Empowering Women in South Asia's Slums: The Challenges of Environmental Degradation

By Amit Patel, Marcia D. Mundt and Hyunjung Lee (University of Massachusetts Boston); Hina Lotia and Muhammad Arshed Rafiq (LEAD Pakistan); Ammar A. Malik (Urban Institute)

Abstract

Environmental degradation is characterized by a reduction in the capacity of the environment to meet social and ecological needs. Marginalized groups in urban communities, particularly women and the poor, are disproportionately affected by the negative consequences of environmental degradation, including natural disasters and extreme climate events. To better understand the relationship between environmental degradation and women's empowerment, we surveyed 1,199 households in 12 slums in India, Bangladesh and Pakistan, to create detailed profiles of men's and women's social and economic lives, and their experiences with natural disasters and extreme climate events. Using this data, we created the Empowerment in Slums Index (ESI) and the Women's Empowerment in Slums Index (WESI), which systematically measure men's and women's empowerment. We found that women were significantly less empowered than their male counterparts in all three countries, with widest gaps in Pakistan. We also tested several linkages between environmental degradation and empowerment using regression analyses and found many significant associations. For example, in India, the experience of climate change related torrential rain, lack of access to a toilet, poor drainage systems and long distance to a water source significantly lowered empowerment. Poor drainage systems and flooding were also associated with lower empowerment in Pakistan. In Bangladesh, empowerment levels decreased due to lack of access to a toilet, poor street conditions and long distance to water. Across all three countries, shorter stay at current residence, poor street conditions and overcrowding in the home were negatively associated with empowerment, particularly for women.

Keywords

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Introduction

Economic growth combined with structural inequality and rapid urbanization in the global South has resulted in the formation and expansion of slums in many cities, including across South Asia. The widespread presence of slums in South Asian cities suggests that macro-economic growth does not automatically translate to improvements in the lives of the poor (UN-HABITAT 2003, 28). On the contrary, economic growth that leads to rapid and unplanned urbanization can exaggerate existing inequalities, increasing the vulnerability of economically marginalized groups within society. Environmental degradation also diminishes the positive impacts of growth for economically depressed neighborhoods, including slums, and for marginalized groups like women and the poor. Disaster-related shocks such as flooding or heat waves often have severe impacts on slum dwellers, increasing daily costs of survival, reducing household incomes, and resulting in asset losses and increased debt.

Scholarly literature indicates that the household economies of slums are highly vulnerable to economic and environmental shocks (e.g. Braun and Abheuer 2011; White et al. 2013). A household can fall into poverty in the aftermath of natural disasters and extreme climate events, with women most negatively impacted (Jahan 2008; Nasrim 2012). For example, women's access to economic opportunities and earnings suffers in the wake of such shocks since they are often forced to take time off work during reconstruction efforts, and find ways to continue with their regular household and care responsibilities. Since a huge portion of women's work is unpaid in the domestic sphere, and their work in the informal economy is not regulated (Kuiper and Ree 2006; Ballesteros 2011), these women can become trapped in a vicious cycle of poverty and disempowerment unless concrete policy actions are taken. Poverty-related environmental conditions further exacerbate these effects by limiting households' access to water and sanitation, contributing to poor air quality, and exacerbating precarious living conditions.

The impact of urbanization on women has also been well researched. Several studies have found differential impacts of urban poverty for women and men (Gomez et al. 2008; UN Women Watch 2012; Warth and Koparanova 2012; Tacoli 2012, 2013; ADP 2013). There is an extensive body of literature on environmental degradation and climate-induced risks in slums, including studies in South Asia (e.g. Sengupta 1999; Harriss-White et al. 2012; Ahmed 2014; Gruebner et al. 2014). However, only a handful of these studies focus specifically on links between environmental degradation in South Asian slums and women's empowerment (e.g. Jahan 2008; Fisher 2008; Hazarika 2010; Nasrin 2012). Furthermore, such studies rely solely on reviews of existing literature, program evaluations or secondary datasets. Our study makes a unique contribution to the current knowledge base by employing a mixed methods approach using original quantitative and qualitative data, thus providing empirical evidence on how these environmental factors are systematically associated with women's empowerment in South Asian slums.

More specifically, our research explores how urbanization and economic growth – which have both contributed to the expansion of slums and environmental degradation in South Asia – impact women's empowerment. We use original data collected from India, Bangladesh and Pakistan. Our findings indicate that women slum residents are less empowered than men in all three countries, and that lack of infrastructure and public services (i.e. water, sanitation and drainage systems), overcrowding and poor street conditions had negative effects for women's and men's empowerment alike. The nuances underlying these effects are then explored through qualitative interviews with slum residents and policy experts in each country. The interviews highlight challenging systemic conditions that contribute to divergent impacts across national and political contexts, such as the failure of governments to provide social security, public services and basic infrastructure in slums.

This paper is structured as follows. First, we review literature on urbanization and environmental degradation and their impact on empowerment of slum residents. Second, we delve into the South Asian context providing background information on each of the three country case studies – India, Bangladesh and Pakistan. Third, we outline our research methodology and analysis, including a detailed description of the original datasets developed for the study, the measures and empirical models applied, and the study implications and limitations. We close by providing specific policy recommendations that could improve the lives of women living in slums in South Asian cities.

Literature review

Urbanization, the growth of slums and environmental degradation

Over half of the world's population lives in urban areas, and nearly a quarter of these individuals reside in slums (UN-HABITAT 2012; UN 2014). The term 'slum' refers to a wide range of neighborhoods with poor-quality housing, insufficient infrastructure and deteriorated living environments. Empirical research indicates that cities with higher rates of population growth generate more slums (UN-HABITAT 2003, 26), and slums are considered both a symptom and a cause of environmental degradation. As a symptom, migration from rural areas to cities combined with degeneration of land and natural resources are cited as the root cause of slum population growth (Suhrke and Hazarika 1993; Larose and Ponton 2000; Shandra et al. 2003; Warner et al. 2010; Sawhney 2013). According to this view, slums are not necessarily causing environmental decline themselves, but are the result of rural-push factors associated with resource depletion and extreme climate change events (Shandra et al. 2003). Conversely, some authors believe that slums, as a consequence of rapid urbanization, cause various health and environmental issues for residents and the areas they live in (Ehrlich and Ehrlich 1990; El Araby 2002; Maiti and Agrawal 2005; Majumder et al. 2007; Dewen et al. 2012; Saha et al. 2012; Awadalla 2013; Gruebner et al. 2014). Whether we consider slums a symptom or direct cause of environmental degradation, poor living conditions combined with extreme poverty make slum residents especially vulnerable to economic and environmental shocks.

Environmental degradation is characterized by a reduction in the capacity of the environment to meet social and ecological needs. Environmental deterioration is occurring alongside the growing frequency and intensity of natural disasters and extreme climate events, leaving communities vulnerable (United Nations Environment Program (UNEP) and United Nations Office for Disaster Reduction (UNISDR) 2008). A popular hypothesis linking environmental degradation and economic development posits that urban environmental quality increases with economic development levels but then decreases again due to overuse of energy and resources as economies develop. This theory has been coined the 'Environmental Kuznets Curve' (Kuznets 1955). In an empirical study exploring the validity of this theory in India, Sinha and Bhattacharya (2014) tie economic liberalization to a decline in environmental quality. Poverty and policy play a key role in this connection, according to Majumder et al. (2007), who write: "The quality of urban environment depends a great deal on the quality of the essential infrastructure and utility services like sanitation, sewerage, drinking water supply, garbage disposal, electricity and gas or fuel for cooking" (2).

Scholars have studied the relationship between urban poverty and environmental degradation at various levels, namely the household, neighborhood and city (Hardoyet al. 2001). At the household level, domestic and work-related pollutants and poor infrastructure contribute to low levels of hygiene and increased injury and illness. Inadequate or unsanitary disposal of garbage and human excreta is a leading cause of environmental degradation and illness in the home and workplace (Sengupta 1999; Dewan et al. 2012). Overcrowding in small homes, which often serve as both living quarters and workplaces in slum households, results in a higher chance of accidents (Hardoy and Satterthwaite 1991; Awadalla 2013). Finally, air pollutants in homes due to fossil fuel use for cooking and chemical use in home-based manufacturing give rise to respiratory illness and shorter lifespans (Vyas and Reddy 1998; Ezzati and Kammen 2002). At the neighborhoods and city levels, insufficient and underdeveloped infrastructure is a root cause of poor environmental conditions in slums. Improper waste management (garbage collection) and open sewage create unsanitary surroundings and a deteriorating social environment (as explored by Larose and Ponton 2000; El Araby 2002; Dewan et al. 2012; Capps et al. 2016). As a direct result, slum neighborhoods experience a higher incidence of disease vectors such as mosquitos, spiders, cockroaches and mites (Hardoy et al. 2001, 82). For urban areas, the household and neighborhood effects are further exaggerated as city grids become overwhelmed by population growth; sources of clean water are compromised and depleted; transit and traffic contribute to increased accidents, noise pollution and emissions; and industry pollutes air and water quality (Hardoy et al. 2001).

Beyond the daily environmental factors that detract from slum dwellers' quality of life, the urban poor face the highest risk and are the first to experience the negative effects of extreme climate events due to their hazardous environment and poor housing quality, as well as their socio-economic and political status in society (Majumder et al. 2007; UN-Habitat 2008; Glaeser and Joshi-Ghani 2013; Hanlon et al. 2016). Consequently, natural disasters are known to disproportionately kill impoverished populations – two thirds of the deaths related to natural

disasters between 1991 and 2000 were in cities with low human development index (HDI) scores even though half of all disasters were in countries with medium HDI levels (Wisner et al. 2014).

Impacts of urban slum environmental degradation on women's empowerment

The interrelated forces of urbanization and the growth of urban slums raise a number of potential concerns for women's empowerment. Several studies make links between climate change or environmental degradation and women's role in society (e.g. Pearson and McPhedran 2008; Alston and Whittenbury 2010; Dankelman 2010; Mahon and Fernandes 2010; Alston 2014). Peters et al. (2016) set out a clear framework for the factors that act as either enablers or barriers for women's empowerment and how gender-focused public policy can contribute to these dynamics. Environmental degradation can undermine enablers like infrastructure development and public service provision, and consequently impact women's labor force participation. Likewise, environmental factors can exacerbate barriers to women's empowerment by pushing urban women toward the informal labour sector and leaving them vulnerable to workplace violence and exploitation from employers.

Poor infrastructure, lack of public service provision, and physical and structural violence are strongly linked to environmental factors in urban slums. For women specifically, a primary concern is the lack of safe and affordable housing. Housing deprivation is a key source of the disparity in security outcomes between men and women in urban slums. According to Gomez et al. (2008), the absence of safe and private spaces, including amenities as basic as toilets, has a negative impact on women. When forced to relieve themselves in public, women often wait until nightfall when they have the additional privacy of darkness, but this also increases their danger of being assaulted (Fisher 2008). Women living in urban areas are more likely to suffer gender-based violence from a non-partner and are far less likely to report gender-based violence than those living in rural areas (McIlwaine 2013).

Poverty-related environmental conditions also increase the incidence of specific health ailments and diseases with more intense impacts for women slum residents (Awadalla 2013). Overcrowding and use of solid fuels for cooking raises the risk of respiratory illness for women and children who spend a majority of their time indoors (Ezzati and Kammen 2002). Additionally, long-term exposure to traffic-related air pollution causes cardiovascular and respiratory illness (Jahan 2008). Contaminated water supply and unsanitary human and household waste disposal cause gastrointestinal problems, skin ailments, cholera, typhoid and other infectious diseases. Garbage dumps, often located close to slum settlements, serve as breeding grounds for harmful bacteria, fungus and other parasites (Asian Development Bank 2012; Mavropoulos and Newman 2015).

Labor force participation, identified as an enabler of empowerment (Peters et al. 2016), and women's predominance in informal sector labour, identified as a barrier, are also tied to environmental degradation in slums. In particular, urban poor women bear high costs due to lack of access to economic resources and the agency to make decisions that may improve their

wellbeing (Kabeer 1999a, 1999b, 2001). For example, women lack land and asset ownership, access to education, and employment or income generating opportunities, resulting in high income insecurity (Asian Development Bank 2012). The drudgery and time spent on domestic and care work also increase in the absence of basic services like running water (World Bank 2014). In a study on environmental degradation in Gujarat, India, Mahadevia (1999) found that women lost up to two or three hours per day collecting water for their household. Lack of access to infrastructure and basic services means women and girls are preoccupied with household chores that deprive them of time for education, income generating activities and leisure (Warth and Koparanova 2012).

The size of the informal economy and the urban population often grow in tandem (Glaeser 2011; Malik et al. 2016), and informal workers are known to be economically worse off than their counterparts employed in the formal sector (Jutting and de Laiglesia 2009). Urban working women are disproportionality employed in the informal labor sector, occupying low-paid, low-productivity and low-security jobs (Tacoli 2012; Warth and Koparanova 2012). Trapped by a vicious cycle of family responsibilities, lack of access to quality education, low job earnings and job insecurity, women struggle to lift themselves and their families out of poverty (Tacoli 2013). Some women also have limited mobility and decision-making power to improve their circumstances in both the household and wider community (Asian Development Bank 2012).

Urban women's vulnerability to natural disasters and extreme climate events is directly related to their physical and economic wellbeing. While all urban poor populations are more susceptible to climate risks, more women tend to die than men during and after climate disasters (Terry 2009). Siddique and Chanchai (2013) point out that in the wake of a natural disaster or environmental event, the needs of women are often neglected. For example, Alston (2014) argues that gender-based violence is often overlooked during disaster response interventions. Studies have also shown that women who are the sole breadwinners for their families are more likely to be poor and to experience shelter deprivation in the face of natural hazards (Jahan 2008; Nasrim 2012), as disasters disrupt the common, often informal, forms of paid labor for women. Post-disaster income generation is therefore more difficult for women, resulting in heightened financial insecurity in an already tenuous struggle for daily survival (UN-HABITAT 2007).

Study context: Urbanization, environmental degradation and gender inequality in South Asia

South Asian cities are growing rapidly, and although they are centers of economic development, many urban residents face significant poverty and economic deprivation. The challenge for the region is that economic growth is not reaching the urban poor (Mahbub ul Haq Human Development Centre Lahore 2014). South Asia's urban population is poised to grow by almost 250 million people by 2030 (Ellis and Roberts 2016). Cities have been unable to support current levels of urbanization, as demonstrated by the growing prevalence of slums, which account for

around 35 percent of the urban population in South Asia (UN-HABITAT 2012). In Bangladesh and Pakistan, this proportion is around 50 percent. In India, the number of people living in slums is more than the sum of the entire slum population of other South Asian cities.

According to Ellis and Roberts (2016), the majority of South Asia's cities are characterized by high levels of poverty and lack of basic services, inadequate housing conditions and generally poor livability. South Asia has the highest urban poverty levels in Asia and the Pacific with countries like India (20.9%), Bangladesh (21.3%), and Pakistan (13.1%) reporting high proportions of urban populations living in slums (Asian Development Bank 2012, 10). For the five most populous countries in the region – India, Bangladesh, Pakistan, Afghanistan and Nepal, in that order – the number of urban residents below the national poverty line ranges from about one in eight in Pakistan to more than one in four in Afghanistan. Compounding this situation, poor urban residents living in peripheral areas are often excluded from key urban services such as access to piped water, sanitation and waste management (Mahbub ul Haq Human Development Centre Lahore 2014).

South Asia's mega-cities are already experiencing a decaying urban environment (Mahbub ul Haq Human Development Centre Lahore 2014). The World Bank data indicates there is a shortage of over 38 million housing units in the South Asian region, not counting housing in need of repair or replacement. The majority of houses are small, congested or makeshift arrangements (Ellis and Roberts 2016). Hazardous levels of air and water pollution, improper waste management, and the inability of cities to provide clean water and sanitation to urban residents have called the sustainability and livability of South Asian cities into question (Sahibzada and Qutub 1993; Mahadevia 1999; Sengupta 1999; Maiti and Agrawal 2005; Alam et al. 2006; Majumder et al. 2007; Bohle and Warner 2008; Dewan et al. 2012; Sahaet al. 2012; Goswami and Manna 2013; Sawhney 2013; Ahmed 2014; Gruebner et al. 2014).

South Asian cities are also prone to natural disasters and climate change events such as heat waves and torrential rains, which lead to urban flooding. Since 1971, around 825,000 people in the South Asian region have died in natural disasters, while direct damages total over 80 billion dollars. In the past decade alone, nearly 700 million people, half of the region's population, were personally affected by one or more disasters (World Bank 2013).

Gender inequality is pervasive in South Asian countries, especially in India and Pakistan where deeply-rooted patriarchal belief systems are widespread. Women in the region suffer from high levels of gender-based violence as well as discrimination in education, nutrition, health and employment opportunities (Dwivedi 2017). Due to low rates of education and literacy, and lack of access to preventative resources, South Asian women are particularly vulnerable to risks associated with urban poverty and the lack of urban infrastructure and services (Nabeel 2014).

Research questions and hypotheses

At the outset of this study, we were interested in understanding possible outcomes related to the effects of urbanization and economic growth on women due to environmental factors in slums. This interest gave rise to following central research question of this study and three related sub-questions:

Central research question:

i.   How and to what extent do environmental degradation and climate change events impact men's and women's empowerment in South Asian slums?

Sub-questions:

i.   Does environmental degradation impact women more adversely than men in South Asian slums?
ii.   Do climate change events impact women more adversely than men in South Asian Slums?
iii.   What are the specific environmental degradation factors and climate change events associated with a lack of women's empowerment in South Asian slums?

Using statistical analyses of an original survey dataset covering 1,199 households from 12 South Asian slums across four cities in India (New Delhi), Bangladesh (Dhaka) and Pakistan (Lahore and Islamabad), we tested several theoretical pathways linking environmental degradation and women's empowerment. The first hypothesis outlined anticipated effects of poverty-related environmental degradation on empowerment, and the second hypothesis outlined expected impacts of climate change vulnerability on empowerment.

Hypothesis 1: *Poor infrastructure and lack of or inadequate access to water, sanitation and energy are associated with a lack of women's empowerment.*

Hypothesis 2: *Loss of income and vital resources, such as one's home, during and after climate events are associated with a lack of women's empowerment.*

Methodology

This study employed a mixed methods approach combining both quantitative and qualitative data to discover the links between environmental degradation and women's empowerment. Quantitatively, we analyzed original survey data to measure the extent of climate change vulnerability and poverty-related environmental degradation as associated with men's and women's empowerment. We further collected qualitative interview data from slum dwellers and policy experts in each city to triangulate and add further depth to our quantitative findings. The semi-structured interview protocol was developed based on our findings from the household

surveys to further our understanding of climate change events and environmental degradation and their impacts on women slum residents. The research design was reviewed and approved by the Urban Institute Institutional Review Board.

Sampling strategy

We used a two-stage stratified random sampling strategy to select survey respondents. In the first stage, we selected three slums from each of the four study cities, totaling 12 slums. We purposively selected slums that are non-notified (a term used in South Asian context to refer to communities that lack official governmental recognition as a slum community), larger than 400 households (for sample size reasons detailed below), and prone to environmental hazards. Specifically, we selected slums located in high risk regions such as floodplains, land parcels next to open drains, sewerage lines and landfills, to name a few.

In the second stage, we used a circular systematic sampling to select households within each slum. First, we mapped the geography of each slum with the help of the community and then randomly selected a dwelling as our starting point using ArcGIS (see Appendix A for details). Every fourth household was then selected for an interview using a skipping pattern. We sought to complete 100 interviews per slum, thus our rationale for selecting slums with 400 or more households. We conducted interviews at the household level with either a man or woman respondent aged 18 and above, who had been living in the house for at least six months and were not guests. We also worked to ensure equal representation of both men and women respondents in our surveys to the extent possible. Table 1 summarizes our slum samples and gender distribution of our survey respondents. A map with details on each slum is provided in Appendix A.

For each of the four cities, we also collected qualitative information by conducting interviews with 15 slum residents and 10 or more policy experts. The selection of slum respondents for these interviews was made using screening criteria developed from a preliminary quantitative data analysis, including key variables such as gender, age, occupation, education and household income level. From each slum, we selected five respondents for a qualitative interview: three women and two men. All respondents were of working age (i.e. 18-65 years old) and included unemployed, employed and homemaker respondents. Policy experts included individuals from government, non-governmental organizations and academia.

Survey instruments and field protocols

The survey instrument, a structured questionnaire, was designed after extensive consultation with stakeholders in each of the four case cities. The survey instrument was pre-tested in the targeted slums with the aim of examining and validating the proposed questions, identifying any comprehension or formatting-related issues in the questionnaire, and validating the data entry and tablet program. Finalized surveys were administered by fieldworkers seven days a week from 10:00am-6:00pm. To ensure the quality and accuracy of survey responses, field supervisors back-checked ten percent of all responses, randomly selected, by phone. Semi structured interviews with

relevant stakeholders such as the representatives of city development authorities in Dhaka, New Delhi, Lahore and Islamabad, as well as with community leaders from the 12 slums were conducted using the interview protocol that was developed based on preliminary analyses of survey data. The average time taken for each semi structured interview was about 40 minutes.

TABLE 1—— SELECTED SLUMS AND SAMPLING PROFILE

City, Country	Slum Name	Population (Approx)	Sample Size (Men/Women)
New Delhi, India	Ghazipur	2,700	101 (37/64)
	Tughlakabad	2,700	99 (35/64)
	Hanuman Camp	3,700	100 (37/63)
Dhaka, Bangladesh	Keranijang	3,000,000	100 (50/50)
	Jhutt Patti Tong Basti	1,937	100 (51/49)
	Sattala Basti	5,063	99 (51/48)
Lahore, Pakistan	Basti Esayan	3,000	100 (50/50)
	Gao Shalla	10,000	100 (50/50)
	Altaf Colony	10,000	100 (50/50)
Islamabad, Pakistan	Chora Stop	5,000	100 (55/45)
	Akram Gill Colony	2,000	100 (50/50)
	Mera Jaffar	1,000	100 (50/50)

Study measurements and empowerment indices

The first compilation of gender disaggregated data in the 1970s gave rise to literature that measured women's status vis-a-vis men (Boulding et al. 1976). However, the challenge of comprehensively defining and conceptualizing women's empowerment was a major challenge that Kabeer (1999a, 1999b, 2001) set out to address by distinguishing between its associated preconditions, processes and outcomes (Danner et al. 1999). Kabeer defines women's empowerment as "the expansion in people's ability to make strategic life choices in a context where this ability was previously denied to them" (1999b, 437). In this approach, empowerment is conceptualized across three dimensions:

> *resources* (defined broadly to include not only access, but also future claims, to both material and human and social resources); *agency* (including processes of decision making, as well as less measurable manifestations of agency such as negotiation, deception and manipulation); and *achievements* (well-being outcomes). (Kabeer 1999a, 1, emphasis added).

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Kabeer's three-way conceptualization of empowerment has been widely adopted by scholars and practitioners alike, and it has further been expanded to include things like individual security and structural power dynamics (gender relations) that impact on empowerment (e.g. Grown et al. 2015; Powers et al. 2016; Bird 2018). Taylor and Pereznieto (2014), for example, build on Kabeer's work but define women's economic empowerment more narrowly as, "the process of achieving women's equal access to and control over economic resources, and ensuring they can use them to exert increased control over other areas of their lives" (as cited by Laszlo and Grantham 2017, 6).

Another approach used in the literature to measure women's empowerment is to select indicators from various domains – such as economic, political or socio-cultural measures – to create more comprehensive indices. Well known examples include the Women's Empowerment in Agriculture Index (IFPRI 2012), or the simplified Women's Empowerment Index (The Hunger Project 2014) using the Alkire-Foster (AF) method (Alkire and Foster 2011; Alkire et al. 2012, 2013). The AF method is a popular technique used to measure poverty or wellbeing because it is flexible and can incorporate various measures and dimensions to create indices for specific contexts.

For this study we combined several approaches for defining and measuring women's empowerment in slums, opting to utilize individual measures of resources and agency, while also integrating additional measures of individual security for women respondents only. We hypothesized that women in slums lack access to key resources and the agency to make decisions to improve their quality of life, especially given their exposure to poverty-related environmental conditions and climate change events. In line with the work by Kabeer as well as Taylor and Pereznieto, we developed indicators pertaining to the domains of agency and resources, and within each domain, we developed indicators pertaining to sub-domains – economic, socio-cultural, political and security – to create a novel composite index, named the Women's Empowerment in Slums Index (WESI). We also created a modified index named the Empowerment in Slums Index (ESI) for analysis comparing men's and women's respective levels of empowerment. The ESI excludes some of the indicators that are only relevant for women, such as gender-based violence. Similar to the studies reviewed to create the Growth and Economic Opportunities for Women measurement inventory (Laszlo and Grantham 2017), we have used both direct measures (such as women's autonomy over household decision-making), and indirect measures (such as labor force participation and education levels).

Constructing the WESI and the ESI

The WESI is comprised of 23 indicators of women's empowerment specific to the conditions of slums in South Asia. This includes 18 agency and resource-related indicators and five indicators on human security (i.e. gender-based violence). Since violence against women is an important mark of gender power relations in a society (Grown et al. 2015; Powers et al., 2016; Bird, 2018), we were compelled to include measures on gender-based violence in the WESI, which is focused on women's empowerment only. The ESI, on the other hand, includes only the 18 agency and resource-related indicators of empowerment, but captures data for both men and women, allowing

for comparisons to be made between genders within each population set. Table 2 lists all indicators used in the research along with descriptive statistics on each, disaggregated by country and gender.

TABLE 2 —DESCRIPTIVE STATISTICS FOR THE WESI INDICATORS

Indicators	India		Bangladesh		Pakistan	
	Women	Men	Women	Men	Women	Men
Sample size	108	173	150	145	305	295
Resources						
Do not work for money/earn an income	21.39	7.41	0	0	68.47	9.84
Less than 5,000/month for Bangladesh/Pakistan, less than 2,000/month for India	27.17	7.41	53.47	2.00	77.29	16.39
Equal to or less than secondary (grade 6-8) level education	93.64	86.11	94.44	90.00	79.66	79.34
No knowledge of laws against gender violence	82.08	N/A	10.42	N/A	39.66	N/A
No government ID	8.67	1.85	14.58	8.67	21.69	2.62
No access to health facilities	6.94	26.85	6.25	1.33	12.54	25.57
Monthly medical expenditure is more than 2 days worth of income	68.21	57.41	37.50	38.00	68.47	49.51
Having experience with sexual harassment, verbal, or physical abuse	11.56	N/A	7.64	N/A	11.19	N/A
Having experience with verbal abuse	38.15	N/A	77.08	N/A	20.00	N/A
Having experience with physical abuse	17.92	N/A	50.69	N/A	11.19	N/A
Agency						
Never or only on a festival for purchasing personal items such as jewelry, beauty products, toiletries, perfume	41.62	61.11	18.75	2.67	45.08	36.72
Sometimes/rarely/never making decisions for using personal income or saving	22.54	9.26	17.36	6.00	21.02	12.79
Spouse or some other family members for making decisions for everyday and special events/expenditure	18.50	29.63	40.97	12.00	42.03	28.20
Not alway being consulted for spending the household income for working women Rarely/never being consulted for non-working women	24.86	18.52	26.39	26.67	21.02	56.07
Sometimes/Rarely/never traveling outside of the home for recreation or work	83.82	86.11	89.58	83.33	82.37	77.05
Never using public transportation	52.60	64.81	17.36	24.67	76.61	67.21
Spouse/some other family member of making decision to use time	12.14	11.11	38.19	4.00	58.98	37.38
Spending more than 10 hrs for kitchen work, childcare, cleaning, commuting, caring for others, and to go to toilet	56.07	11.11	51.39	7.33	95.25	23.61

Not engaged in a community group	5.20	10.19	1.39	12.00	1.36	9.84
No voting	80.92	91.67	70.83	77.33	58.64	84.59
Main information source is family, friends or neighbors	32.95	27.78	4.17	0.67	28.47	13.77
No self-decisions on personal health	9.83	12.04	43.75	8.67	50.51	39.67
No report of sexual harassment to employer/police	6.94	N/A	4.86	N/A	10.17	N/A

Note: Cases were not weighted. N/A: Not Applicable.

As shown in Table 2, the results for different indicators vary greatly by country and gender. In Bangladesh, all respondents reported that they work for money, but India and Pakistan showed a higher unemployment rate. Pakistani women are particularly highly unemployed (68.47%). Men are less likely to have access to health facilities than women in India and Pakistan, and women in these two countries spend a high proportion of their personal income on medical expenditures (68%). Some similarities also emerge across slums in all three countries, for example, in every country the majority of slum resident were poorly educated, women had lower incomes than men, and were less likely than men to make decisions about how to spend their personal income. Moreover, time-use related indicators for cooking, childcare, cleaning and going to the toilet show that women experience greater time poverty than men in all three countries. Decision making in other areas reveal no consistent pattern between countries or by gender. For example, women in Bangladesh and Pakistan are more deprived in terms of decision making for health care, compared to women in India.

We used the AF method to construct the WESI and the ESI (Alkire and Foster 2011). The first step in the AF method is to create a binary indicator of whether an individual is deprived or not on a specific measure. Our cut-off definition is included in the first column of Table 2. For example, we used secondary level education (grade eight or below) as the cut-off point for our education measure, and considered an individual as deprived if they have not attained higher than secondary level education. The same cut-off definitions were applied for all three countries except in the case of income, to account for the of the different standard of living in each country.

In the second step in the AF method, each indicator is weighted to assign adequate importance in the composite index. For constructing the WESI, we used equal weights for both domains (agency and resources) and within each domain, applied equal weights to all four sub-domains, namely, economic, socio-cultural, political and security. We set the same weight across the eight sub-dimensions, assuming that each sub-dimension is an equally important factor for measuring empowerment. Subsequently, each individual indicator received a specific weight as shown in Appendix B.

The third step in the AF method is to calculate a normalized disempowerment score ranging from 0 to 1, using binary measures and associated weights, as described above. In essence, a

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disempowerment score is simply a weighted summation of all twenty-three indicators and provides a measure of disempowerment for each individual. In order to make our measure intuitive, we subtracted disempowerment scores from 1 to obtain empowerment scores. These empowerment scores were used as a dependent variable in regression analyses presented later in this paper. Finally, we used these individual empowerment scores to calculate an aggregate WESI score for each study country. Appendix C provides details on computing the WESI, our assumptions, as well as mathematical formulas.

As shown in Table 3, country aggregated WESI scores indicate that women who reside in the slums in Bangladesh and India are more empowered than women living in slums in Pakistan. As mentioned earlier, the ESI was constructed using both men and women samples and excluding indicators related to violence. Country aggregated ESI scores, also presented in Table 3, show that women are less empowered than men across all three countries even if we do not include violence related indicators. Overall, these findings show that gender gaps are wider in Pakistan and Bangladesh compared to India, that women who reside in slums in Bangladesh and India are more empowered than women in Pakistan, and that Bangladeshi men are more empowered than men in India and Pakistan.

TABLE 3⸻ESI AND WESI FOR INDIA, BANGLADESH AND PAKISTAN

Index	India		Bangladesh		Pakistan	
	Men	Women	Men	Women	Men	Women
ESI	0.687	0.644	0.814	0.643	0.656	0.495
WESI	-	0.604	-	0.642	-	0.526

Note: ESI is statistically different ($p<0.05$) from one another across India, Bangladesh, and Pakistan except for women in India and Bangladesh as indicated by ANOVA test results. WESI is statistically significantly different ($p<0.05$) from each other across India, Bangladesh and Pakistan as indicated by ANOVA tests. Any observations with missing data in any of the ESI and WESI indicators were removed from the overall computation.

Measuring environmental degradation in slums

From our quantitative survey data, we have operationalized 13 indicators of environmental degradation, as shown in Appendix D. These indicators include poverty-related environmental degradation such as housing deprivation, lack of infrastructure and lack of tenure in the slum, as well as experience with extreme climate events. All factors used in the analysis have been selected based on environmental degradation and climate change factors considered important for women's empowerment in existing literature.

Approximately 82 of the observations in our sample are missing the environmental degradation variables or individual level covariates in addition to missing data on WESI variables, as discussed above. As a consequence, our final sample size for regression analyses is 1,077. Table 4 contains the unadjusted sample means of independent variables for men and women in India, Bangladesh and Pakistan.

TABLE 4⸻ DESCRIPTIVE STATISTICS OF INDEPENDENT VARIABLES BY GENDER AND COUNTRY

Variable	India		Bangladesh		Pakistan	
Gender	Men	Women	Men	Women	Men	Women
Age (mean; years)	37.67	33.65	35.04	30.74	34.72	33.64
Married	87.6%	92.9%	93.5%	91.5%	83.1%	82.4%
Government Land	100.0%	100.0%	42.4%	36.4%	44.2%	50.8%
Rented house	35.2%	40.0%	92.8%	96.1%	26.6%	35.9%
Residency < 2yrs	5.7%	10.0%	8.6%	25.6%	2.9%	6.6%
Poor street condition	36.2%	44.1%	61.2%	62.8%	77.7%	92.2%
No permanent structure	55.2%	53.5%	30.9%	32.6%	17.6%	18.8%
Overcrowded	63.8%	64.7%	79.9%	75.2%	37.1%	54.7%
Lack of toilet	90.5%	81.8%	87.8%	91.5%	1.1%	1.2%
Lack of drain system	100.0%	98.2%	64.0%	63.6%	64.0%	74.2%
Long-distance from water	99.0%	93.5%	0.0%	1.6%	48.9%	41.0%
No waste facility	61.9%	82.9%	63.3%	46.5%	76.6%	53.9%
Heatwave	79.0%	80.0%	94.2%	96.9%	2.9%	6.3%
Torrential rain	23.8%	14.7%	66.9%	56.6%	1.8%	6.6%
Flood	68.6%	69.4%	0.0%	0.0%	0.0%	0.8%
Sample Size	105	170	139	129	278	256

Note. The means were unweighted and no survey weights are applied.

This descriptive data set indicates many differences existing across the three country case studies. In India, for example, there are more paved roads than both Pakistan and Bangladesh, and all slums in India are located on government land. However, few Indian slum dwellers have access to water close to home, and floods are reported more frequently than in the other two countries. In Bangladesh, few slum dwellers own their homes, which corresponds to high levels of overcrowding. Water access in Bangladesh is better than in India and Pakistan, yet Bangladesh also reports the highest number of heatwaves and torrential rain. In Pakistan, nearly all slum residents have access to toilets. Pakistan also has fewer reports of all types of climate disasters

than in the other two countries. These cross-country comparisons are important because they provide insight into the influence of slum conditions on the empowerment of men and women residents. Additionally, at a root level, many of the differences observes across the three countries are directly tied to national-level responses to urbanization and slum growth in community planning and policy-making.

Regression analyses and results

Our research aim was to examine whether women's empowerment is associated with environmental degradation, and we performed multiple regression analyses to answer this question. We used an individual-level empowerment score for both men and women as our dependent variable, and environmental degradation and climate change indicators were included in the model as independent variables. Age, marriage and slum location on government land were included as individual-level control measures. We performed multiple regression analysis using a combined sample from all three countries as well as using stratified samples by country. We calculated clustered standard errors by city in the combined model and by slums for the country specific models.

Table 5 presents our empirical findings on the relationship between the empowerment scores and several poverty-related environmental degradation indicators. Model 1 uses a combined sample from all three countries, and model 2, 3 and 4 use stratified samples by country for India, Bangladesh, and Pakistan respectively. For all models, we used nine poverty-related environmental degradation factors and three climate change event related factors as independent variables to test our hypothesized relationships. In order to determine whether determinants of empowerment were different for men and women, we created interaction terms for all environmental degradation factors and factors associated with climate change events, with gender in Model 1. We also added control variables for age, marital status and slum location on government land.

It is clear from Table 5 that women had significantly lower empowerment compared to men across all three countries, with the highest difference in Pakistan. Interestingly, gender differences were not statistically significant in Bangladesh after controlling for other factors, thus suggesting the possibility of lower inequality in Bangladesh compared to India and Pakistan. This result should not be confused with the fact that women are less empowered than men in Bangladesh on average, as is clear from descriptive statistics reported in Table 3.

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TABLE 5⸺ ENVIRONMENTAL DETERMINANTS OF EMPOWERMENT

	All three countries (1)		India (2)	Bangladesh (3)	Pakistan (4)
	Main Effect	**Interaction Effect**			
Age	0.001* (0.000)	-	0.000 (0.001)	0.001 (0.001)	0.002* (0.001)
Married	0.012* (0.004)	-	0.023 (0.009)	0.009 (0.051)	0.015 (0.010)
Women	-0.113* (0.039)	-	-0.056*** (0.001)	-0.109 (0.055)	-0.143*** (0.013)
Slum on Govt Land	0.010 (0.010)	0.011 (0.027)	~	0.013 (0.030)	-0.006 (0.009)
Rented house	0.014 (0.012)	0.011 (0.012)	-0.000# (0.063)	-0.008 (0.048)	-0.006 (0.013)
Residence less than 2 yrs	-0.029* (0.017)	-0.09** (0.02)	-0.037 (0.032)	-0.037** (0.007)	0.006 (0.015)
Poor condition of streets	-0.006 (0.023)	-0.049* (0.021)	-0.005 (0.042)	-0.099# (0.071)	-0.022 (0.019)
No permanent structure	-0.017 (0.019)	0.000 (0.020)	-0.014# (0.010)	-0.004 (0.050)	0.010 (0.012)
Overcrowded house	-0.005 (0.009)	-0.019* (0.006)	-0.027** (0.003)	-0.014 (0.014)	-0.001 (0.006)
Lack of toilet	-0.067** (0.012)	0.062* (0.025)	-0.035* (0.011)	-0.049# (0.023)	-0.010 (0.019)
Lack of drain system	-0.012 (0.009)	-0.007 (0.042)	-0.131** (0.026)	-0.013 (0.064)	-0.023** (0.007)
Long distance from water	-0.041*** (0.006)	0.034 (0.019)	-0.049* (0.012)	-0.055# (0.048)	-0.030 (0.021)
No waste facility	0.005 (0.020)	0.014 (0.022)	0.029*** (0.003)	0.032 (0.049)	0.014 (0.010)
Climate Events					
Heatwave	-0.001 (0.027)	-0.013 (0.018)	-0.028 (0.045)	-0.031 (0.019)	0.019 (0.044)
Torrential rain	-0.022 (0.024)	-0.029 (0.035)	-0.065*** (0.004)	0.019 (0.021)	-0.010 (0.034)
Flood	-0.024 (0.017)	0.023* (0.009)	0.026 (0.016)	~	-0.206*** (0.024)
Constant	0.767 (0.044)		0.905 (0.071)	0.857 (0.132)	0.560 (0.021)

Sample Size	1077	275	268	534
Adj. R-squared	0.4337	0.1920	0.4098	0.4336

Note. We performed multiple regression and no survey weights were applied. Standard error was clustered by slum and is presented in parentheses. ~Variables were omitted because of collinearity. New Delhi was omitted as a reference category for cities. Tughlakabad was omitted as a reference category from India model, Ghaterchor Basti, Keraniganj was omitted from Bangladesh model, and Mira Abadi were omitted from Pakistan model as reference category for slums.***p<0.01; **p<0.05; *p<0.1. Coefficients marked with # were found significant and negatively associated with empowerment in stepwise regressions (revised coefficients not reported here).

Many of the hypothesized poverty-related environmental degradation factors were statistically significantly associated with empowerment. For example, the combined model (Model 1) suggests that those who recently moved into their house, with no toilet on the premises, and had to fetch water from far distance, were less empowered compared to their counterparts with access to better living conditions. Interestingly, none of the climate change events were statistically significant in the combined model. However, when the sample was stratified by country, it is clear from Model 2 that torrential rain was statistically significantly associated with lower empowerment scores in India, and flooding was statistically significantly associated with lower empowerment scores in Pakistan. Model 2 and 4 also suggested that in addition to poverty-related environmental degradation factors found earlier in the combined model, the lack of a drainage system was also negatively and statistically significantly associated with lower empowerment in slums of both India and Pakistan. In addition, overcrowding was another factor that was negatively associated with lower empowerment in slums in India.

While it is surprising that in a full model for Bangladesh, only one environmental degradation factor (moved into this home recently) was associated with lower empowerment, when we dropped all the variables that were not significant at 0.1 level (with a stepwise model selection process), we found that the lack of a toilet, poor street conditions and long distance to water were all negatively associated with empowerment (coefficients marked with # in Table 6, values not reported). Another surprising result was that the lack of a solid waste management facility led to more empowerment in India, however, in a stepwise regression model we did not find this variable significant for Indian slums.

As it is clear from interaction effects (Model 1), that shorter stay at current residence, poor street conditions and overcrowding are particularly significant for reducing women's empowerment in slums. Interaction effects of lack of toilets and flooding were positive but it should not be confused as more empowering for women since the net effect for women with no toilet (-0.118) still suggested lower empowerment compared to their female counterparts with toilets at home (-0.046), and male counterparts with no toilet at home (-0.067). We also stratified our pooled sample into men and women and developed two more models (coefficients not reported here for brevity). Here we found that lack of toilet affects both men and women, whereas recently moved to the house, overcrowding and temporary housing structure were additional factors that affected only women's empowerment negatively.

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Qualitative results

The value of using a mixed methods research approach for this study was the ability to better understand the mechanisms underlying our quantitative findings. Across all three countries, as shown in the quantitative analysis above, several environmental conditions demonstrated statistically significant associations with women's empowerment. However, these effects differed by country. This suggests that context-specific variables present in each country may be the cause of divergent impacts. Several key points raised in our qualitative interviews with slum residents and key informants help to explain how and why women are impacted differently across slums and countries in South Asia.

India

Although the slums in our study are all non-notified, that policy experts that we interviews report that India has a higher proportion of notified slums and a positive policy environment for slum residents as compared to the other two countries. Slums in India have increased their basic amenities over the last five years, according to one government official, in order to meet the goal of making Delhi 'open defecation free' by 2018. However, there are still many challenges associated with creating targeted and appropriate slum policies and infrastructure supports. One of the key challenges outlined by policy experts is that of installing water lines to slum areas where there is very little space to build these facilities. Most slums are built near open drains where the government will not put a sewer line, and inside the slum there is no space to put a line because it is not a planned settlement. Thus, public toilets are usually built at one of the ends of the slum. In one of the slums surveyed, there was only one community toilet available; insufficient if one recalls that all slums in our sample had over 400 households. Toilets are also often closed from 11:00pm to 5:00am, though in some places there are now guards so the toilets can be open all day and night.

This insight on policy and infrastructure development in India helps explain our finding that lack of toilets negatively impacts the empowerment of both men and women. Considering the impact of approaches to Water supply, Sanitation, and Hygiene (WASH) in slums, one bureaucrat reflects: "It is hard to distinguish policies in terms of gender because our policies are meant for all sections of the population. Thus, for instance, our community toilets serve both men and women." Regardless of gender, individuals lacking access to toilets must spend extra time waiting to use a public toilet, negatively impacting the amount of time spent participating in the labor market. This finding suggests that water line installation and human waste disposal infrastructure investments can benefit both men's and women's livelihoods and empowerment.

Extreme climate events are commonly reported in India and have substantial impacts on slum residents according to our interview data. Policy experts in India shared that most of the calls to police and government received during monsoons are from slum households because of floods. This report is consistent with our quantitative analysis findings indicating that torrential rains are associated with lower levels of empowerment for both men and women in India. One slum resident

explains, "During rains, all our work stops for at least a month. All the water from this drain gets filled up till our knees. It causes all sorts of diseases too." Given that floods are the primary environmental event experienced in Delhi, it is not a surprise that poor drainage systems which can cause pooled and stagnant water after floods are also associated with lower levels of women's empowerment as women often stay in the home to care for children versus traveling to outside worksites.

Authorities indicated that emergency services are provided to all the slums, irrespective of whether they are notified or non-notified. However, slum residents presented a different perspective on government support. As one individual resident shares, "municipal workers come here to clean up this drain and dump all the muck in front of our houses. Every time we have to bring our carts and dump it out of the slum ourselves. Nobody from the government comes here except around elections." Another resident reiterates this point, "Nobody ever comes to our aid in times of emergencies. Leaders come here, see the situation and leave." Indian public service investments and basic provisions in the wake of natural disasters could help expedite women's return to the labor market.

Bangladesh

The only variable in Bangladesh that was associated with lower empowerment scores related to residency of less than two years in current household. This finding is directly tied to the government's policy of regularly forcing evictions. One resident shared her personal experience in this policy environment: "Once I was evicted from the slum. And that experience shattered me. We lived one week in the open sky. Lost all our family assets. Extreme poverty engraved us. We did not have any food or money for purchasing food." Many residents spoke about fear of forced evictions. Given that women spend most of their time in the home and must rely more heavily on local social networks for work in the informal economy than men, it is not surprising to find that women are more negatively impacted than men by shorter tenure in a slum.

Though not statistically significant in the original model, several infrastructure investments did affect empowerment in stepwise regression. For example, like in India, slum residents in Bangladesh do not often have access to toilets. According to one policy expert, 65 percent of Dhaka slums have no access to safe latrines. In nearly all slums, latrines are shared; and in 50 percent of slums, toilets are shared by at least six families. Indeed, both men and women appear to be disempowered from a lack of toilets. Water access is another issue that highlights Bangladesh's policy approach as the source of our finding. One official notes, "The electricity, gas, water connection in the slums are illegal ones. So awareness for law must be generated in them (slums)." Government officials in Dhaka explain that funding and land rights cause many problems for developing appropriate policy responses to these challenges. As identified in the literature, infrastructure investments and public service provision can act as enablers of women's economic empowerment; however, the current policy approach to slums in Dhaka does not promote this type of intervention.

Policy experts and residents of slums in Bangladesh indicate that climate change has been a serious issue. However, of the three nations, Bangladesh has a much stronger emphasis on the personal responsibility of slum residents and landowners to resolve the problems in slums as opposed to welfare-based policy interventions. As one urban development official states, "The slum dwellers mostly live in low land areas, and heavy rainfall means their homes are flooded. We have not taken any steps to solve this problem. Maybe some other government agency is working towards solving this problem. We are not." Rather than reinforcing slum infrastructure, agencies prefer to provide incentives for slum residents to move into more permanent residences, such as providing housing loans. Our quantitative empirical findings suggest that a lack of investment in infrastructure such as roads has a negative effect on empowerment. In order for Bangladesh to improve empowerment, the city would need to enable slum dwellers' economic development and resilience to natural disasters by strategically investing in public infrastructure, thereby reducing residents vulnerability to climate events.

Pakistan

In Pakistan, government officials and policy experts emphasized that there are no formal 'slums,' rather they exist always as informal settlements. While this means that there are laws in place to prevent evictions, some of the same challenges with lack of infrastructure that cause disempowerment in Bangladesh continue to be an issue in Pakistan. Waste disposal and lack of drainage was specifically mentioned as an increasingly important issue in Pakistan's slums by policy experts and residents alike. However, most waste in slums is not generated by residents, but rather by the nature of the sites on which they are built such as the outskirts of city dumps, behind factories, in cattle grazing holds, or on riverbeds near wastewater or storm water drains.

In our interviews, the health impacts of pollution writ large were often mentioned. Interviewees asserted that they spent large amounts of money on health expenditures for themselves and their family members. Many slum residents said that fever, headaches and dizziness were common health issues in their locality. As one key informant explains:

> *Health expenditures are health assuming an increasingly significant portion of people's incomes. So in reality they may be living below the poverty line. Whatever income gains they have made from coming to the city are being subsumed by mounting expenditures on health issues caused by environmental degradation and climate change corollaries.*

Women, spending more time in the home or in informal labor near the home in poorly situated slum neighborhoods, are more likely to suffer from the negative health effects of pollution. Government officials interviewed are aware of such effects, and anticipate that this challenge will only worsen in coming years as urbanization increases.

Rainfall combined with poor waste management leading to flooding was mentioned frequently during interviews with slum residents in Pakistan. Field surveyors observed waste accumulating in the drains that flowed through one slum and noted, "a lingering, pungent stench in the air due to the open drains, the nearby waste dumping site and garbage accumulation point." Furthermore, brick or soil street construction material was referenced by both residents and policy experts as a challenge during flooding. As one of our enumerators remarked in field note observations, "The unpaved streets are packed with cow dung and dirt. Rain water makes the streets slushy for days, thus making life even harder for the dwellers."

Unlike India or Bangladesh, Pakistan had the highest rate of reported dirt or brick versus cement streets in our quantitative dataset. This reality, combined with the fact that many slums in Pakistan lack drainage (with the exception of the Basti Esayan slum) resulted in an association between poor drainage, floods and lower empowerment scores for women. Women's experience with flooding streets was frequently discussed as problematic in interviews. A number of interviewees pointed out that flooding in the area had become more frequent in recent years, even while rains had decreased. Most respondents indicated that these floods were prevalent because of poor drainage or the complete absence of a drainage system, which led to pooling water and rising water levels that threatened homes. This qualitative finding supports the idea that environmental degradation related to conditions of poverty do, in fact, exacerbate the effects of climate change for slum residents. Street and drainage investments in Pakistan's slums by city government would enable empowerment if adopted as a policy intervention.

Discussion and policy recommendations

The hypothesized links between poverty-related environmental degradation and climate change with women's empowerment are confirmed by both the quantitative and qualitative data collected in India, Bangladesh and Pakistan. Women, overall, experience lower levels of empowerment in slums as compared to men. In all three countries better policies and interventions are needed to support women living in impoverished, urban and informal settlements. However, the indicators of environmental degradation with statistically significant impacts are not consistent across the three case countries. This suggests that, although these countries are all located in South Asia and experiencing similar urbanization, economic growth, slum development and environmental conditions, policies that governments adopt related to slums could make a difference in how women (and men) experience and respond to these changes. Investments in infrastructure and public services that are currently lacking in South Asian slums can reverse the trend toward disempowerment by improving conditions that degrade the environment and by enhance the resiliency of these neighborhoods as they face natural disasters and extreme climate events.

Our findings suggest that the more integrated slums are in the formal urban infrastructure in terms of paved roads, proper drainage, safe water sources and secured tenure, the more empowered both male and female residents are. For example, having access to toilets is highly beneficial to both

men and women by giving them more time to spend on education or income generating activities. Improved physical infrastructure can also provide greater security and health to slum residents; and for women, in particular, it can improve their agency to engage in and regularly access the labor market. In an era of growing climate change effects, the tenuous, if inventive, livelihood strategies of slum residents are under threat due to the vulnerabilities introduced by poverty-related environmental degradation. Developing building codes and construction guidelines, or focusing the public sector's role in community planning and housing development (which is currently outsourced to the private or informal sector across the region), can greatly reduce the economic productivity and health of the urban poor as a means of disaster risk reduction. As this vital infrastructure is installed, and as residents are able to establish tenure and social capital in their neighborhoods, men and women can improve their resilience in the face of climate change and related natural disasters.

The needs of individual slums differ widely. This points to the need for more frequently updated data on slums' environmental conditions to aid planners in making context specific, targeted policies and address local concerns. One way to integrate slums would be through notification and official recognition. This will help planners to ensure the inclusion of all households in regional development interventions. The achievement of the New Urban Agenda goals of the UN-HABITAT should not automatically mean the tearing down of slums. Instead of demolition, slum upgradation processes need to be aided by interventions that empower slum dwellers to manage their own urban environments. Policies that develop "cities for all" can offer a more inclusive response to urban poverty and economic development in the future.

Study limitations and next steps

We faced several challenges and limitations collecting data for the study. A key issue faced during our preliminary research in all 12 slums was the lack of data on important development indicators such as slum population, employment, household size or access to services, and the absence of reliable mapping of non-notified slums. Because of the lack of basic mapping and census data for slum populations, a considerable amount of time was dedicated to identifying the geographic spread and population sizes of the surveyed settlements. Although reasonably reliable estimates on these indicators were obtained from extensive scoping exercises in all four cities, the data obtained was based on approximations as opposed to precision. Notwithstanding the challenges faced due to the lack of data collection by state agencies, slum residents' general reluctance to share information was also a challenge for our survey team. Most residents were distrustful of enumerators, and thus it took substantial time to recruit respondents for the survey. This interfered with the speed at which the data could be collected, and more importantly, indicated the extent to which slum residents feel alienated from mainstream society.

Beyond the limitations of data collection for this study, there are several theoretical limitations to our approach and the indicators included in both the WESI and the ESI and our overall statistical

model. For example, in line with the majority of literature on women's empowerment, we have included labor force participation as an indicator of empowerment. However, women in slums may be working due to financial stress related to poverty versus a conscious choice or desire to earn a paid wage. In our policy expert interviews, several respondents referenced the fact that it is culturally undesirable and stigmatized for women to work outside the home. Likewise, we have given equal weight to resources versus agency indicators in developing the empowerment indices. Logically, women must have access to resources to get to the point of exerting agency in some areas; it is therefore recommended that future researchers look to refine the weights provided each variable when re-creating a women's empowerment index for areas of high urban poverty. In addition, our empowerment indices included indicators that were historical and may not have any relationship with current climate change events. For example, a woman's education level may have been reflecting her distant past whereas her experience of climate change events may have been more recent. Hence, even if climate change events might be affecting educational outcomes for current students, they may not be the determinants of lack of empowerment for those who are not pursuing education at the moment. Finally, this study is first of its kind and exploratory in nature, and hence we included all hypothesized independent variables in our model; however, our sample size was rather small. Future studies should consider larger and representative sample for more conclusive findings.

Conclusion

In an era of growing environmental degradation and climate change effects, the tenuous, if inventive, livelihood strategies of slum residents are increasingly under threat. Thus, there is a growing need for climate change adaptation and mitigation measures in urban resilience strategies, with particular attention paid to the experience of slum residents. This study shows promise, due to divergent results across countries, that public policies can make a difference. To achieve the New Urban Agenda goals of the UN-HABITAT (2017), slum upgradation processes need to be aided by interventions that empower both men and women slum residents. Furthermore, women-focused policy making and gender mainstreaming are essential to ensuring an equitable economic development process for both male and female slum residents as urbanization and growth continue.

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References

Ahmed, I. 2014. "Factors in building resilience in urban slums of Dhaka, Bangladesh." *Procedia Economics and Finance* 18: 745-753.

Alam, M. J. B., Rahman, M. H., Khan, S. K., and G.M. Munna. 2006. "Unplanned urbanization: Assessment through calculation of environmental degradation index." *International Journal of Environmental Science & Technolog*y 3(2): 119-130.

Alkire, S., and J. Foster. 2011. "Understandings and misunderstandings of multidimensional poverty measurement." *The Journal of Economic Inequality* 9(2): 289-314.

Alkire, S., Meinzen-Dick, R., Peterman, A., Quisumbing, A. R., Seymour, G., and A. Vaz. 2012. "The Women's Empowerment in Agriculture Index." IFPRI Discussion Paper No. 1240, Washington, DC: International Food Policy Research Institute.

Alkire, S., Meinzen-Dick, R., Peterman, A., Quisumbing, A., and A. Vaz. 2013. "The Women's Empowerment in Agriculture Index." *World Development* 52: 71-91.

Alston, M. 2014. "Gender mainstreaming and climate change." *Women's Studies International Forum* 47: 287-294.

Alston, M., and K. Whittenbury. 2010. "Impacts of declining water availability in the Murray–Darling basin: Short report." Report by the Gender, Leadership and Social Sustainability (GLASS) research unit, Monash University, Melbourne.

Asian Development Bank. 2012. "Key Indicators for Asia and the Pacific." Manila: Asian Development Bank.

Asian Development Bank. 2013. "Gender and Urban Poverty in South Asia: Proceedings Report of the 2012 Subregional Workshop." Mandaluyong City: Asian Development Bank.

Awadalla, H. I. 2013. "Health effect of slums: A consequence of urbanization." *Scholarly Journal of Medicine* 3(1): 7-14.

Ballesteros, M. 2010. "Linking Poverty and the Environment: Evidence from Slums in Philippine Cities." Manila: Philippine Institute for Development Studies.

Bird, K. 2018. "Practical measures to enable the economic empowerment of chronically poor women." Working Paper 529. London: Overseas Development Institute. Accessed on March 27, 2017. https://www.odi.org/sites/odi.org.uk/files/resource-documents/12048.pdf

Bohle, E. H., and K. Warner. 2008. *Megacities: Resilience and Social Vulnerability*. Bonn: Studies of the University Research, Counsel, Education.

Boulding, E., Nuss, S. A., Carson, D. L., and M.A Greenstein. 1976. *Handbook of International Data on Women*. New York: Wiley.

Braun, B. and T. Aßheuer. 2011. "Floods in megacity environments: vulnerability and coping strategies of slum dwellers in Dhaka/Bangladesh." *Natural Hazards* 58: 771-787.

Capps, K. A., Bentsen, C. N., and A. Ramírez. 2016. "Poverty, urbanization, and environmental degradation: urban streams in the developing world." *Freshwater Science* 35(1): 429-435.

Gomez, M., Gomez, S., Kabajuni, A., Kaur, P., King, W. and V. Ricciardi. 2008. "Women, slums and urbanisation: Examining the causes and consequences." *The Centre on Housing Rights and Evictions (COHRE). Geneva*, pp.1-129.

Dankelman, I. 2010. "Climate change, human security and gender." In *Gender and climate change: An introduction* edited by I. Dankelman, 55-77. London: Earthscan.

Danner, M., Fort, L., and G. Young. 1999. "International data on women and gender: Resources, issues, critical use." *Women's Studies International Forum* 22(2): 249-259.

Dewan, A. M., Kabir, M. H., Nahar, K., and M. Z. Rahman. 2012. "Urbanisation and environmental degradation in Dhaka Metropolitan Area of Bangladesh." *International Journal of Environment and Sustainable Development* 11(2): 118-147.

Dwivedi, S. S. 2017. "Understanding South Asian Vulnerability: Perspectives of Regional Security." *Archeology & Anthropology Open Access* 1(3): 1-10.

El Araby, M. 2002. "Urban growth and environmental degradation." *Cities* 19(6): 389-400.

Ellis, P. D., and M. Roberts. 2016. *Leveraging urbanization in South Asia: Managing spatial transformation for prosperity and livability.* Washington, DC: World Bank Group.

Ehrlich, P. R., and A. H. Ehrlich. 1990. *The population explosion*. New York, NY: Simon and Schuster.

Ezzati, M., and D. M Kammen. 2002. "The health impacts of exposure to indoor air pollution from solid fuels in developing countries: Knowledge, gaps, and data needs." *Environmental Health Perspectives* 110(11): 1057-1068.

Fisher, J. 2008. "For her it's a big issue: putting women at the centre of water supply, sanitation and hygiene." Water, Sanitation and Hygiene: Evidence Report.

Glaeser, E., and A. Joshi-Ghani. 2013. "Urban Imperative: Toward Shared Prosperity." Washington, DC: World Bank Group.

Goswami, S., and S. Manna. 2013. "Urban Poor Living in Slums: A Case Study of Raipur City in India." *Global Journal of Human Social Science, Sociology & Culture* 13(4): 15-22.

Government of Pakistan. 2017. "Press Release on Provisional Results of the 6th Population and Housing Census." Accessed on March 27, 2018. http://www.statistics.gov.pk/assets/publications/Population_Results.pdf

Grown, C., Gupta, G. R., and A. Kes. 2005. *Taking action: achieving gender equality and empowering women*. London: Earthscan.

Gruebner, O., Sachs, J., Nockert, A., Frings, M., Khan, M. M. H., Lakes, T., and P. Hostert. 2014. "Mapping the Slums of Dhaka from 2006 to 2010." *Dataset Papers in Science*: 1-7.

.

Hanlon, J., Roy, M., and D. Hulme. 2016. *Bangladesh confronts climate change: Keeping our heads above water*. New York: Anthem Press.

Hardoy, J. E., Mitlin, D., and D. Satterthwaite. 2001. *Environmental problems in an urbanizing world: finding solutions in cities in Africa, Asia and Latin America*. Washington, DC: Earthscan.

Hardoy, J. E., and D. Satterthwaite. 1991. "Environmental Problems of Third World Cities: A Global Issue Ignored." *Public Administration and Development* 11(4): 341-361.

Harriss-White, B., Olsen, W., Vera-Sanso, P., and V. Suresh. 2013. "Multiple Shocks and Slum Household Economies in South India." *Economy and Society* 42(3): 400-431.

Hazarika, I. 2010. "Women's Reproductive Health in Slum Populations in India: Evidence from NFHS-3." *Journal of Urban Health* 87(2): 264-277.

International Food Policy Research Institute (IFPRI). 2012. *Women's Empowerment in Agriculture Index*. Washington, DC: International Food Policy Research Institute.

Jahan, M. 2008. "The Impact of Environmental Degradation on Women in Bangladesh: An Overview." *Asian Affairs Journal* 30(2): 5-20.

Jutting, J. and J. R de Laiglesia. 2009. *Is Informal Normal?* Paris: Organisation for Economic Co-operation and Development.

Kabeer, N. 1999a. "The Conditions and Consequences of Choice: Reflections on the Measurement of Women's Empowerment." UNRISD Discussion Paper No. 108, Geneva: United Nations Research Institute for Social Development.

Kabeer, N. 1999b. "Resources, Agency, Achievements: Reflections on the Measurement of Women's Empowerment." *Development and Change* 30: 435-465.

Kabeer, N. 2001. "Resources, Agency, Achievements: Reflections on the Measurement of Women's Empowerment." In *Discussing Women's Empowerment: Theory and Practice*, edited by B. Sevefjord. Stockholm: Swedish International Development Agency.

Kuiper, M., and K. V Ree. 2006. "Growing out of Poverty: Urban job creation and the Millennium Development Goals." *Global Urban Development* 1(2): 1-20.

Kuznets, S. 1955. "Economic growth and income inequality." *The American Economic Review*: 1-28.

Larose, F., and M. Ponton. 2000. "Locus of control and perceptions of environmental risk factor: Inhabitants of slums facing domestic garbage." *Swiss Journal of Psychology* 59(3): 137-149.

Laszlo, S., and K. Grantham. 2017. "Measurement of women's economic empowerment in GrOW projects: inventory and user guide." GrOW Working Paper Series GWP-2017-08, Montreal: Institute for the Study of International Development.

Mahadevia, D. 1999. "Economic Growth and Environmental Degradation: Case of Gujarat." Working Paper for the Research Foundation for Science, Technology, and Ecology, New Delhi, India.

Mahbub ul Haq Human Development Centre Lahore. 2014. "Human Development in South Asia 2014: Urbanization: Challenges and Opportunities." Accessed on March 28, 2018. http://mhhdc.org/wp-content/themes/mhdc/reports/SAHDR_2014_Urbanization_Challenges_and_Opportunities.pdf

Mahon, T., and M. Fernandes. 2010. "Menstrual hygiene in South Asia: A neglected issue for WASH programmes." *Gender and Development* 18(1): 99-113.

Maiti, S., and P. K. Agrawal. 2005. "Environmental Degradation in the Context of Growing Urbanization: A Focus on the Metropolitan Cities of India*." *Journal of Human Ecology* 17(4): 277-287.

Majumder, A. K., Hossain, M. E., Islam, M. N., and M. I. Sarwar. 2007. "Urban Environmental Quality Mapping: A Perception Study on Chittagog Metropolitan City." *Kathmandu University Journal of Science, Engineering, and Technology* 1(4): 1-14.

Malik, A. A., Majid, H., Fateh, H., and I. Perera. 2016. *Women in Pakistan's urban informal economy: vulnerabilities, opportunities and policy solutions.* Washington, DC: The Urban Institute.

Mavropoulos, A., and D. Newman. 2015. *Wasted Health: The tragic case of dumpsites.* Vienna: International Solid Waste Association.

McIlwaine, C. 2013. "Urbanization and gender-based violence: exploring the paradoxes in the global South." *Environment and Urbanization* 25(1): 65-79.

Nabeel, F. 2014. "South Asia's Growing Urban Divide." Policy Briefing by the Mahbub ul Haq Human Development Center, Lahore, Pakistan.

Nasrin, F. 2012. "Women, environment and environmental advocacy: Challenges for Bangladesh." *Asian Journal of Social Sciences & Humanities* 1(3): 149-172.

Pearson, J., and K. McPhedran. 2008. "A literature review of the non-health impacts of sanitation." *Waterlines* 27(1): 48-61.

Peters, H. E., Astone, N. M., Malik, A. A., Maret, F., and C. Heller. 2016. *Women's economic empowerment: A review of evidence on enablers and barriers.* Washington, DC: The Urban Institute.

Saha, B., Tarek, M. H., and P. Saha. 2012. "Quantification of the Environmental Degradation due to the Urbanization of Dhaka Narayanganj Demra (DND) Project Area in Bangladesh." *Global Journal of Science Frontier Research Environment & Earth Sciences* 12(1): 15-23.

Sahibzada, S. A., and S. A Qutub. 1993. "Urbanisation and Environmental Degradation in Pakistan." *The Pakistan Development Review* 32(4): 639-649.

Sawhney, U. 2013. "Slum population in India: Extent and policy response." *International Journal of Research in Business and Social Science* 2(1): 2147-4478.

.

Sengupta, C. 1999. "Dynamics of community environmental management in Howrah slums." *Economic & Political Weekly* 34(21): 1292-1296.

Shandra, J. M., London, B., and J. B Williamson. 2003. "Environmental Degradation, Environmental Sustainability, and Overpopulation in the Developing World: A Quantitative, Cross-National Analysis." *Sociological Perspectives* 46(3): 309-329.

Siddique, O., and R. Chanchai. 2013. "Addressing Urban Poverty, Inequality, and Vulnerability in a Warming World." Asia-Pacific Issue Brief Series on Urbanization and Climate Change No. 1, Bangkok: United Nations Development Program & United Nations Human Settlements Program.

Sinha, A., and J. Bhattacharya . 2014. "Is Economic Liberalization Causing Environmental Degradation in India? An Analysis of Interventions." *Journal of Applied Business and Economics* 16(5): 121-136.

Suhrke, A., and S. Hazarika. 1993. "Pressure points: Environmental Degradation, Migration and Conflict." *Peace and Conflict*: 3-43.

Tacoli, C. 2012. "Urbanization, gender and urban poverty: paid work and unpaid carework in the city." Working Paper 7 on Urbanization and Emerging Population Issues, New York; London: United Nations Population Fund & International Institute for Environment and Development.

Tacoli, C. 2013. "The benefits and constraints of urbanization for gender equality." *Environment and Urbanization Briefs* 25(1): 1-6.

The Hunger Project. 2014. *The Women's Empowerment Index.* New York: The Hunger Project.

Taylor, G., and P. Pereznieto. 2014. *Review of evaluation approaches and methods used by interventions on women and girls' economic empowerment.* ODI Report. London: ODI.

Terry, G. 2009. "No climate justice without gender justice: An overview of the issues." *Gender & Development* 17(1): 5-18.

United Nations. 2014. *World Urbanization Prospects: The 2014 Revision, Highlights ST/ESA/SER.A/352.* New York: United Nations Department of Economic and Social Affairs, Population Division.

United Nations Environment Program (UNEP) and United Nations Office for Disaster Reduction (UNISDR). 2008. *Environment and Disaster Risk: Emerging Perspectives (2nd edition).* Geneva: United Nations Environmental Program & United Nations Office for Disaster Risk Reduction.

UN-HABITAT. 2003. *Slums of the World: The Face of Urban Poverty in the New Millennium.* Nairobi: United Nations Human Settlements Program.

UN-HABITAT. 2007. *Global Report on Human Settlements 2007: Enhancing Urban Safety and Security.* London; Sterling, VA: Earthscan.

UN-HABITAT. 2008. *State of the world's cities 2008/2009: Harmonious cities*. London; Sterling, VA: Earthscan.

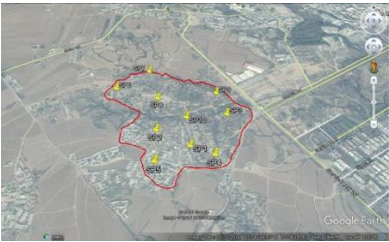UN-HABITAT. 2012. *State of the world's cities: Prosperity of cities*. Geneva: United Nations.

UN-HABITAT. 2017. *New Urban Agenda (A/RES/71/256)*. New York: United Nations.

United Nations Women Watch. 2012. "Women Watch Gender Equality and Sustainable Urbanization." Accessed on March 27, 2018. http://www.un.org/womenwatch/feature/urban/

Vyas, V. S., and R. V Reddy. 1998. "Assessment of Environmental Policies and Policy Implementation in India." *Economic and Political Weekly* 33(1/2): 48-54.

Warner, K., Hamza, M., Oliver-Smith, A., Renaud, F., and A. Julca. 2010. "Climate change, environmental degradation and migration." *Natural Hazards* 55: 689-715.

Warth, L., and M. Koparanova. 2012. "Empowering Women for Sustainable Development." Discussion Paper Series No. 2012.1, Geneva: United Nations Economic Commission for Europe.

White, B.H., Olsen, W., Sanso, P.V. V. Suresh. 2013. "Multiple shocks and slum household economies in South India." *Economy and Society* 42(3): 398-429.

Wisner, B., Blaikie, P., Cannon, T., I. Davis. 2014. *At Risk: Natural Hazards, People's Vulnerability and Disasters*. New York: Routledge.

World Bank. 2013. "Disaster risk management in South Asia: A regional overview." GFDRR Project Highlights Report no. 6, Washington, DC: World Bank Group.

World Bank. 2014. *Voice and Agency: Empowering Women and Girls for Shared Prosperity.* Washington, DC: World Bank Group.

Zaman, H. U., Alam, T., J. Islam. 2010. "Urbanization in Bangladesh: Present Status and Policy Implications." *ASA University Review* 4(2): 1-16.

Appendix A: Slum mapping and sampling households using GIS

We mapped each of the 3 slums selected for our field survey in Islamabad, Lahore, Dhaka and Delhi in collaboration with local communities who delineated area boundaries that they considered their community. We used Google Earth Images to facilitate such community mapping. Population estimates for each slum were also obtained during the mapping exercise with communities. In absence of official census data for non-notified slums, we found community knowledge to be the most reliable and viable approach. We found this approach the most viable alternative to census data on non-notified slums. Subsequently, 10 starting points for sample selection were generated randomly within each slum boundary using ArcGIS.

TABLE A1— SLUM MAPPING AND SAMPLING HOUSEHOLDS USING GIS

India

Ghazipur Slum	Tughlakabad Slum	Hanuman Camp Slum
Slum is located in East Delhi near a garbage dump and landfill site.	Slum is located south of Delhi on a steep slope; the surrounding area is used for open defecation and garbage disposal.	Slum is located in Central Delhi adjacent to an open city drain.

Bangladesh

Keranijang Slum	Jhutt Patti Tong Basti	Sattala Basti
Slum is located in the West City of Dhaka which falls at the low-lying area of the confluence of the Buriganga River and the Shittalakhya River.	Slum is located in northern part of Dhaka in Pallabai neighborhood without access to potable water for consumption.	Slum is located in the Banani neighborhood in Dhaka North City Corporation with proximity to the Banani-Gulshan Lake where garbage, sewage, and flood waters accumulate.

Pakistan

Basti Esayan

Slum is located in Lahore behind a major paper and pulp industry factory which emits hazardous waste.

Gao Shalla Slum

Slum is located in Lahore on the brink of the River Ravi, making it highly susceptible to flooding.

Altaf Colony

Slum is located near the Ranger's Headquarters in Lahore close to a ring road, garbage dumping site, and open city drain.

Chora Stop Slum

Slum is located in E-12 sector in Islamabad and formed on a steep slope beside a garbage dumping site.

Akram Gill Colony

Slum is located in the H-9 sector of Islamabad near a high voltage power line and a major highway.

Mera Jaffar Slum

Slum is located in the G-12 sector of Islamabad close to a major highway and garbage dumping site.

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Appendix B: Deprivation indicator weights in the women's empowerment in slums index (WESI)

TABLE A2— DEPRIVATION INDICATOR WEIGHTS IN THE WOMEN'S EMPOWERMENT IN SLUMS INDEX

Domain	Indicator for the WESI	Deprivation Indicators	Weight	
Resources			WESI	ESI
Economic	Employment	Do not work for money/earn an income	1/16	1/16
	Income	Less than 5,000/month Taka for Bangladesh/ Pakistani Rupees for Pakistan, less than 2,000/month Indian Rupees for India	1/16	1/16
Socio-Cultural	Education	Equal to or less than secondary (grade 6-8) level education	1/8	1/8
Political	Legal Rights	No knowledge of laws against gender violence	1/16	N/A
		No government ID	1/16	1/8
Security	Health	No access to health facilities	1/32	1/16
		Monthly medical expenditure is more than 2 days worth of income	1/32	1/16
	Safety from Violence	Having experience with sexual harassment, verbal, or physical abuse	1/48	N/A
		Having experience with verbal abuse	1/48	N/A
		Having experience with physical abuse	1/48	N/A
Agency			WESI	ESI
Economic	Decision-making	Never or only on a festival for purchasing personal items such as jewelry, beauty products, toiletries, perfume	1/32	1/32
		Sometimes/rarely/never making decisions for using personal income or saving	1/32	1/32
		Spouse or some other family members for making decisions for everyday and special events/expenditure	1/32	1/32
		Not alway being consulted for spending the household income for working women Rarely/never being consulted for non-working women	1/32	1/32
Socio-Cultural	Mobility	Sometimes/Rarely/never traveling outside of the home for recreation or work	1/32	1/32
		Never using public transportation	1/32	1/32
	Time	Spouse/some other family member of making decision to use time	1/32	1/32
		Spending more than 10 hrs for kitchen work, childcare, cleaning, commuting, caring for others, and toilet	1/32	1/32
Political	Civic Engagement	Not engaged in a community group,	1/24	1/24
		No voting	1/24	1/24
		Main information source is family, friends or neighbors	1/24	1/24
Security	Preventative Care	No self-decisions on personal health	1/16	1/8
	Violence Response	No report of sexual harassment to employer/police	1/16	N/A

Appendix C: Computing the women's empowerment in slums index (WESI)

To compute WESI and ESI at the aggregate country level, we adopted Alkire & Foster's (2011) method as follows.

First, the disempowerment scores for each respondent were then computed and can be expressed as:

$$C_j = w_1 I_1 + w_2 I_2 + \cdots w_d I_d$$

where, j is an indicator and d is the number of dimensions. C_j is the disempowerment score for each respondent created by summing the products of w_j, the weight of a given indicator, and I_j, a binary variable, equal to one if the respondent is deprived (disempowered) in that indicator, and zero otherwise. The summation of weight is 1 ($\sum_{j=1}^{n} w_j = 1$).

Then, we calculated the censored headcount ratio (Alkire & Foster, 2011), by setting the second cutoff (k) to identify the number of people who were disempowered in the sample. The individual disempowerment scores equal to or less than the second cutoff (k) were replaced by 0. The equation of the censored individual disempowerment scores can be expressed as follows:

$$ci(k) = \{0, x \le k$$
$$ci, x > k$$

We selected the disempowerment cutoff at 20 percent (k=20). The 20 percent disempowerment cutoff means that we only classify women whose disempowerment (A) score is greater than 0.2 as the disempowered person.

The average disempowerment score for each country was then computed by summing all individual disempowerment scores and dividing by the number of disempowered persons.

$$A_{country} = \frac{\sum_{i=1}^{n} ci(k)}{q}$$

Then, we computed the censored headcount ratio (H) for each country by dividing the number of individuals who were classified as disempowered (q) by the total population (n).

$$H_{country} = \frac{q}{n}$$

Lastly, we computed the product of the average censored disempowerment score ($A_{country}$) and the censored headcount ratio ($H_{country}$) to obtain the disempowerment index. We compute the WESI for each country by simply deducting the disempowerment index from 1:

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$$WESI_{country} = 1 - M_0$$

This aggregate WESI_{country} could be used to compare country level women's empowerment.

Similarly, individual empowerment score E_j was also calculated by simply deducing the disempowerment score C_j from 1:

$$E_j = 1 - C_j$$

We used empowerment score E_j for all our regressions.

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Appendix D: Specification of environmental degradation indicators

TABLE A4— SPECIFICATION OF ENVIRONMENTAL DEGRADATION INDICATORS

Indicator	Coding
Government land	1=Government land; 0=Corporate land or private land
Rented house	1=Rented house; 0=Owned house
Residence less than 2yrs	1=Have been living here less than 2 years; 0=Have been living here more than 2 years
Poor condition of street	1=Kaccha/ Packed with cow dung/ dirt or Brick/soiling street; 0=Cement street
No permanent structure	1= grass/ straw/ leaves/ Mud/ Wood/ Tin sheet/block's house (Pakistan); 0= Cement/brick/Bricks (without plaster)/Bricks (with plaster)/ Stone/Concrete
Overcrowded house	1= Greater than or equal to three persons per room; 0= less than three persons per room
Lack of toilet	1= Public/ community toilet/ Paid public toilet/ Open defecation/ Don't Know/ refused to answer/None; 0= Household toilet
Lack of drain system	1=No drain system, open drain, open gutters; 0=underground/covered drain system
Long-distance water source	1=Main source of water locates inside the premise/inside the household; 0=no
No waste facility	1=Locality provided with regular/ daily waste management facility; 0=no
Heatwaves	1=Have experienced heatwaves in the last 3 years; 0=no
Torrential Rain	1=Have experienced torrential rain in the last 3 years; 0=no
Flooding	1=Have experienced flooding in the last 3 years; 0=no