerations that can make Sino-African relations to improve Africa's climate change resilience and the attainment of the sustainable development goals. *Advances in Climate Change Research, 7*(4), 253-263.

Christoff, P. (2010). Cold climate in Copenhagen: China and the United States at COP15. *Environmental Politics, 19*(4), 637–656.

Cobb, J.A., Wry, T., & Zhao, E.Y. (2016). Funding Financial Inclusion: Institutional Logics and the Contextual Contingency of Funding for Microfinance Organizations. *The Academy of Management Journal, 59*(6), 2103–2131.

Coppock, D.L. & Desta, S. (2013). Collective Action, Innovation, and Wealth Generation Among Settled Pastoral Women in Northern Kenya. *Rangeland Ecology & Management, 66*(1), 95–105.

Corrado, G. & Corrado, L. (2017). Inclusive finance for inclusive growth and development. *Current Opinion in Environmental Sustainability, 24*, 19-23.

Cull, R., Demirgu¨ç-Kunt, A., & Morduch, J. (2007). Financial performance and Outreach: A Global Analysis of Leading Microbanks. *The Economic Journal, 117*(517), F107–F133.

Cull, R. & Morduch, J. (2018). Microfinance and economic development. In *Handbook of Finance and Development* (pp. 550-572). Edward Elgar Publishing.

Dash, S.K. et al. (2007). Some evidence of climate change in twentieth-century India. *Climatic Change, 85*(3–4), 299–321.

Datar, S.M., Epstein, M.J., & Yuthas, K. (2010). Enamored with scale: Scaling with limited impact in the microfinance industry. In *Scaling social impact: New thinking* (pp. 47-64). New York: Palgrave Macmillan US.

Dell, M., Jones, B.F., & Olken, B.A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics, 4*(3), 66-95.

den Elzen, M.G., Hof, A.F., & Roelfsema, M. (2011). The emissions gap between the Copenhagen pledges and the 2 C climate goal: options for closing and risks that could widen the gap. *Global Environmental Change, 21*(2), 733-743.

D'Espallier, B., Guérin, I., & Mersland, R. (2011). Women and Repayment in Microfinance: A Global Analysis. *World Development, 39*(5), 758–772.

Dowla, A. (2018). Climate change and microfinance. *Business Strategy and Development, 1*(2), 78–87.

Epstein, M.J. & Yuthas, K. (2010). Mission impossible: diffusion and drift in the microfinance industry. *Sustainability Accounting, Management and Policy Journal, 1*(2), 201-221.

Fenton, A., Paavola, J., & Tallontire, A. (2017). The Role of Microfinance in Household Livelihood Adaptation in Satkhira District, Southwest Bangladesh. *World Development, 92*, 192–202.

Figueiredo, P., & Perkins, P. E. (2013). Women and water management in times of climate change: participatory and inclusive processes. *Journal of Cleaner Production*, *60*, 188-194.

Fischer, G. & Ghatak, M. (2011). Spanning the chasm: Uniting theory and empirics in microfinance research. In *The Handbook of Microfinance* (pp. 59-75).

Ghosh, J. (2013). Microfinance and the challenge of financial inclusion for development. *Cambridge Journal of Economics, 37*(6), 1203–1219.

Goetz, A.M. & Gupta, R.S. (1996). Who takes the credit? Gender, power, and control over loan use in rural credit programs in Bangladesh. *World Development, 24*(1), 45-63.

Grau, H.R. & Aide, M. (2008). Globalization and Land-Use Transitions in Latin America. *Ecology and Society, 13*(2).

Hallding, K., Jürisoo, M., Carson, M., & Atteridge, A. (2018). Rising powers: the evolving role of BASIC countries. In *The New Power Politics of Global Climate Governance* (pp. 135-158). Routledge.

Hallding, K., Olsson, M., Atteridge, A., Carson, M., Vihma, A. & Roman, M. (2011). Together alone: Brazil, South Africa, India, China (BASIC) and the climate change conundrum. *Stockholm Environment Institute. Consulta, 4*(01), 2017.

Held, D. & Roger, C. (2018). Three Models of Global Climate Governance: From Kyoto to Paris and Beyond. *Global Policy, 9*(4), 527–537.

Houser, T. (2010). Copenhagen, the accord, and the way forward (No. PB10-5). Washington, DC: Peterson Institute for International Economics.

Hubacek, K. et al. (2017). Global carbon inequality. *Energy, Ecology and Environment, 2*(6), 361–369.

Hulme, D. & Mosley, P. (1996). *Finance Against Poverty*. London: Rutledge.

Hunt, J. & Kasynathan, N. (2001). Pathways to empowerment? Reflections on microfinance and transformation in gender relations in South Asia. *Gender & Development, 9*(1), 42-52.

Janzen, S.A. & Carter, M.R. (2019). After the Drought: The Impact of Microinsurance on Consumption Smoothing and Asset Protection. *American Journal of Agricultural Economics, 101*(3), 651–671.

Johnson, B.A. et al. (2019). Investigating the relationships between climate hazards and spatial accessibility to microfinance using geographically weighted regression. *International Journal of Disaster Risk Reduction, 33*, 122–130.

Kabeer, N. (2001). Conflicts over credit: Re-evaluating the empowerment potential of loans to women in rural Bangladesh. *World Development*, *29*(1), 63-84.

Kabeer, N. (2005). Is microfinance a'magic bullet'for women's empowerment? Analysis of findings from South Asia. Economic and Political weekly, 4709-4718.

Khandker, S.R. (2005). Microfinance and Poverty: Evidence Using Panel Data from Bangladesh. *The World Bank Economic Review, 19*(2), 263–286.

Khandker, S.R. & Koolwal, G.B. (2016). How has microcredit supported agriculture? Evidence using panel data from Bangladesh. *Agricultural Economics, 47*(2), 157-168.

Kotir, J.H. (2011). Climate change and variability in Sub-Saharan Africa: a review of current and future trends and impacts on agriculture and food security. *Environment, Development and Sustainability, 13*, 587-605.

Lønborg, J.H. & Rasmussen, O.D. (2014). Can microfinance reach the poorest: evidence from a community-managed microfinance intervention. *World Development, 64*, 460-472.

Mannell, J., Brown, L. J., Jordaan, E., Hatcher, A., & Gibbs, A. (2024). The impact of environmental shocks due to climate change on intimate partner violence: A structural equation model of data from 156 countries. *PLOS Climate*, 3(10), e0000478

McIntosh, C., Villaran, G., & Wydick, B. (2011). Microfinance and home improvement: using retrospective panel data to measure program effects on fundamental events. *World Development, 39*(6), 922-937.

Möllmann, J. et al. (2020). Do remotely sensed vegetation health indices explain credit risk in agricultural microfinance? *World Development, 127*.

Morduch, J. (1999). The Microfinance Promise. *Journal of Economic Literature, 37*(4), 1569–1614.

Morduch, J. (2000). The Microfinance Schism. *World Development, 28*(4), 617–629.

Moser, R.M.B. & Gonzalez, L. (2015). Microfinance and Climate Change Impacts: The Case of Agroamigo in Brazil. *Revista de administração de empresas, 55*(4), 397–407.

Naz, F. & Doneys, P. (2022). Gender-based differences in access to and use of loans from rural credit programs for flood adaptation in the farming-dependent char communities of Bangladesh. *Women's Studies International Forum, 95*.

Nelson, V., Meadows, K., Cannon, T., Morton, J., & Martin, A. (2002). Uncertain predictions, invisible impacts, and the need to mainstream gender in climate change adaptations. *Gender & Development*, *10*(2), 51-59.

Nhamo, G. (2010). Dawn of a New Climate Order: Analysis of USA + BASIC Collaborative Frameworks. *Politikon: South African Journal of Political studies, 37*(2), 353–376.

Osbahr, H. et al. (2008). Effective livelihood adaptation to climate change disturbance: Scale dimensions of practice in Mozambique. *Geoforum, 39*(6), 1951–1964.

Paprocki, K. (2019). All That Is Solid Melts into the Bay: Anticipatory Ruination and Climate Change Adaptation. *Antipode, 51*(1), 295–315.

Parvin, G.A. et al. (2014). Incorporating Microfinance Institutions (MFIs) to Enhance Food Security for Poor Women Vulnerable to Extreme Climate Hazards in Rural Coastal Areas in Bangladesh. *Risk, Hazards & Crisis in Public Policy, 5*(1), 59–76.

Patel, S. K., Agrawal, G., Mathew, B., Patel, S., Mohanty, B., & Singh, A. (2020). Climate change and women in South Asia: a review and future policy implications. *World Journal of Science, Technology and Sustainable Development*, *17*(2), 145-166.

Phuong, H.T. et al. (2024). Climate change, livelihood resilience, and gender: An intersectional analysis of Vietnam's forest-dependent communities. *Environmental Development, 52*.

Pitt, M.M. & Khandker, S.R. (1998). The impact of Group-Based Credit Programs on Poor Households in Bangladesh: Does the Gender of Participants Matter? *The Journal of Political Economy, 106*(5), 958–996.

Pitt, M.M., Khandker, S.R. & Cartwright, J. (2006). Empowering Women with Micro Finance: Evidence from Bangladesh. *Economic Development and Cultural Change, 54*(4), 791–831.

Qi, X. (2011). The rise of BASIC in UN climate change negotiations. *The South African Journal of International Affairs, 18*(3), 295–318.

Quisumbing, A. R., & Pandolfelli, L. (2010). Promising approaches to address the needs of poor female farmers: Resources, constraints, and interventions. World Development, 38(4), 581-592.

Randalls, S. (2010). History of the 2 ° C climate target. *Wiley Interdisciplinary Reviews, 1*(4), 598–605.

Ray-Bennett, N.S. (2010). The role of microcredit in reducing women's vulnerabilities to multiple disasters. *Disasters, 34*(1), 240–260.

Roodman, D., Nielsen, M. Ø., MacKinnon, J. G., & Webb, M. D. (2019). Fast and wild: Bootstrap inference in Stata using boottest. *The Stata Journal*, *19*(1), 4-60.

Sachs, J.D. (2015). Achieving the sustainable development goals. *Journal of International Business Ethics, 8*(2), 53-62.

Saveyn, B., Paroussos, L., & Ciscar, J.-C. (2012). Economic analysis of a low carbon path to 2050: A case for China, India, and Japan. *Energy Economics, 34*(SUPPL. 3), S451–S458.

Shankar, S. (2015). Application of an Alternate Framework for Assessing Microfinance Programs' Contribution to Development: An Empirical Study in Tamil Nadu, India. *Strategic Change, 24*(3), 225–241.

Sikka, T. (2018). Technology, Gender, and Climate Change: A Feminist Examination of Climate Technologies. *Societies*, *8*(4), 109.

Sorensen, C., Saunik, S., Sehgal, M., Tewary, A., Govindan, M., Lemery, J., & Balbus, J. (2018). Climate change and women's health: Impacts and opportunities in India. *GeoHealth*, *2*(10), 283-297.

Spencer, S., Samateh, T., Wabnitz, K., Mayhew, S., Allen, H., & Bonell, A. (2022). The challenges of working in the heat whilst pregnant: insights from Gambian women farmers in the face of climate change. *Frontiers in Public Health*, *10*, 785254.

Stone, K., Blinn, N., & Spencer, R. (2022). Mental health impacts of climate change on women: a scoping review. *Current Environmental Health Reports*, *9*(2), 228-243.

Swain, R.B. & Wallentin, F.Y. (2009). Does microfinance empower women? Evidence from self-help groups in India. *International Review of Applied Economics, 23*(5), 541–556.

Timu, A. et al. (2024). Evaluating the Gendered Credit Constraints and Uptake of an Insurance-Linked Credit Product Among Smallholder Farmers in Kenya. *The Journal of Development Studies*, 1-21.

Tubiello, F. N., Salvatore, M., Rossi, S., Ferrara, A., Fitton, N., & Smith, P. (2013). The FAOSTAT database of greenhouse gas emissions from agriculture. *Environmental Research Letters*, 8(1), 015009

Vitellozzi, S. et al. (2024). Thriving in the rain: natural shocks, time allocation, and women's empowerment in Bangladesh. *World Development, 181*.

von Negenborn, F., Weber, R., & Musshoff, O. (2018). Explaining weather-related credit risk with evapotranspiration and precipitation indices. *Agricultural Finance Review, 78*(2), 246–261.

Vonderlack, R.M. & Schreiner, M. (2002). Women, microfinance, and savings: Lessons and proposals. *Development in Practice, 12*(5), 602–612.

Wright, G.A., Christen, R.P. & Matin, I. (2001). Introducing savings services into ASA, a microcredit institution. *Enterprise Development & Microfinance, 12*(3), 20-32.

Yunus, M. (2007). Credit for the poor: Poverty as distant history. *Harvard International Review, 29*(3), 20.

Yunus, M. & Yusus, A.J.M. (2007). *Banker to the Poor.* Penguin Books India.

Yunus, M., Moingeon, B., & Lehmann-Ortega, L. (2010). Building Social Business Models: Lessons from the Grameen Experience. *Long Range Planning, 43*(2–3), 308–325.

World Bank report (2017):
https://documents1.worldbank.org/curated/en/107171511360386561/pdf/WPS8252.pdf

WMO press release (2025):
https://wmo.int/news/media-centre/wmo-confirms-2024-warmest-year-record-about-155degc-above-pre-industrial-level

Tables

Table 1: Descriptive Statistics

Variable	Observations	Mean	Std. dev.	Min	Max
Number of MFIs	2,337	9.24	14.66	1	128
Active Borrowers	2,280	37751.48	81608.85	2	842818
Active Male Borrowers	2,185	12850.53	38465.88	0	886029
Active Female Borrowers	2,242	26961.01	77726.81	0	1021524
tempchg (temperature change in degrees Celsius)	2,280	0.94	0.47	-0.45	2.772
GDP Per Capita (USD)	2,039	4190.02	6238.95	108.06	63165

Source: World BANK MIX, IMF, FAOSTAT.

Table 2: Descriptive Statistics by BASIC and non-BASIC Countries at the Mean

BASIC Countries	Number of MFIs	Active Borrowers	Active Male Borrowers	Active Female Borrowers	Temperature Change	GDP Per Capita
0	8.47	35032.77	12218.51	25013.33	0.946902	4161.94
1	32.13	116594.2	30388.86	82469.86	0.921224	4915.44
Total	9.24	37751.48	12850.53	26961.01	0.946046	4190.02

Source: World BANK MIX, IMF, FAOSTAT.

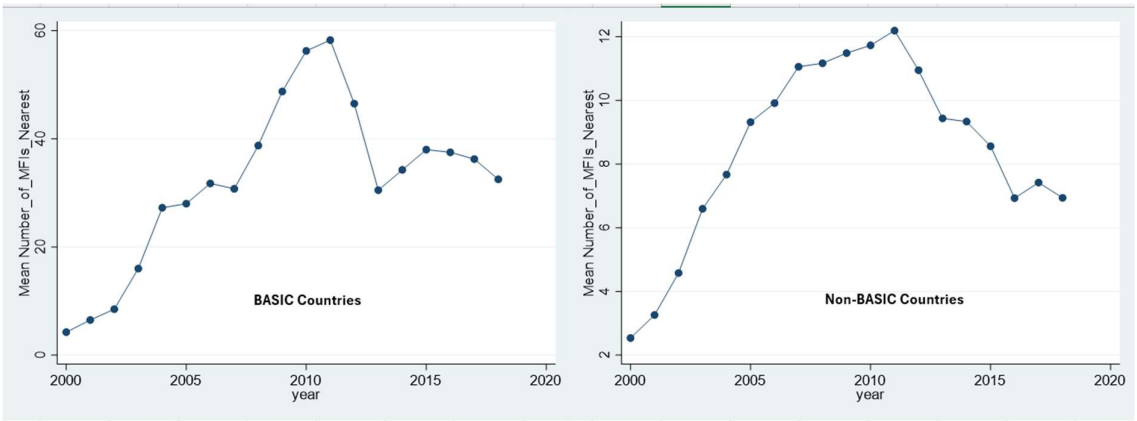
Table 3: Pairwise Correlations of the Variables Used in Our Models

	Number of MFIs	Active Borrowers	Active Male Borrowers	Active Female Borrowers	tempchg (temperature change)	GDP Per Capita (USD)
Number of MFIs	1					
Active Borrowers	0.3006	1				
Active Male Borrowers	0.1001	0.3556	1			
Active Female Borrowers	0.2913	0.8254	0.3752	1		
tempchg (temperature change)	-0.0223	-0.0171	0.0419	-0.0179	1	
GDP Per Capita (USD)	-0.1052	-0.0444	-0.0154	0.008	0.0793	1

Source: World BANK MIX, IMF, FAOSTAT.

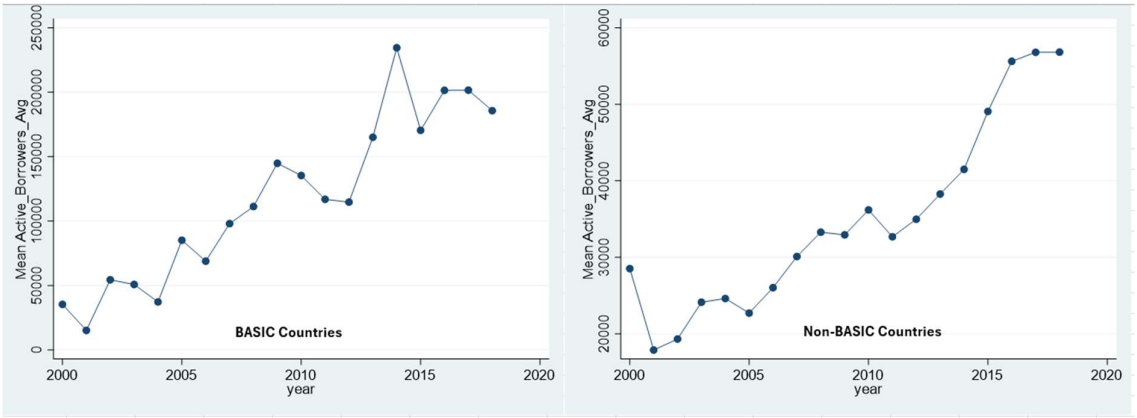
Figures

Figure 1: Evolution of MFIs in BASIC / Non-BASIC Countries Over Time



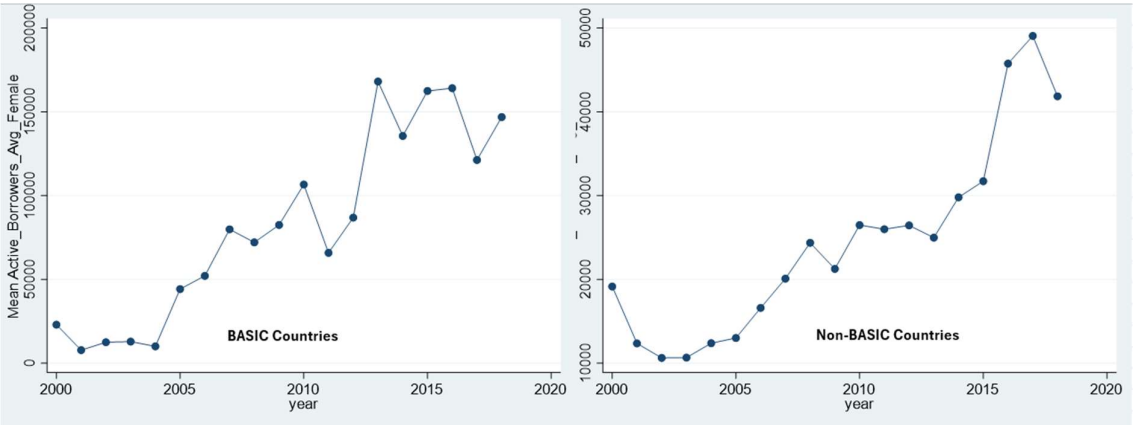
Source: World BANK MIX.

Figure 2: Evolution of Active Borrowers in BASIC/ Non-BASIC Countries Over Time



Source: World BANK MIX.

Figure 3: Female Active Borrowers in BASIC/Non-BASIC Countries Over Time



Source: World BANK MIX.

Table 4: MFIs Decline in BASIC Countries After 2009 With Temperature Change

OLS Regressions	Model (1)	Model (2)	Model (3)	Model (4)
Dependent Variable	*Number of MFIs*	*Number of MFIs*	*Number of MFIs*	*Number of MFIs*
tempchg	1.282	1.805**	1.139	0.160
	(1.058)	(0.830)	(0.790)	(0.478)
basicdummy	43.15**	62.11***	64.46***	-3.109
	(17.34)	(15.75)	(14.76)	(12.80)
dum2009	5.804***	5.497***	6.078***	-
	(1.229)	(0.802)	(1.288)	
basic Xpost2009	45.26	45.43***	41.98***	42.00***
	(27.67)	(16.28)	(15.52)	(15.32)
post2009Xtempchg	-3.691***	-3.540***	-1.461	-0.258
	(1.239)	(0.897)	(0.888)	(0.614)
basicXtempchg	-36.11**	10.19	7.208	7.143
	(16.64)	(14.57)	(13.83)	(13.68)
basicXdum2009Xtempchg	**-19.02**	**-28.67***	**-24.61***	**-24.29***
	(24.24)	**(15.52)**	**(14.70)**	**(14.49)**
GDP Per Capita				-0.000378***
				(7.76e-05)
Constant	6.391***	6.380***	1.919	1.978
	(0.855)	(1.462)	(1.280)	(1.318)
Country Fixed Effects	N	Y	Y	Y
Year Fixed Effects	N	N	Y	Y
Observations	2,280	2,280	2,280	2,001
R-squared	0.143	0.732	0.764	0.779

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: World BANK MIX, FAOSTAT, IMF.

Table 5: Active Borrowers Decline in BASIC Countries After 2009 With Temperature Change

OLS Regressions	Model (1)	Model (2)	Model (3)	Model (4)
Dependent Variable	*Active Borrowers*	*Active Borrowers*	*Active Borrowers*	*Active Borrowers*
tempchg	-16,859***	2,093	-38.16	1,203
	(4,950)	(3,753)	(3,625)	(4,118)
basicdummy	58,045*	-85,437*	-83,666*	-67,057
	(34,782)	(44,716)	(43,983)	(43,723)
dum2009	8,272	7,665	28,782***	-
	(8,349)	(5,385)	(10,131)	
basicXpost2009	176,758**	214,592***	223,526***	222,331***
	(85,361)	(68,506)	(67,420)	(66,476)
post2009Xtempchg	14,163**	9,810**	1,878	2,632
	(6,826)	(4,755)	(5,252)	(6,022)
basicXtempchg	-30,573	139,580***	138,425***	133,730***
	(37,101)	(44,956)	(44,657)	(44,446)
basicXdum2009Xtempchg	**-78,290**	**-149,333****	**-158,427*****	**-156,841*****
	(74,670)	**(60,558)**	**(59,928)**	**(59,215)**
GDP Per Capita				-1.569**
				(0.625)
dum2009	8,272	7,665	28,782***	-
	(8,349)	(5,385)	(10,131)	-
Constant	39,313***	4,792	8,924	4,298
	(5,727)	(4,496)	(7,447)	(8,938)
Country Fixed Effects	N	Y	Y	Y
Year Fixed Effects	N	N	Y	Y
Observations	2,223	2,223	2,223	1,963
R-squared	0.067	0.692	0.702	0.695

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: World BANK MIX, FAOSTAT, IMF.

Table 6: Active Female Borrowers Decline in BASIC Countries Post 2009 With Temperature Change

OLS Regressions	Model (1)	Model (2)	Model (3)	Model (4)
Dependent Variable	*Active Female Borrowers*	*Active Female Borrowers*	*Active Female Borrowers*	*Active Female Borrowers*
tempchg	-13,524***	4,675*	2,426	4,754
	(3,966)	(2,793)	(2,631)	(3,007)
basicdummy	41,434	-78,334**	-78,727**	-55,559
	(26,586)	(37,030)	(36,198)	(35,337)
dum2009	12,645*	11,744***	32,261***	41,647***
	(7,351)	(3,955)	(10,539)	(11,618)
basicXpost2009	120,745*	146,852***	156,425***	154,112***
	(70,792)	(53,796)	(52,886)	(51,468)
post2009Xtempchg	8,234	4,301	-2,457	-2,340
	(5,748)	(3,305)	(3,560)	(4,046)
basicXtempchg	-30,240	108,725***	109,973***	103,222***
	(26,781)	(37,029)	(36,272)	(35,360)
basicXdum2009Xtempchg	**-37,932**	**-91,044***	**-101,214****	**-97,093****
	(61,231)	**(48,335)**	**(47,887)**	**(46,555)**
GDP Per Capita				-2.210***
				(0.578)
Constant	27,101***	-4,039	666.8	-6,318
	(4,736)	(4,406)	(5,167)	(6,562)
Country Fixed Effects	N	Y	Y	Y
Year Fixed Effects	N	N	Y	Y
Observations	2,185	2,185	2,185	1,925
R-squared	0.047	0.666	0.675	0.665

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: World BANK MIX, FAOSTAT, IMF.

Table 7: No Effects on Male Borrowers in BASIC Countries After 2009

OLS Regressions	Model (1)	Model (2)	Model (3)	Model (4)
Dependent Variable	*Active Male Borrowers*	*Active Male Borrowers*	*Active Male Borrowers*	*Active Male Borrowers*
Tempchg	-818.7	-1,385	-2,454	-2,650
	(3,141)	(2,946)	(2,893)	(3,248)
Basicdummy	54,580**	32,721*	31,431*	30,873*
	(24,424)	(17,857)	(18,110)	(18,272)
dum2009	-1,698	-1,585	9,561*	8,506
	(3,678)	(3,306)	(4,879)	(5,474)
basicXpost2009	-62,601**	-50,347**	-46,935*	-45,624*
	(28,247)	(25,038)	(25,162)	(25,418)
post2009Xtempchg	5,930*	5,971*	2,916	3,976
	(3,473)	(3,086)	(3,123)	(3,528)
basicXtempchg	-38,263	-31,562	-32,072	-30,864
	(25,732)	(24,544)	(25,143)	(25,241)
basicXdum2009Xtempchg	58,957**	45,537*	42,103	39,020
	(30,046)	(26,135)	(26,523)	(26,855)
GDP Per Capita				0.525
				(0.351)
Constant	10,794***	7,372**	6,894**	7,153*
	(3,310)	(3,392)	(3,259)	(3,765)
Country Fixed Effects	N	Y	Y	Y
Year Fixed Effects	N	N	Y	Y
Observations	2,128	2,128	2,128	1,887
R-squared	0.015	0.381	0.388	0.386

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: World BANK MIX, FAOSTAT, IMF.

Table 8: Results Are Robust With 2010 Treatment (Instead of 2009 Treatment)

OLS Regressions	Model (1)	Model (2)	Model (3)	Model (4)
Dependent Variable	*Number of MFIs*	*Active Borrowers*	*Active Female Borrowers*	*Active Male Borrowers*
Tempchg	0.199	2,264	5,816*	-2,492
	(0.478)	(3,998)	(2,979)	(3,104)
Basicdummy	-9.585	73,948*	61,355*	25,930
	(13.03)	(43,340)	(34,972)	(17,447)
dum2010	-	-	43,695***	8,273
			(11,887)	(5,548)
basicXpost2010	51.12***	207,453***	173,004***	-35,158
	(15.84)	(69,666)	(52,889)	(25,522)
post2010Xtempchg	-0.485	597.2	-4,585	3,954
	(0.620)	(6,194)	(4,229)	(3,432)
basicXtempchg	17.40	129,358***	114,338***	-26,200
	(14.15)	(39,280)	(37,099)	(23,418)
basicXdum2010Xtempchg	**-37.79****	**-145,099****	**-115,936****	**30,167**
	(15.11)	**(60,512)**	**(48,411)**	**(26,391)**
GDP Per Capita	-0.000347***	-1.535**	-2.193***	0.530
	(7.58e-05)	(0.616)	(0.577)	(0.346)
Constant	2.094	3,450	-6,818	7,205*
	(1.317)	(8,871)	(6,523)	(3,746)
Country Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Observations	2,001	1,963	1,925	1,887
R-squared	0.778	0.694	0.665	0.385

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: World BANK MIX, FAOSTAT, IMF.

Table 9: Results Are Directionally Similar with Poisson Count Data Models

Poisson Regressions	Model (1)	Model (2)	Model (3)	Model (4)
Dependent Variables	*Number of MFIs*	*Active Borrowers Nearest*	*Active Female Borrowers*	*Active Male Borrowers*
tempchg	-0.0405	-0.102	-0.000208	-0.280
	(0.0617)	(0.159)	(0.135)	(0.284)
basicdummy	-0.572	0.957	1.311**	2.177***
	(0.379)	(0.650)	(0.661)	(0.672)
dum2009	1.162***	0.612*	0.904**	0.184
	(0.154)	(0.347)	(0.380)	(0.377)
basicXpost2009	0.0473	1.393**	1.015*	-1.626*
	(0.242)	(0.568)	(0.550)	(0.947)
post2009Xtempchg	0.00506	0.320**	0.349**	0.386
	(0.0775)	(0.156)	(0.143)	(0.283)
basicXtempchg	-0.582*	0.942	0.676	-0.851
	(0.352)	(0.687)	(0.696)	(0.902)
basicXdum2009Xtempchg	**0.541**	**-1.214***	**-0.724**	**1.009**
	(0.331)	**(0.672)**	**(0.687)**	**(0.989)**
GDP Per Capita	-2.01e-05*	-7.60e-06	-5.16e-05*	0.000117***
	(1.09e-05)	(2.81e-05)	(2.64e-05)	(3.21e-05)
Constant	0.973***	9.492***	8.607***	9.049***
	(0.124)	(0.309)	(0.387)	(0.328)
Country Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Pseudo R-square	0.7156	0.8394	0.8815	0.7353
Observations	2,001	1,963	1,925	1,887

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: World BANK MIX, FAOSTAT, IMF.

Annexure I

Methodology

In general, the approach of building the dataset utilized for the regression analysis was to source the individual variables of the dataset, both dependent and independent, from the various public sources of data on climate and microfinance, merge by country and year, and apply certain preprocessing techniques to clean and handle missing data. Python was used as the language for the complete data analytics part before regression, and the libraries used included Pandas and NumPy. The entire process has been explained in detail in the following sections:

Data Acquisition

The Microfinance data has been acquired from the World Bank MIX market dataset [1]. We began by merging the mix-market-mfi-company-metadata.xlsx and mix-market-financial-performance-dataset-in-usd.xlsx sheets by performing an inner join to create a unified dataset containing a complete record of all microfinance institutes, their countries, years of operation, and financial performance metrics.

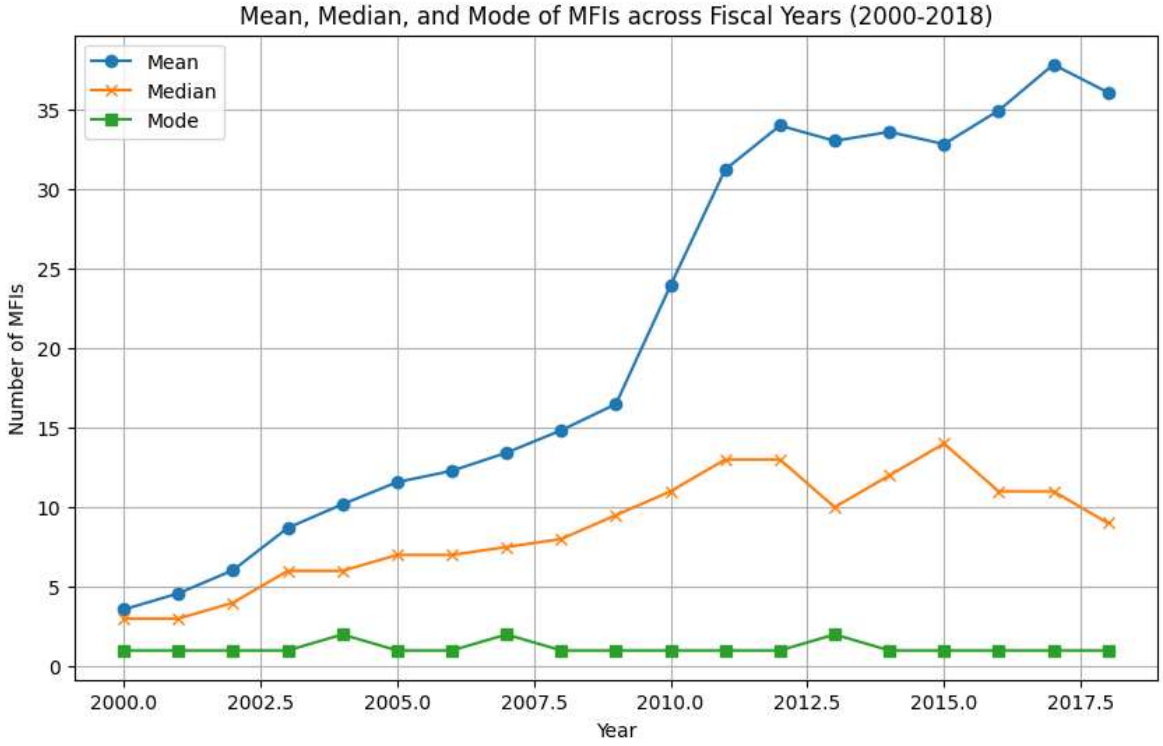
The inner join was performed using MFI ID as the key column, ensuring that only records present in both datasets were retained. For example, the metadata file provided details such as the institute's name, country, and region, while the financial dataset included metrics like fiscal year, revenue, and expenses. The resulting dataset combined these attributes, excluding any microfinance institutes for which either metadata or financial performance data was unavailable. This approach ensured a comprehensive and reliable dataset for subsequent analysis of the relationship between microfinance institutions and climate change factors. This gave us most of the independent variables in our regression equations, the other variables being financial features like portfolio at risk, write-offs etc taken from the MIX dataset.

Further, as part of preprocessing, inconsistencies in feature naming, such as “country” starting with a lowercase letter, were corrected to eliminate errors during subsequent merging. Here, we would like to highlight two important points. First, from this stage onward, we performed a left join using the countries captured in the MIX dataset. A left join ensures that all records from the MIX dataset are retained, even if there is no matching country in the other dataset, while excluding records from the other dataset that do not correspond to any country in MIX. This approach is crucial, as capturing data from any country absent in the MIX dataset would render it unusable for regression analysis.

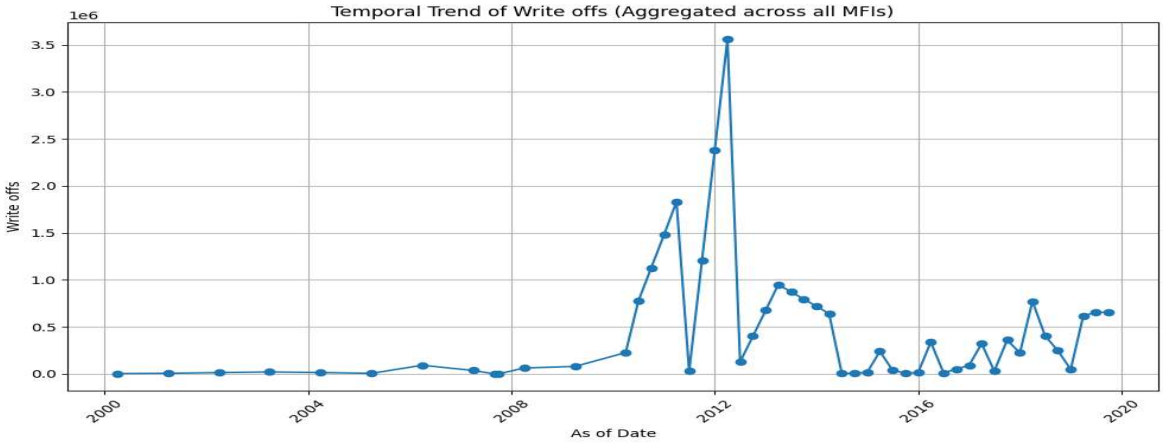
Second, the dataset was maintained at each step of the merge to include only records from the years 2000 to 2018 (both inclusive), ensuring that trends were not distorted by the impact of the COVID-19 pandemic in the post-2019 era.

Basic graphs to perform bivariate analysis among variables were generated to validate the data and get a general sense about the trends from a microfinance perspective. For example, a graph visualizing the mean, median, and mode of microfinance institutes across fiscal years was plotted to analyze the distribution and growth trends within the sector (Annexure I, Figure 1). This visualization revealed a steady increase in the mean number of microfinance institutes, with median values fluctuating over time, indicating regional variations in operational activity. In another analysis, India was found to have the maximum number of microfinance institutions and hence was used as a primary region to perform preliminary tests of data manipulation. Graphs such as the temporal trends of write-offs (Annexure I, Figure 2) and portfolio at risk > 90 days (Annexure I, Figure 3) were plotted for India to observe patterns over time. These visualizations revealed significant spikes during the 2010–2012 period, reflecting the progression from portfolio risk to eventual financial losses, consistent with the Andhra Pradesh

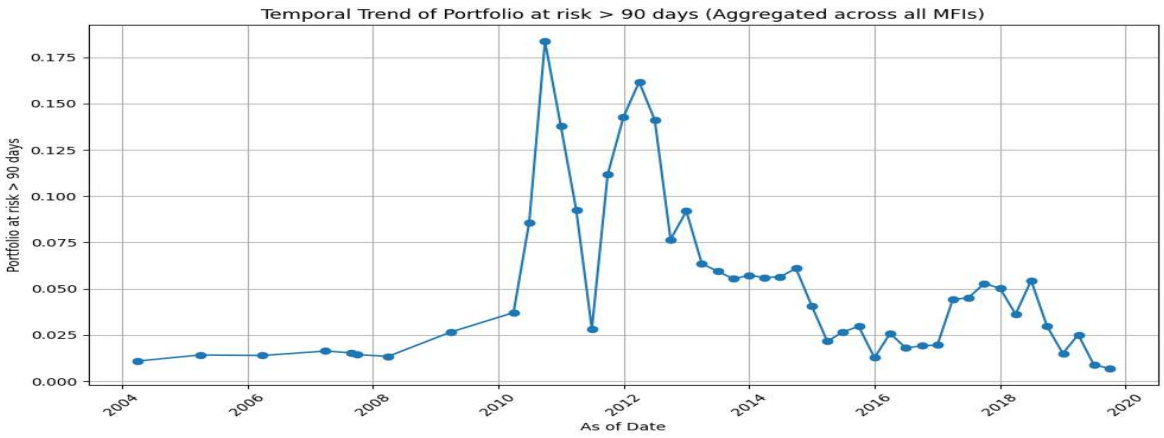
microfinance crisis in India at that time. This analysis suggested the robustness of the data in capturing critical events and its suitability for further exploration of microfinance in relation to climate change.



Annexure I, Figure 1: Temporal Trends of Mean, Median, and Mode of Microfinance Institutes Across Fiscal Years. *Notes: This graph illustrates the trends of mean, median, and mode values for the number of microfinance institutions (MFIs) over time, with a noticeable increase in the mean value after 2010, reflecting the growing number of MFIs during this period.*



Annexure I, Figure 1: Temporal Trend of Write-offs in Indian Microfinance Institutions. Notes: *This graph shows the yearly aggregated write-offs across microfinance institutions in India, highlighting a notable spike during the 2010–2012 period.*



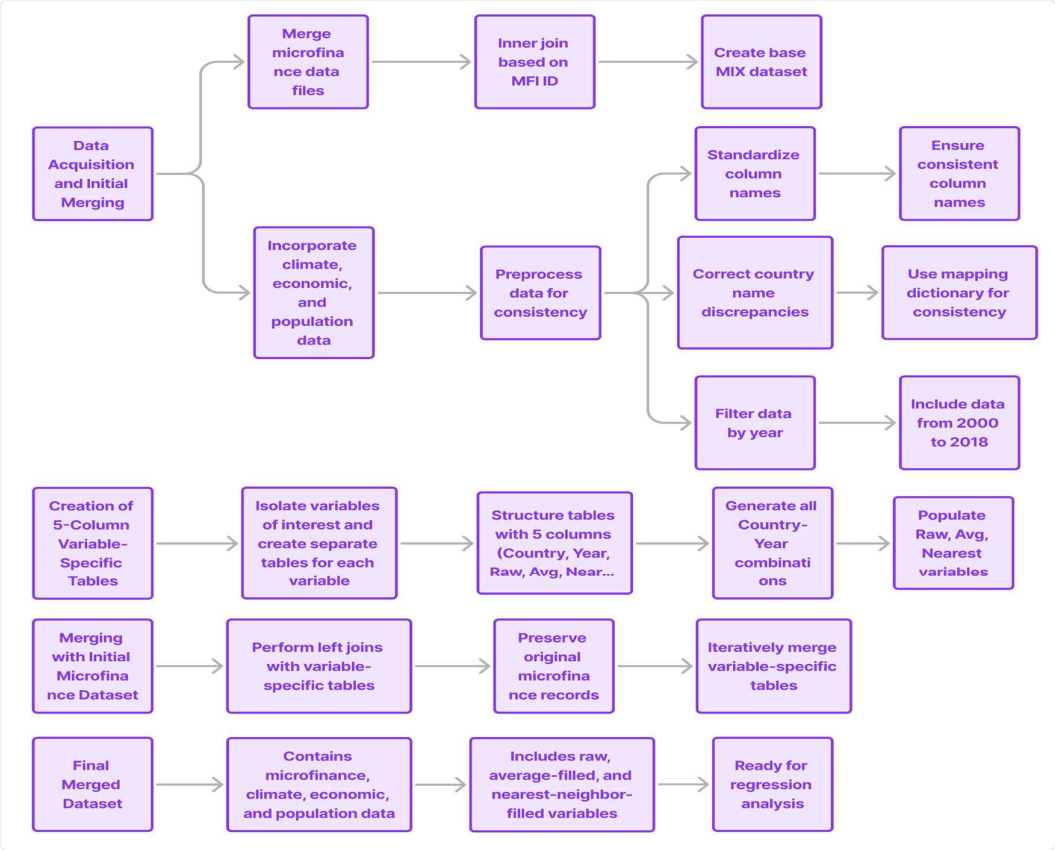
Annexure I Figure 3: Temporal Trend of Portfolio at Risk > 90 Days in Indian Microfinance Institutions Notes: *This graph depicts the percentage of portfolios at risk for over 90 days, showing a significant increase around 2010–2012, aligned with the Andhra Pradesh microfinance crisis.*

Next, climate-related data points were sourced from FAOSTAT (Food and Agriculture Organization Statistics). The FAOSTAT dataset provides data on mean annual surface temperature variations across countries. These datasets were integrated to enable a detailed examination of the interaction between climatic variables and economic indicators. Finally, GDP per capita data was obtained from the International Monetary Fund (IMF).

During the data integration process, some missing country-year observations were identified. These gaps arose either from incomplete reporting by specific countries or from discrepancies across the three datasets during the merging process. To address this issue, we employed three data processing techniques.

First, the variables were retained in their raw form. Second, nearest-neighbour imputation was applied—for example, if Congo did not report write-offs in 2002, the missing value was approximated using data from 2001 or 2003. Third, we calculated country-year averages for each variable and used these averages to fill in missing values where applicable.

As a result, the dataset contained three versions of each variable: the original raw data, values imputed using nearest-neighbour approximation, and values estimated using trend-based averages. Each variable, such as write-offs or the number of natural disasters, was processed independently. The finalized variables were subsequently merged with the World Bank MIX dataset using a left join. This ensured that only information pertaining to countries included in the MIX dataset was retained. For instance, if data on natural disasters were available for the Democratic Republic of Congo but the country was not part of the MIX dataset, the left join excluded such information, aligning the merged dataset exclusively with countries of interest. We outline the data processing and merging schema in the flow chart below in Annexure I, Figure 4.



Annexure 1. Figure 4: Data Merging and Preprocessing Methodology

Notes: This flowchart details the steps to create a dataset for regression analysis. It merges microfinance data using an inner join, and incorporates climate, economic, and population data. Preprocessing includes standardization, correcting country names, and filtering for years 2000-2018. Variable-specific tables with Raw, Avg, and Nearest values are created, and merged with the microfinance data using left joins. The final dataset includes raw data and imputed values.

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Synopsis

PhD candidate at the Bennett Institute for Innovation and Policy Acceleration, based at the Science Policy Research Unit (SPRU) of the University of Sussex Business School, UK. My research explores the intersection of microfinance, climate vulnerability, and inclusive financial systems. I bring nearly two decades of experience as a senior editor, economic writer, and policy journalist covering economic and business affairs, public finance, inequality, and climate change in India. My work combines empirical and institutional approaches to examine how climate risks affect the microfinance ecosystem and how inclusive finance can support equitable climate adaptation in low- and middle-income countries.

Research Interests

- Microfinance under climate stress: institutional vulnerability, borrower exclusion, resilience roles, and inclusive policy design.
- Designing inclusive financial architectures for climate resilience in developing and emerging economies.
- Empirical analysis of climate shocks and their effects on microfinance diffusion, borrower inclusion, and gendered financial outcomes.
- Gendered impacts of climate change on access to and control over credit and other financial services, and adaptive capacity.
- Institutional and political dynamics of adaptation finance: the role of microfinance in equitable and gender-responsive climate transitions.

Education

PhD in Science and Technology Policy
September 2024 – September 2027 (expected)
Bennett Institute for Innovation and Policy Acceleration, SPRU, University of Sussex Business School, UK
Fully funded through the **Bennett Fellowship** for Doctoral Research

Master of Research (M.Res.) *(part of integrated PhD)*
September 2024 – August 2025 (awaiting results)
Bennett Institute for Innovation and Policy Acceleration, SPRU, University of Sussex Business School, UK

M.A. in Economics
2002 – 2004
Visva Bharati University, India
• Ranked 1st Class 2nd (68.1%)

B.A. (Honours) in Economics
1999 – 2002
Visva Bharati University, India
• Ranked 1st Class 1st (71.3%)

Publications and Working Papers

- **Adhikari, I., Sovacool, B. K., & Chatterjee, C.**
  Warming Economies, Shrinking Credit: Climate Change and Gendered Impacts on Microfinance in BASIC Countries, 2000–2018
  Under review at *Journal of Development Studies.*
  This paper uses a triple-differences estimation strategy on panel data from 123 countries to examine how rising temperatures affect the viability of microfinance institutions and borrower inclusion, with a focus on gendered impacts in BASIC countries following the 2009 Copenhagen Accord.

- **Adhikari, I., Sovacool, B. K., & Chatterjee, C.**
  Microfinance, vulnerability, and climate change adaptation: A systematic, global, and critical review
  Resubmitted to *World Development* (invited revision, under editorial review)
  This paper presents a critical systematic review of 42 peer-reviewed studies on microfinance and climate adaptation across diverse geographies and hazard contexts. Using thematic coding, categorization and institutional analysis, it maps intervention outcomes, identifies success and failure drivers, and highlights conceptual gaps in program design and institutional resilience.

Conferences, Seminars and Invited Talks

- **Valedictory Lecture** – *International Seminar on Crony Journalism, Evolution of Indian Media and The Decay in Information Diffusion*, **Visva Bharati University**, India
  Topic: Political economy of media and accountability in democratic systems.

- **Invited Talk** – *Public Forum on Direct Taxation*, **Income Tax Bar Association, Kolkata**, India *(2023)*
  Topic: Direct Tax Laws and Their Impact on Society

- **Invited Speaker** – *International Seminar on South Asian Trade and Poverty*, **University of Calcutta**, India

- **Panelist** – *International Workshop on Sustainable Development*, **World Bank**, India
  Topic: Development communication and inclusive growth.

- **Invited Speaker** – *Policy Forum on Technological Unemployment*, **Government of India & University of Burdwan**, India *(2023)*
  Topic: Technological unemployment and the future of jobs.

- **Panelist** – *Industry Dialogue on Insurance in India*, **Confederation of Indian Industry (CII)**, India
  Topic: Importance of insurance in Indian financial inclusion.

- **Valedictory Speaker** – *International Seminar on Media Ethics*, **Swami Vivekananda University**, India
  Topic: Ethics, narrative, and economic journalism.

- **Valedictory Lecture** – *International Conference on the Evolution of Indian Media*, **Swami Vivekananda University**, India *(2023)*
  Topic: Efficiency of information diffusion and the political economy of media.

- **Delegation Member** – *British Foreign & Commonwealth Office Program for Indian Journalists*, UK *(October 2015)*
  Engagement: Policy briefings, media-government interactions, institutional visits.

- **Participant** – *Workshop on South Asian Trade*, Dubai *(February 2019)*
  Organizer: Arizona State University
  Focus: Trade integration, regional development, and policy analysis.
- **Participant** – *Workshop on Business Reporting in a Global World*, India
  Organizer: Government of Canada through High Commission of Canada (New Delhi)
  Theme: Financial journalism, global economics, and policy transparency.
- **Delegate Journalist** – *Official Visit of Chief Minister of West Bengal to Germany & Italy (October 2018)*
  Role: Policy reportage, investor summits, bilateral engagement coverage.
- **Invited Speaker** – *Roundtable on the Indian Economy*, **ASSOCHAM**, India *(2016)*
  Topic: The state of the Indian economy – policy, growth, and equity.

Teaching and Academic Engagements

- **Visiting Faculty; Visva Bharati University, University of Calcutta, IEM Business School (MBA) and BIBS (MBA):** Taught economics, public policy, and development-related topics. Delivered lectures on economic trends, public finance, and policy analysis in business contexts.
- **Consulting Faculty; IMS India (CAT/GRE/GMAT prep institute):** Taught Economics and General Knowledge modules for competitive exams and mentored students preparing for higher studies in management and public policy.

Awards and Scholarships

- **Bennett Fellowship for Doctoral Research**, University of Sussex Business School (2024–2027)
  Awarded full funding for PhD study at the Bennett Institute for Innovation and Policy Acceleration, SPRU
- **National Scholarship for Academic Excellence**, Government of India
  Received at both undergraduate and postgraduate levels
- **University Scholarships**, Visva Bharati University
  Awarded for ranking 1st in B.A. (Honours in Economics) and 2nd in M.A. (Economics)
- **Institute Board Nominee**, Visva Bharati University
  Sole student member selected for academic excellence and leadership potential
- **State Ranker**, Science Aptitude and Talent Search Test, West Bengal
- **Youth Parliament Competition** – 1st Place (National level debate competition), Government of India
- **All-India Speech Competition** – 3rd Place
- **All-West Bengal Essay Writing Competition** – 2nd Place
- **Multiple Awards in Debate, Elocution, and Extempore Speaking** at school and university levels

Technical Skills

- **Econometrics and Statistical Analysis**: Stata (quantitative analysis, panel data estimation)

- **Data Visualization and Scripting:** Python (data processing and visual outputs for literature review)
- **Writing and Presentation**: Microsoft Word, PowerPoint
- **Spreadsheet and Data Handling**: Microsoft Excel
- **Design and Layout**: Adobe InDesign, QuarkXPress

Professional Experience

- **News Coordinator**, *Anandabazar Patrika*, Kolkata (https://www.abp.in/)
  April 2021 – July 2024
  Led the newsroom of one of India's largest dailies (Total circulation: 1.08 million; Total readership: 12.7 million). Was responsible for editorial direction, front-page content, and daily planning for both print and mobile platforms. Supervised editors, reporters, and visual teams. Oversaw socio-economic coverage on fiscal and monetary policies, policy reforms, poverty, inequality, climate risks, MSME stress, and rural vulnerability. Wrote editorials and op-eds on public finance, employment, and governance.

- **Deputy News Editor**, *Anandabazar Patrika*, Kolkata
  Dec 2020 – Mar 2021
  Managed the main news desk. Oversaw story selection, breaking news response, and critical policy coverage during the COVID-19 period. Coordinated with marketing and distribution teams and HR department.

- **Special Representative**, *Anandabazar Patrika (Delhi Bureau)*, New Delhi
  Aug 2019 – Dec 2020
  Covered key national economic and political developments: Union budget, RBI policies, inequality and unemployment, trade and investment bottlenecks, labour migration in the Covid context, and social protests. Reported on major events such as CAA-NRC movement, elections, and parliamentary debates.

- **Editor – Business**, *Anandabazar Patrika*, Kolkata
  Apr 2018 – Aug 2019
  Led the Business Bureau. Directed coverage on investment and economy, fiscal and monetary policy, employment data, and financial markets. Developed visual-first, data-driven reporting style.

- **Chief Sub Editor**, *Anandabazar Patrika (Business Bureau)*, Kolkata
  Apr 2013 – Mar 2018
  Managed editorial standards for economic news and business content. Wrote on demonetization, fiscal deficit and runaway inflation, introduction of GST, rural distress, farmer suicides, climate-linked economic disruption, and global trends. Interviewed leading economists, policymakers, and corporate leaders.

- **Reporter and Sub Editor (various roles)**, *Anandabazar Patrika*, Kolkata
  Dec 2005 – Mar 2013
  Wrote extensively on global and Indian macroeconomy, financial crises including the subprime mortgage crisis leading to the recession of 2008, inflation, and policy analysis. Reported on the MSME sector, big industry, and public finance. Created visual layouts and pages using Adobe InDesign and QuarkXPress.

References

Available upon request