SHELTERING FROM A GATHERING STORM

TEMPERATURE RESILIENCE IN PAKISTAN

Sheltering From a Gathering Storm: Temperature Resilience in Pakistan

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April 2014

Published by: Institute for Social and Environmental Transition-International, Boulder, CO USA

For a downloadable PDF of this publication, please visit: www.i-s-e-t.org/SHELTER

Citation: Khan, F., Malik, S., & Rehman, A. (2014). Sheltering from a gathering storm: Temperature resilience in Pakistan. Boulder, CO: ISET-International.

ACKNOWLEDGMENTS

The authors wish to thank the Climate and Development Knowledge Network (CDKN) for funding this research.

We would also like to express our gratitude to Dr. Marcus Moench for valuable comments and suggestions on our study design and analysis. We would like to acknowledge the climate team, Dr. Caspar Amman and Mr. Ken MacClune, for their keen insights into Pakistan's complex temperature issues.

This project would not have been possible without the critical support and partnership of many organizations, especially the Akhtar Hameed Khan Memorial Trust, Behbood-e-Niswan Network, and Roshini Organization. Furthermore, we would like to thank the architects, local masons, and contractors who provided information on local construction practices and costs, and the communities who participated in this research.

The authors would also like to acknowledge Dr. Mehreen Mujtaba for secondary data on health in Pakistan, Mr. Haider Abu Zafar for climate data and support on primary data management, Ms. Kate Hawley for project management, Ms. Michelle F. Fox for art direction, Ms. Thanh Ngo for graphic design support, Ms. Lea Sabbag and Ms. Abrina Williams for editorial support, Linda Gorman and Dr. Taimur Khan for copy editing support, and Jamie Stroud for illustration of the map.

The analyses and opinions in this report are those of the authors and do not necessarily reflect the views of the CDKN. The authors alone remain responsible for any errors in this report.

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TEMPERATURE RESILIENCE IN PAKISTAN

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LIST OF ACRONYMS

T-max: Maximum Daily Temperature

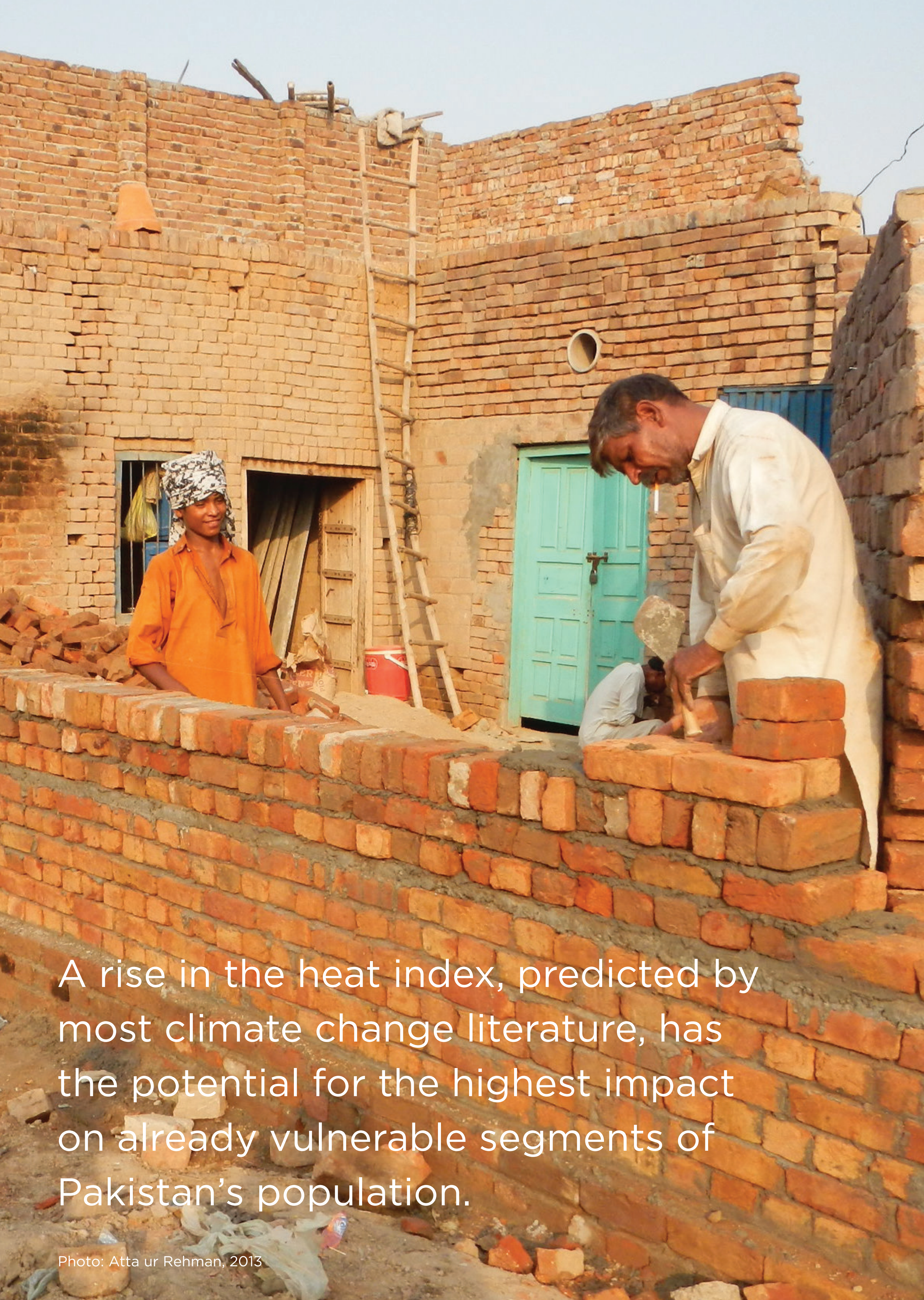
T-min: Minimum Daily Temperature

PKR: Pakistani Rupee

TFUD: Task Force on Urban Development

DALYs: Disability Adjusted Life Years

DRR: Disaster Risk Reduction



A rise in the heat index, predicted by most climate change literature, has the potential for the highest impact on already vulnerable segments of Pakistan's population.

Photo: Atta ur Rehman, 2013

KEY POINTS IN BRIEF

1 **Climate change will seriously impact urban areas in Pakistan.** As climate changes, increases in temperature and the heat index (a measure that combines temperature and humidity) will have a major affect on the health and productivity of urban residents in Pakistan.

2 **Increases in the temperature minimums and heat index need greater attention.** While most attention in the published literature has focused on increases in T-max (peak daily temperature), extended increases in T-min (temperature minimums) and the overall heat index will be larger and thus represent a greater threat to human health than increases in T-max. Hospital data on heatstrokes are closely correlated with the heat index.

3 **The T-min is the most important variable for shelter design.** In comparison to a 2°C –3.5°C increase in T-max, projections indicate the heat index will increase 4°C–7°C in our study sites. T-min and the duration of the summer hot season are also expected to increase more than the T-max.

4 **Heat impacts vary by gender and occupation.** Increases in temperature may have a differential impact according to gender and occupation. In some locations, women face continuous exposure to the heat buildup in poorly ventilated houses. In contrast, men doing construction and similar labor face greater exposure to peak daily temperature extremes.

5 **Temperature increases will make cities unaffordable for the poor.** Poor households in Multan currently spend approximately PKR 15,000 per month in the summer on heat-related expenses out of an average monthly income of PKR 15,000–25,000. Projected increases of 1.5°C by 2050 above current temperatures will make Multan unaffordable. In Faisalabad, projected increases of 2°C will bring it above present-day Multan, and if we use projections on heat indexes, even Rawalpindi will face conditions worse than present-day Multan by 2050.

6 **New T-min heat reduction measures are needed.** Cost-effective measures exist to reduce the impact of increases in T-max within buildings. However, aside from active air-conditioning, building design measures to reduce the impact of extended increases in baseline ambient T-min are not currently available.

7 **Several passive technologies for heat reduction have been proven effective.** Excluding active cooling (air-conditioning), the best-performing passive technologies for heat reduction are radiant barriers that reflect the sun during the daytime and insulation below the roof that reduces heat conduction indoors at night. Any form of insulation above the roof reduces thermal performance by preventing nighttime cooling.

8 **Concrete is unsuitable for heat resilient housing.** The thermal performance of concrete, the most common roof material in Pakistan, makes it an unsuitable construction material for heat resilient housing. Concrete roofs elevate nighttime temperature within houses by approximately 3°C. None of the available technologies are able to counter that effect completely.

9 **Greater awareness of heat reduction measures is needed.** Most people are not aware of cost-effective strategies in shelter design to reduce heat-related expenditures. Instead, they tend to spend funds on nonstructural adaptive measures and curative health measures within the confines of their disposable income.

10 **Heat is not the only problem affecting poor communities.** In addition to heat, lack of clean drinking water and poor sanitation were identified as problems by most of the communities and by both genders, demonstrating the cascading effects of poor governance and service provision.

1. INTRODUCTION

Among all climate parameters, changes in temperature are the most accurately predicted consequence of global climate change. The Pakistan Meteorological Department estimates there has been an increase of 3°C in temperature during the period of May to September between 1961 and 2007, that is, the summer season for Pakistan (Chaudhry, Mahmood, Rasul, & Afzaal, 2009).

In order to study the impact of temperature changes and the return on investment in climate resilient shelter, this project selected Rawalpindi (at the foot of the Hindu Kush mountain range), Faisalabad (central plains), and Multan (hot desert) as case locations. These sites represent a range of conditions in Pakistan and rank among the top five most populous cities in the province of Punjab. In all of these locations, increases in temperature are a central concern. Summer peak temperatures of 50°C in Multan have been officially recorded. Even Rawalpindi, at the base of the mountains, has recorded temperatures in excess of 46°C.

Shelter design can alleviate or exacerbate the extent of heat stress. Therefore, we use existing empirical evidence on the impact of summer temperatures in Rawalpindi, Faisalabad, and Multan that represent a 4.5°C temperature range to understand the economic impact of heat with rising temperatures and to identify the extent to which changes in shelter design might mitigate these impacts.

This case is part of a larger study on the costs and benefits of climate resilient housing. Research in other regions has focused on the impacts of floods and extreme storms, both of which affect the shelter itself as well as the occupants. In the case of heat in Pakistan, however, heat does not affect the housing structure but causes direct harm to the people who live in the shelter. Unlike many other expected consequences of climate change, the impact of heat on human health has not been given much attention, especially in the developing South (Ye, Wolff, Yu, Vaneckova, Pan, & Tong, 2012). This is due to the complexity of heat and human health interaction and a lack of understanding of how people may adapt to the increase in heat stress in the future, based on socioeconomic conditions and technological options available in the future. For these reasons, in evaluating the costs and benefits of heat resilient shelter, we focus on the expenses people incur to address heat, and where they are possible to quantify, based on available data, the health impacts.

1.1 Objectives

This study aims to gather empirical evidence and explore the economic impact of temperature on shelter, the fastest growing segment in the rapidly growing cities of Pakistan. It also analyses the thermal performance and cost-effectiveness of commercially available passive (low-cost) solutions for reducing temperature in urban shelters. Cost-benefit analysis, based on current and predicted climate scenarios, is performed to determine the cost-effectiveness of these technologies. The analysis is performed from the perspective of poor urbanizing home owners, who will be very vulnerable to increasing temperatures.

1.2 Overall Context

Pakistan is the second largest country in South Asia and the fifth most populous in the world. According to the Task Force on Urban Development (2011), the total population of the country reached 173.5 million in 2010, with the urban population reaching 36.3% of the total. If dense peri-urban settlements (and those above 5,000 inhabitants) outside municipal boundaries are also counted as urban, the current urbanization density is assessed at 50% (Planning Commission, 2011).

Climate-Related Hazards in Pakistan

The economically promising urban areas of Pakistan are exposed to multiple natural hazards, including cyclones, floods, droughts, intense rainfall, and earthquakes. Threats to water, food, and energy security, as well as the vulnerability of coastal areas and an increased risk of extreme events, have been declared as the most serious concerns for Pakistan (Task Force on Climate Change, 2010). Lately, Karachi, Lahore, and Rawalpindi have been exposed to urban flooding, which is partly attributable to an inadequate storm-water drainage system (National Disaster Management Authority, 2007).

A rise in the heat index, predicted by most climate change literature, has the potential for the highest impact on already vulnerable segments of Pakistan's population (Mustafa, 2011; Zahid & Rasul, 2008). Nighttime temperatures are projected to increase more rapidly than the maximum temperatures, which is compatible with global projections

Photo: Atta ur Rehman, 2013

(Cheema, Rasul, Ali, & Kazmi, 2010). In Lahore, a study aimed at monitoring the spatial, temporal, and micro-level climatic variations from 1950 to 2010 established that the increase in nighttime temperatures is caused by the urban heat island effect and is the main source of this warming (Qureshi, Mahmood, Almas, Irshad, & Rafique, 2012).

Increased Temperatures and Human Health

Healthy adults have an efficient heat regulatory mechanism, which copes with increases in temperature up to a certain threshold, so that even when there are considerable fluctuations of temperature, a constant core body temperature is maintained. According to the scientific literature, the ability of the body to combat heat is seriously compromised, however, under the following conditions:

- unusually high temperatures over several days in succession (Deschenes & Moretti, 2009);
- hot periods when there is relatively little nighttime cooling because daily minimum temperatures are elevated (Lyster, 1976); and
- high humidity levels that limit the cooling effect of sweat evaporation and hence lead to heat stress (Steadman, 1979).

High temperatures cause medical conditions such as heatstroke, heat exhaustion, fainting, and heat cramps (Kilbourne, 1997). At the same time, many communicable disease-causing organisms find increased temperatures and humidity favorable (Mustafa, 2011). Preexisting conditions, such as cardiovascular diseases, may be exacerbated by heat stress (Patz, Campbell-Lendrum, Holloway, & Foley, 2005). Brick houses with a high thermal mass and houses with little or no ventilation are associated with an increased risk of mortality during a heat wave (Vandentorren et al., 2006). Such factors, combined with the low socioeconomic conditions and deprivations characteristic of urban slums, are important determinants of heat wave–induced mortality (Michelozzi et al., 2005).

1.3 Key Stakeholders

Household and Masons

In the absence of a regulated house-building sector, masons decide how houses are built. They advise on the size of the structure that can be built within a family's budget. Many houses are built "incrementally"—that is, rooms are added as more resources become available. Choices in construction technologies are limited to the skills of the masons (who are also contractors) and comprise mostly brick and concrete construction. Traditional building methods are rarely used in new urban developments and are considered less desirable. Therefore, innovation and choices in the use of materials are very limited, and most new peri-urban construction is standardized. Masons trained in these materials also act as the architects and engineers for construction as part of their contract/wages. These combined services, in this sense, are very cost-effective for the newly urbanizing poor.

National Government and Policies

At the national level, a number of policies exist[1] that deal with housing; however, there remain serious challenges in implementation. The Housing Policy of 2001 addresses the issues of uncontrolled and unplanned urbanization, but it does not look at climate resilience. The Energy Conservation, National Conservation, and Climate Change policies do look at energy efficiency, use of low-polluting materials, use of local materials, and so forth, but focus mainly on energy conservation and not on adaptation to heat.

These policies generally lack implementation mechanisms and instruments. Challenges in implementation arise from the fact that housing construction is personally financed and only a very small proportion of home builders take formal loans. A meager 2% of housing is financed by formal mechanisms and another 10%–12% through informal loans. Housing insurance in Pakistan is very rare and practically nonexistent among the poorer urban dwellers.

Local Government's Role in Land Use Planning, Building Codes, and Enforcement

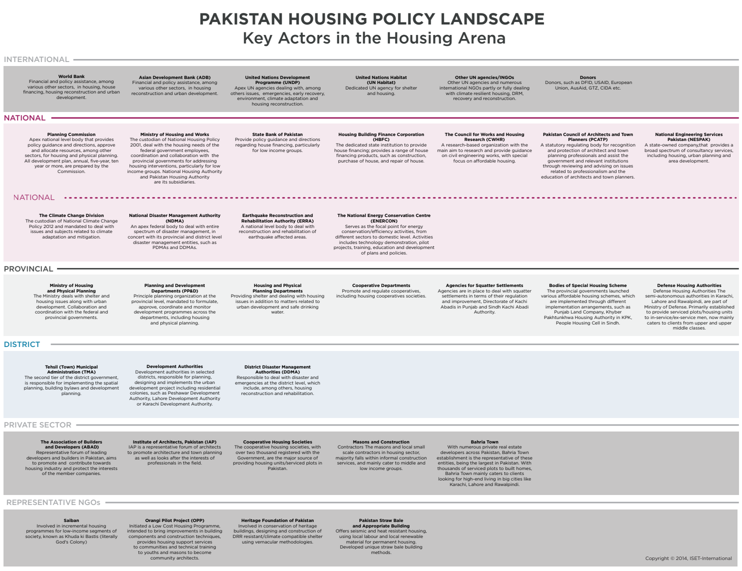
Tehsil and town municipal administrations, responsible for developing and enforcing building standards, remain politically weak. There is also a lack of expertise and qualified professionals for dealing with these responsibilities (World Bank & International Finance Corporation, 2010). Hence, enforcement of the building codes by the relevant local government institutions and respective development authorities remains ineffective.

Private Sector Developers

In the private sector, numerous agents with formal and informal enterprises serve the housing sector, catering to the needs of clients from a range of economic groups. According to the Planning Commission, high-income groups, which constitute 20% of the total population, are being served by both the private and public sectors (State Bank of Pakistan, 2012).

Endnotes

1. For more information concerning the Pakistan Shelter Policy Landscape, see http://www.i-s-e-t.org/images/pdfs/DPS_Pakistan-ShelterPolicyLandscape_131230.pdf



Pakistan Housing Policy Landscape
Key Actors in the Housing Arena
See full size infographic on page 24.

2. RESEARCH METHODS

FIGURE 1

RESEARCH PROCESS FOR HEAT RESILIENCE STUDY

1 LITERATURE REVIEW

- Global review of heat and health literature
- Review of literature and data in Pakistan on heat and health impacts

2 SECONDARY DATA COLLECTION

- Review of cost and thermal performance data on technologies geared toward reducing heat impact in Pakistan
- Procurement of climate data from Pakistan Meteorological Department

3 PRIMARY RESEARCH

- Identification of cities, research partners, and sites
- Qualitative research (shared learning dialogues)
- Quantitative research (questionnaires)

4 ANALYSIS

- Cost-benefit analysis
- Climate change analysis

This study is a part of the regional research "Sheltering From the Gathering Storm" and uses the same methodology for climate change–based cost-benefit analysis of adaptation strategies. Unlike the other two case studies, however, where damages were linked to structural and owned assets, heat-related impacts do not affect the housing structure but rather the inhabitants of the house.

The research process included four components, as shown in Figure 1.

2.1 Literature Review

The process started with a global literature review to identify the impacts of heat on health. At the same time, specific peer-reviewed and unpublished literature on heat and health for Pakistan was assembled. Since there was not much material on the topic, we extended our search to newspapers and magazines for evidence of links between heat and health.

2.2 Secondary Data Collection

Unlike the other two studies in Vietnam and India, a design competition was not held. Instead, research on commercially available technologies to reduce heat impact from a UN-Habitat (2010) study was used to identify commercially available options for heat reduction in shelters. Heat-related illness data was collected from hospitals that gather this information. These hospitals are some of the leading institutions in the cities and do not cater

TABLE 1

PROFILE OF STUDY SITES

Site	City	Summary Statistics
Habib Colony	Rawalpindi	32.0*
Rehmanabad	Faisalabad	34.0*
Feroz Colony	Multan	35.5*
Average household size		7–9 persons
Income range (mode)		PKR 15–25,000
Age of house (mode)		15 years

* Average June temperature (degrees Celsius)

to the key target group of this study, low-income home owners. However, the seasonality of incidence of heatstroke was very useful for our analysis. At the same time, 30 years of historical data on health-related climate variables was procured from the Pakistan Meteorological Department. The parameters were daily maximum and minimum temperatures, combined with daily data on relative humidity at 00:00 and 12:00 UTC (Coordinated Universal Time).

City Selection

For the purpose of this case study, three cities were selected: Rawalpindi, Faisalabad, and Multan, as illustrated in Figure 2.

Rawalpindi, Faisalabad, and Multan rank among the top five most populous cities in the province of Punjab and have varying degrees of urbanization. These cities are located on a north-to-south transact in Punjab and represent an average temperature range of 5°C. The selection of these cities allows us to record the cost to households of temperatures across this range, in terms of adaptive behavior, the cost of illness, and loss of productivity. A large number of communities located in these cities are characterized as "low income," are located in the peri-urban areas, and are relatively newly developed (15–20 years); they are, therefore, representative of current trends in urban construction growth (see Table 1).

Site Selection

Within the three selected cities, preliminary field visits were made, guided by local nongovernmental organizations (NGOs) already operating in the area, in order to identify the specific communities to be studied. The criteria for selection were as follows:

- peri-urban communities;
- affected by heat and urban flooding/ waterlogging;
- low-income housing; and
- housing design is current, that is, construction dates back about 15–20 years.

2.3 Primary Research

To explore heat-related economic impacts, community-based qualitative research was initiated through a shared learning process that enabled inclusion of the knowledge and perceptions of the communities of the climate change issues in the selected locations. Based on the literature review and feedback from communities, a questionnaire was developed to document household and shelter characteristics and expenditures related to heat. Forty households

FIGURE 2

STUDY SITES

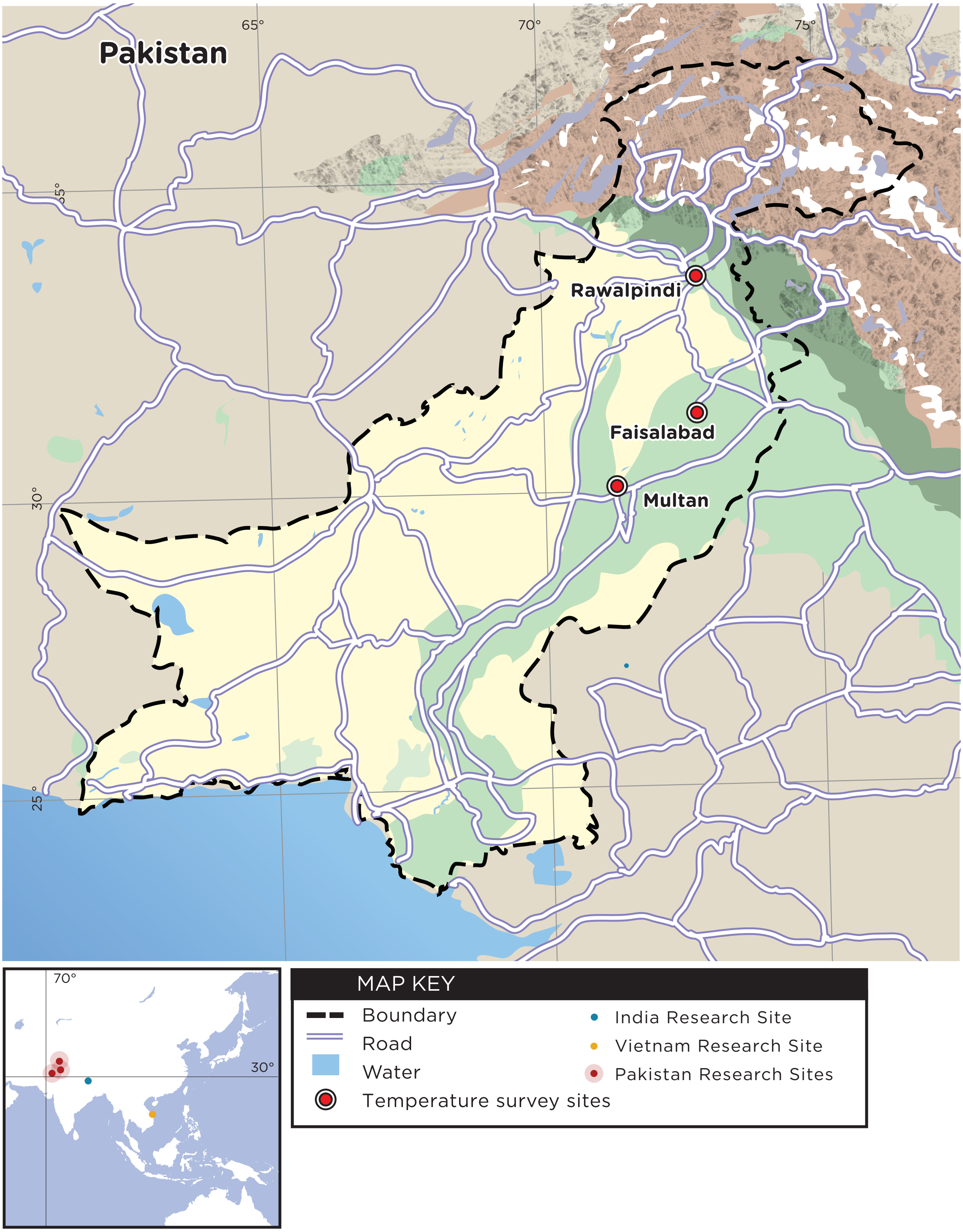


TABLE 2

QUALITATIVE AND QUANTITATIVE TOOLS USED

Pre-steps	Area profile	Temperature	Health impacts	Livelihood/ Adaptation measures	Shelter
• City visit • Initial contact - Selection of NGO partners • Transect walk • Site selection • Partner NGO training	• Background information • Community mapping - Service availability - Construction - Hazard exposure	• Literature review • MET data • Hazard mapping/ ranking • Trend line • Seasonal calendar • HH survey	• Literature review • Hazard listing/ ranking • Solution listing/ranking • HH survey	• Heat-related measures listing • Expenditure listing/ranking • HH survey	• Literature review • Home adaptation listing/ranking • HH survey • Market survey

Note: NGO = non-governmental organization. MET = meteorological. HH = household.

from each site participated in the survey, and the interviewers selected every fourth house on the left side of the street. Where the fourth house was unavailable, the fifth house was selected.

This process allowed us to identify and empirically analyze the issues and also include the communities in explaining causal relationships and anomalies as they arose. The qualitative and quantitative tools used for the research are summarized in Table 2.

2.4 Analysis

In order to perform an economic analysis of the costs and benefits of heat resilient shelter, we first calculated the cost of rising temperatures in summer months in each location. This data was plotted as a curve that depicts temperature versus heat-related cost per person. Currently available technologies to reduce temperatures in shelters were analyzed for their cost and effectiveness in reducing both maximum and minimum temperatures. A cost-benefit analysis for using these technologies was performed at each location under current and projected climate conditions.

Climate analysis was performed by our partners at the U.S. National Center for Atmospheric Research and ISET–International's climate scientists. Available climate data over the past 30 years on historical temperature trends from 1950 to current conditions was used for climate projections in the period 2040-60 using multi-model analysis.

3. RESULTS

The following section presents the key findings of our research. It starts with the identification of hazards by communities, then moves into an analysis of the seasonality of the impact of heat on human health from the data that was collected from hospitals in Rawalpindi and Islamabad. Heat-related expenditures are then analyzed to show the impact of different temperature regimes in our selected sites. Thereafter, we examine the thermal performance and cost of the various technologies that are commercially available in the market to keep concrete roofs cooler. Economic analysis of both the cost and thermal efficiency of various technologies and the expected reduction in the heat-related expenditure allows us to perform a cost-benefit analysis of the available options. Analysis is performed under current climatic conditions and with climate change estimates for 2050. Finally, the results of climate projections and their implications are presented.

Hazards

During the shared learning process, we asked the communities at all locations, in gender-segrated groups, to rank major hazards in order to understand how important the issue of heat was at present. Table 3 lists the hazards that communities identified at each location. We can see that heat is invariably ranked higher by females than males in the relatively cooler climate of Rawalpindi but is ranked relatively higher by males in the hotter climate of Multan.

Lack of clean drinking water was identified as a problem in most of the communities by both genders. Lack of drainage and sanitation was ranked either directly or indirectly through indicators such as pollution, mosquitoes, or plain open drainage, called nallah in local parlance. Women in certain locations complained that their mobility was constrained by social norms, and that

TABLE 3

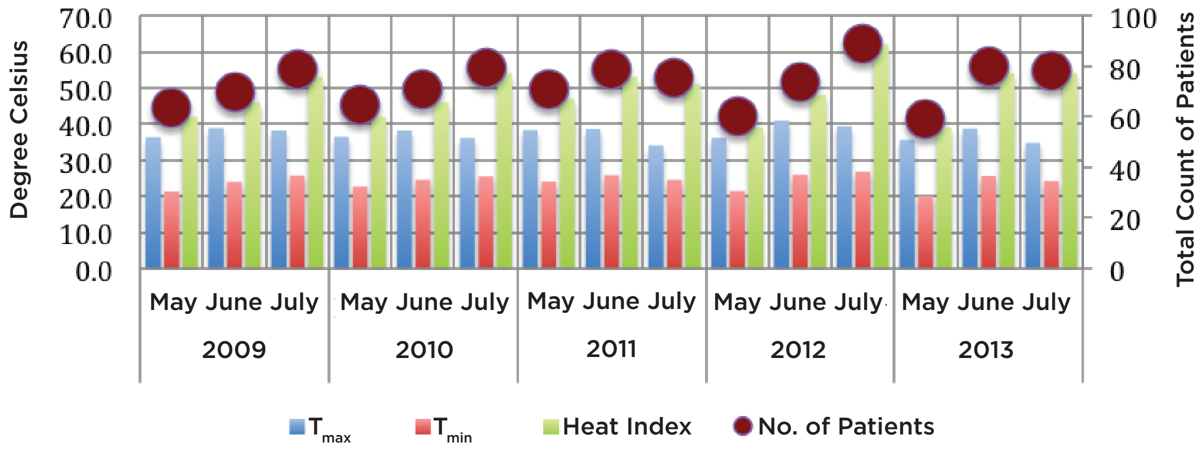
RANKING OF HAZARDS BY LOCATION AND GENDER

HAZARD SCORING MATRIX					
Ranking	**1**	**2**	**3**	**4**	**5**
Habib Colony, Rawalpindi					
Female	Heat	Mosquitoes	Nallah	Rain	Pollution
Male	Lack of clean drinking water; factories		Lack of civic sense among new settlers	Traffic/car emissions	Nallah/pollution/ blockage
Rehmanabad, Faisalabad					
Female	Pollution	Nallah	Mosquitoes	Inadequate water supply	Heat
Male*	Mosquitoes	Lack of clean drinking water	Nallah	Roads	Garbage
Feroz Colony, Multan					
Female	Inflation; lack of clean drinking water		Load shedding	Mosquitoes	Heat
Male	Heat; electricity; inflation			Lack of clean drinking water	Insects

*Heat was intentionally not mentioned, as it is considered to be god-given and hence nothing can be done about it.

FIGURE 3

INCIDENCE OF HEATSTROKE RECORDED DURING PEAK SUMMER TEMPERATURES



prevented them from going out to get some fresh air. The lack of drainage and open sewers created even more problems in some places. Women reported that they could not keep the windows open because of the smell and fear of mosquitoes coming in. Cooking and working within these confines created an additional heat burden for those who spent most of their time indoors.

The length of heat stress and the combined effect of humidity and raised minimum temperatures are more accurate proxies for heat stress on human health, compared to the maximum temperature alone.

Heat and Health Evidence in Pakistan

Epidemiological data on heat-related morbidity and mortality is very limited in Pakistan. However, data related to heatstrokes from two of the largest hospitals in the twin cities of Rawalpindi and Islamabad is illustrative of how heat impacts human health.

We see from Figure 3 that there is a rise in heatstrokes over the three hottest months of May, June, and July between 2009 and 2013. When we compare heatstroke incidence to average maximum temperatures in those months, the temperature invariably falls in July, whereas the heatstroke incidence spikes in the same month. The minimum temperatures (T-min) and relative humidity follow the pattern of heatstroke incidence more closely. This observation highlights the fact that both the length of heat stress and the combined effect of humidity and raised minimum temperatures are more accurate proxies for heat stress on human health, compared to the maximum temperature alone. Most of the climate data is based on maximum temperatures. Humidity is not predicted as accurately with current climate models but is essential in determining heat stress on humans.

3.1 Economic Analysis

In order to perform an economic analysis of the costs and benefits of heat resilient shelter, we first calculated the cost of rising temperatures in summer months in each location. This data was plotted as a curve that depicts temperature versus heat-related cost per person. Currently available

TABLE 4
AVERAGE MONTHLY HEAT-RELATED COSTS PER HOUSEHOLD OVER 6 MONTHS OF SUMMER (IN PKR)

Location	Direct illness	Indirect illness		Total health	Adaptation	Productivity loss	Total heat burden	Heat burden/ person
		Commu-nicable	Pre-existing					
Habib Colony	813	817	431	2,061	6,658	115	8,834	971
Rehmanabad	671	1,338	1,061	3,070	5,778	420	9,268	1,305
Feroz Colony	1,738	881	1,990	4,609	9,065	1,022	14,696	2,130
Percentage of total heat burden	10%	10%	15%	34%	62%	4%	100%	

technologies to reduce temperatures in shelters were analyzed for their cost and effectiveness in reducing both maximum and minimum temperatures. A cost-benefit analysis for using these technologies was performed at each location under current and projected climate conditions.

Economic Impact of Heat

In order to determine the potential benefit of temperature reduction in households, the total cost of heat in terms of actual expenditures in summers was recorded. It included the following parameters in each site:

- direct cost of treating heat-related illnesses;
- cost of treating an increase in indirect heat-related illnesses (both communicable and those stemming from preexisting conditions);
- loss of productivity from these diseases and heat;
- increase in expenditure from adaptive behavior such as traditional drinks, clothing, electricity, water, and ice costs as compared to expenditures on the same in March; and
- measures taken in the housing structure.

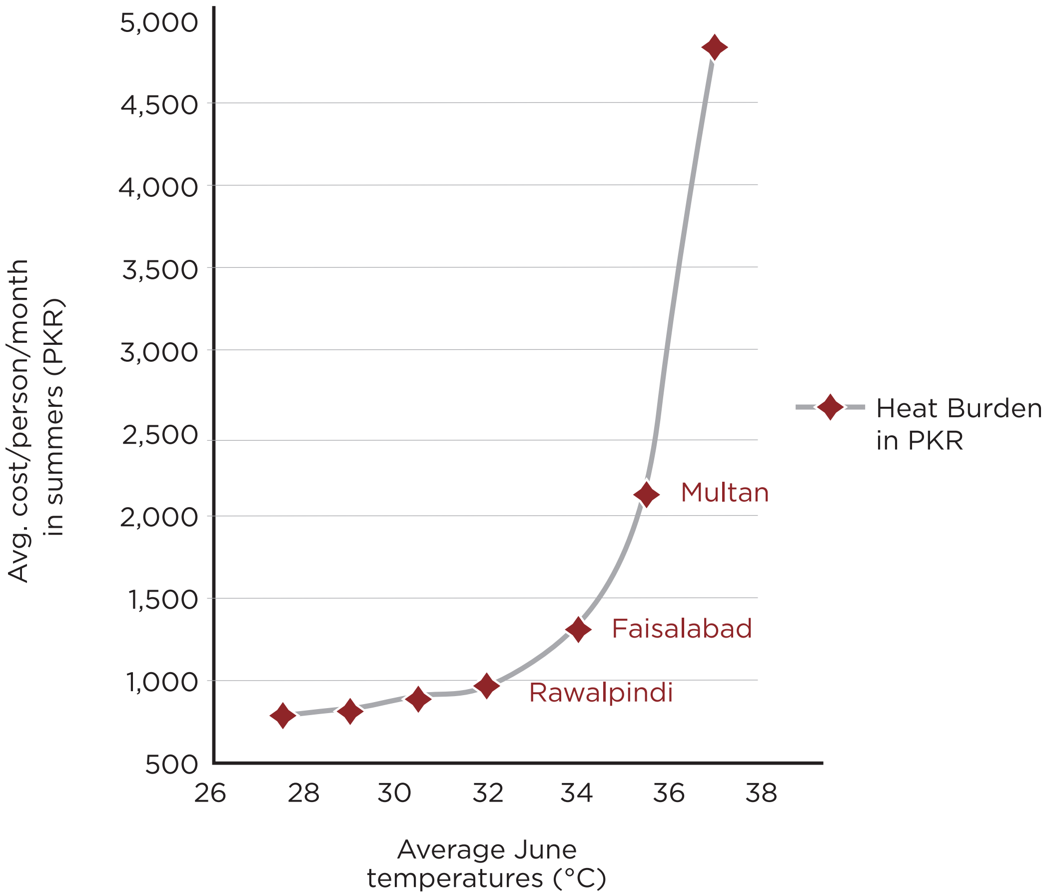
Actual expenditures made by the households in the research sites are summarized in Table 4. It is interesting to note that the expenditure on health and adaptation is divided in almost equal proportions throughout the sample, irrespective of the location of the site.

Since the average household size varied in each site, heat-related expenses were calculated per capita for comparison among sites, and these are provided in the last column of Table 4. Per capita, heat-related expenditures were plotted in the three sites and a smooth curve was drawn through them (see Figure 4). Through extrapolation, the curve was plotted at 37.0°C (i.e., 1.5°C above Multan's current June average temperature). At the lower end, the curve was extrapolated to 3 points below Rawalpindi in the same manner so it tended to 0 heat-related expenditures in March temperatures, per study design parameters.

It becomes evident here that the heat-related economic burden increases disproportionately with every degree of temperature, giving rise to the J-shaped curve predicted in the public health literature (McMichael, Haines, Slooff, & Kovats, 2006; Ye et al., 2012). Since communities tend to spread expenditures evenly among adaptive and curative measures, the expenditure pattern for adaptation expenditure also increases exponentially with increases in temperature.

FIGURE 4

HEAT-RELATED EXPENDITURES IN DIFFERENT TEMPERATURE REGIMES



We see that for an increase of 2°C of average June temperature, from 32°C to 34°C, the increase in expenditure is about 30% (15% cost increase per degree Celsius of temperature rise). In contrast, an increase of just 1.5°C of average June temperature in Faisalabad, from the current 34°C to 35.5°C, translates to an increase of over 60% in cost (i.e., 40% increase per degree of average rise in temperature). The extrapolation of the same trend shows an increase of more than 200% for the next 1.5°C rise in temperature beyond the average of 35.5°C toward 37°C, which is the human body core temperature. Beyond a 37°C ambient temperature, the body is unable to cool itself.

With most household incomes ranging from PKR 15,000 to 25,000, households in Multan are already spending about PKR 15,000 in summers on heat-related expenses. A further increase of 1.5°C beyond Multan's current temperature will make Multan unaffordable to the population attracted to the city during the past 15 to 20 years. Similarly, the summer expenditures in June in Faisalabad would increase to a level higher than present-day Multan, with an increase in average temperatures of 2°C.

3.2 Performance of Heat Resilience Options

Aside from air-conditioning, there are a few technologies offered by the private sector to reduce the heat burden in terms of indoor temperature. These include insulation techniques, reflective techniques, and radiant barrier techniques (UN-Habitat, 2010). These technologies are meant to improve the thermal performance of reinforced concrete flat roofs (see Table 5). A UN-Habitat study confirmed that the available techniques do attenuate the indoor temperatures within the range of highly effective to average.

TABLE 5

THERMAL AND ECONOMIC PERFORMANCE OF COMMERCIALLY AVAILABLE TECHNOLOGIES

Time of day	T-min 6 am	T-max 3 pm	T-min 6 am	T-max 3 pm	Economic performance: T-max and T-min combined (at 18% discount rate)
Outside temperature	29.1	41.0	Difference between inside and outside		
Inside temperature control	32.6	36.2	3.5	-4.8	
Treatment	**Inside temperature**		**Difference between treated and control**		**Cost/sq. ft. for each degree of cooling (PKR)**
Lime wash	30.2	32.2	-1.6	-3.1	6.50
Paperboard false ceiling	31.0	33.1	-2.4	-4.0	7.47
White enamel paint	30.0	33.1	-2.6	-3.1	7.74
Thermo pole false ceiling	29.5	34.4	-3.1	-1.8	9.25
Weather-shield paint (white)	30.0	32.2	-1.8	-2.5	10.26
Extruded polystyrene	30.8	33.7	-2.6	-4.0	12.81
Brick tiles w/ stabilized mud	30.8	34.7	-0.7	-3.1	15.50
OCEVA-MOL chemical	31.2	34.6	-1.8	-1.5	16.61
Mud with thermo pole	31.1	34.0	-0.6	-2.6	19.16
Sachal CLC tiles	31.5	33.7	-1.5	-2.2	20.57
Smart concrete tiles	31.2	34.9	-1.1	-2.5	21.64
Munawar AC tiles	31.9	33.1	-0.9	-3.2	21.71
Gypsum board false ceiling	31.3	34.1	-1.4	-1.6	24.98
Alnoor tile	32.0	33.6	-1.3	-2.1	26.51
Gypsum board/aluminum foil	31.7	33.0	-1.4	-1.3	27.75
Concrete wizard tiles	31.8	34.7	-0.8	-1.5	37.74
Aerosol heat-reflecting paint	30.3	34.2	-2.3	-2.0	50.04
Stabilized mud	32.5	35.1	-0.0	-0.9	53.69
Green netting	32.6	35.3	-0.1	-1.1	177.76
Avg. top 5 most cost-effective	30.1	33.0	-2.3	-2.9	8.25

Top five T-min reductions. Top five T-max reductions.

Source: UN-Habitat, 2010.

Table 5 summarizes the results from testing of the technologies. All of these tests were performed on concrete roofs. What is most remarkable is that in the control house, the concrete roof has a heating effect on the inside temperature and keeps the inside temperature 3.5°C warmer at night. It acts like a heat sink, absorbing solar energy and becoming a thermal mass that radiates heat inside the house when the temperature gets cooler outside. None of the available technologies are able to counter that effect completely. Therefore, if T-min is a very important factor for human health, concrete's thermal performance renders it an unsuitable material for roof construction, much like its use in low-cost earthquake-proof shelters.

For T-max, the performance of concrete roofs was acceptable, with a reduction of as much as 4.8°C

TABLE 6

HEAT-REDUCING MEASURES MENTIONED BY SURVEYED COMMUNITIES AND MASONS

Insulation	Reflection	Ventilation	Shade	Environmental
Lapai[a] of mud	Choona[b]	Roshan daans[c]	Creepers on walls	Trees, plants
Double wall	Paint on roof	Screens	Creepers on roof	Open spaces
False ceiling			Green cloth[d]	Basements
Mud blocks[e]				
Bamboo				

[a] Local plastering technique using clay, straw, and other natural materials

[b] Limewash

[c] A small window just below the roof; acts as both an exhaust and a skylight

[d] A green synthetic screen meant for plant nurseries that reduces sun exposure and allows for ventilation

[e] Blocks made in a mechanical press using mud, cement, and rice husks

If T-min is a very important factor for human health, concrete's thermal performance renders it an unsuitable material for roof construction.

in the indoor temperature. The best-performing technologies are radiant barriers, such as paints that reflect the sun, and insulation below the roof that reduces the heat-impact of the roof. Any form of insulation above the roof reduces the thermal performance by keeping the heat in when the temperature goes down.

During the shared learning dialogues, home owners and masons said they were aware of several measures for combating heat (see Table 6). Despite this knowledge, very few houses were using these techniques, the survey data revealed.

Unfortunately, we did not have performance data for some of the strategies identified and hence could not compare them to the other options. However, some of these strategies may be cheaper and more effective. For example, a creeper on the roof is low cost, completely shades the roof, and also produces a cooling effect from the natural evaporation process of the leaves. More trials need to be done on these simpler technologies to determine their cost-effectiveness. Also, it is quite possible that the combined impact of multiple treatments may give even better results. For example, lime wash coupled with a paperboard false ceiling may have a much greater combined effect. However, this would increase cost, which would be a prime consideration for these households.

3.3 Cost-Benefit Analysis of Resilient Housing

Following are the results from the cost-benefit analysis of the heat resilience options available for shelters.

Costs

Table 5 lays out the cost associated with each technology and its cooling effectiveness. For our climate analysis, we used the average of the five most cost-efficient technologies to reduce temperature, which turned out to be about PKR 8/sq. ft., to represent the current state of heat resilient technology affordable to the poor.

Benefits

Benefits were calculated in terms of actual expenditure saved by families with 2.6°C of average temperature reduction indoors. The savings

TABLE 7

BENEFIT-COST RATIOS FOR INVESTMENT IN HEAT RESILIENCE

		Current conditions		Climate change in 2050	
Discount rate		12%[a]	18%[b]	12%	18%
Feroz Colony	Multan	2.1	1.9	9.1	8.2
Rehmanabad	Faisalabad	0.6	0.5	11.7	10.5
Habib Colony	Rawalpindi	0.1	0.1	0.5	0.5

[a] Social discount rate from Livermore and Revesz (2013).

[b] Current cost of capital from micro-credit institutions in Pakistan.

estimates are derived from the J-shaped curved in Figure 4. The curve is based on different outdoor ambient temperatures, and the interventions we are considering reduce the indoor temperature only. Therefore, we reduced the expected savings from all categories of heat impacts listed in Table 4 by 50% except for communicable diseases, as we did not expect any reduction in communicable diseases due to indoor temperature reduction. With the exclusion of impact on communicable diseases, the effective reduction of benefits is 55%.

The 55% reduction in benefits may underestimate the actual impact of indoor temperature reduction. T-min and T-max are the most critical periods of the day in terms of impact on human health, and the majority of the members of the households are indoors at that time. Therefore, we may expect a much larger return. We performed sensitivity and break-even (threshold) analysis on this assumption to determine how valid our results were under a range of reduction estimates. Results are discussed below.

Table 7 summarizes the results of the cost-benefit analysis. Under current conditions, investment in the available technologies is worthwhile only in Multan. With climate change predictions factored into the analysis, we see that the return on investment becomes high in Faisalabad also. In Rawalpindi, these interventions do not justify the expenditure from a purely financial point of view. However, if we consider predictions for a rise in the heat index for Rawalpindi, the results would be different. The predicted 4°C change would yield close to the same benefit-cost ratios as those for Multan in current conditions, that is, a twofold return in terms of heat-related costs avoided.

The increase in returns do not indicate an increase in effectiveness of the technologies analyzed but rather are a function of the increased economic burden of heat on the population based on empirical observations on heat-related expenditures in the selected sites in different temperature regimes.

Sensitivity analysis of the assumptions of percentage reduction of heat burden from a decrease in indoor temperature alone shows that our results on cost-effectiveness are robust and valid at even more conservative estimates. In Multan, under current climate conditions, our cost-effectiveness remains valid as long as 20% of the cost-reduction predicted by the J-curve is realized with indoor temperature reduction. With climate change, the investment brings positive returns even if only 5% of the expected reduction predicted by the J-curve is realized.

We used discount rates of 12% and 18% for our analysis. The 12% rate represents the social discount rate for Pakistan (Livermore & Revesz, 2013) and would be useful for public policy analysis. The 18% rate represents the cost of capital from micro-lending institutions in Pakistan and is illustrative of the cost to home owners if they were to take a loan to add temperature resilience to their house. Once again, we found that the results of the cost-benefit analysis are not very sensitive to discount rates and remain valid throughout this range of discount rates and beyond.

The heat index, which combines temperature and humidity, is the most accurate variable in measuring heat impact on humans.

Photo: Atta ur Rehman, 2013

3.4 Climate Analysis

Using available climate data over the past 30 years, climate analysis was performed by our partners at the U.S. National Center for Atmospheric Research and ISETÐ–International's climate scientists on historical temperature trends from 1950 to current conditions and also estimated for the year 2050. Results from these analyses are detailed in the accompanying technical report on climate.

Climate Scenarios

Due to limitations in the availability of relevant data for the construction of climate scenarios, preliminary analysis was carried out using available data for the Lahore, Pakistan. This area has very similar conditions to those found in Faisalabad (being in the same geographical region with the same latitude). Data for Rawalpindi and Multan was purchased from the Pakistan Meteorological Department.

Key Findings From Climate Modeling

Analysis of the Lahore data revealed that all parameters that impact health will increase significantly. These include an increase in the length and intensity of summer, both in terms of T-min and T-max. There is an increase in the incidence of extreme temperature events. The incidence of the number of days with a high T-min increases per the following pattern:

- T-min > 26°C: from 120 to 150 days (x 1.25)
- T-min > 28°C: from 90 to 120 days (x 1.34)
- T-min > 30°C: from 40 to 80 days (x 2)
- T-min > 40°C: from 10 to 40 or 50 days (x 4 or 5)

Since our climate data on Lahore did not include humidity, only data for Rawalpindi and Multan was analyzed for humidity. The heat index, which combines temperature and humidity, is the most accurate variable in measuring heat impact on humans.

Findings on the Heat Index

We had previously seen that along with T-min in the hot months, humidity plays a direct role in the impact of heat on human health and its economic costs. With the prediction of roughly a 2°C increase in average temperatures in our study areas, the heat index actually rises even more because of increased humidity (see Table 8).

Our analysis was based on empirical data collected from different temperature regimes, with a difference of 3.5°C between average June temperatures of Rawalpindi and Multan. With the increase of the heat index on the order of values predicted in Table 8, current empirical evidence will be insufficient to predict the exact economic impact. However, we can still safely say that it will be much higher than what our analysis on temperature alone has shown.

Figure 5 illustrates the trends for increases in the number of days when the heat index in Multan is constantly above the threshold of 37°C, the temperature at which the human body cannot cool itself. Such periods have already increased from 3 to 5 months in Multan since the 1950s and will reach 5.5 months in the 2050s. However, a trend of heat waves with a nearly continuous rise in the heat index above 37°C will become prevalent starting in 2020. Such periods will increase to nearly 3 months in 2050, when passive cooling will not be able to support human life.

TABLE 8

MULTI-MODEL PROJECTIONS OF HEAT INDEXES (°C)

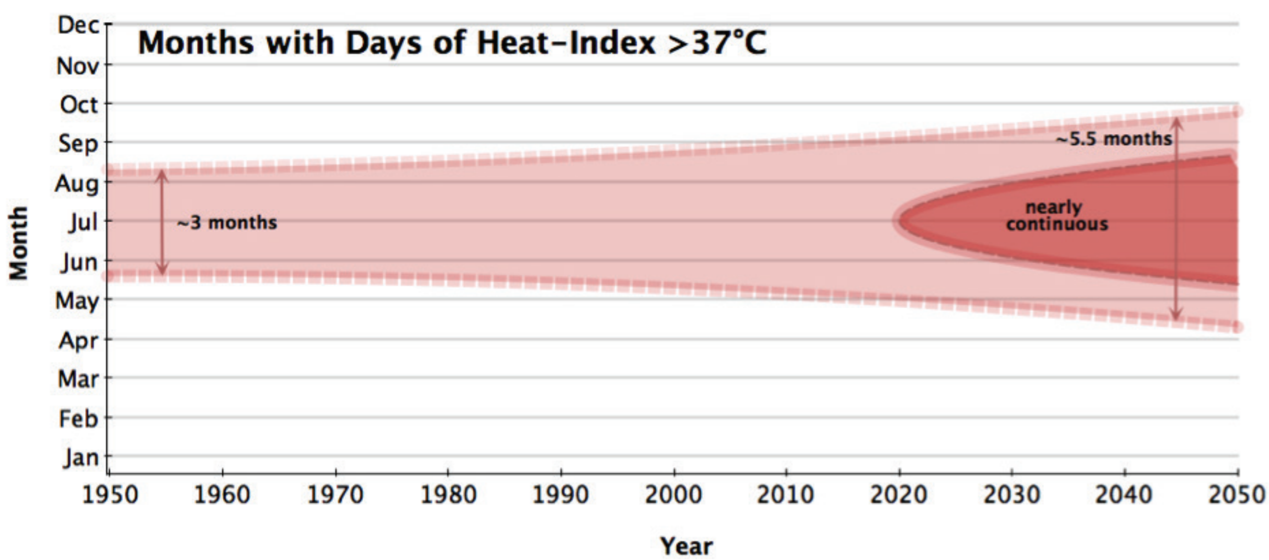
	Observed 1991–2010	Projected 2041–2060	Net increase
Multan			
June	39	45	6
July	42	49	7
August	41	48	7
Rawalpindi			
June	33	37	4
July	35	41	6
August	33	40	7

Source: Ammann & MacClune, 2014.

A trend of heat waves with a nearly continuous rise in the heat index above 37°C will become prevalent starting in 2020.

FIGURE 5

TRENDS IN HEAT INDEX THRESHOLDS IN MULTAN



Source: Ammann & MacClune, 2014.

4. DISCUSSION

This section describes the limitations and implications of our analysis. It highlights the areas of analysis that cannot be interpreted without further analysis. Some implications are clear, however, even with the current level of knowledge.

4.1 Caveats and Nuances (Limitations)

The economic analysis in this study was done from the perspective of a home owner's costs and benefits and his or her ability to pay. Heat also has great impact on the public and private sector in terms of loss of productivity, availability of cheap labor, and costs related to epidemics. These impacts were not evaluated under the current study. Given the heat projections, however, such impacts are likely to be significant and should be evaluated through additional research in the future.

The heat burden calculated here is, therefore, just an estimation of the expenditure of the household, which is constrained by disposable income. The actual heat burden is much larger, and using disability adjusted life years (DALYs) would be a much more accurate and ethically appropriate measure of the actual burden on the population. Since health expenditures are limited by the ability to pay, a reduction of the predicted heat-related costs may not translate into actual savings as those funds may be spent on health care that was previously unaffordable.

As we project economic heat burden beyond the empirical data collected for a selected temperature, we implicitly assume that a more intensive use of current strategies to combat heat stress would yield proportionate results. However, there are limits to the efficacy of the current strategies and a sheer increase in quantity will not be sufficient to prevent losses. For example, the impact of heat indexes constantly rising above the human body's threshold of 37°C cannot be reduced with the passive cooling technologies available at the moment. To address this, some form of active cooling will be essential.

T-max predictions tend to underestimate the impact because of a lack of consideration for the impact of increased humidity and an elevation of T-min in hot months. Projections of T-max increases with climate change tend to be much lower than those of T-min and the heat index and underestimate its impact on human health.

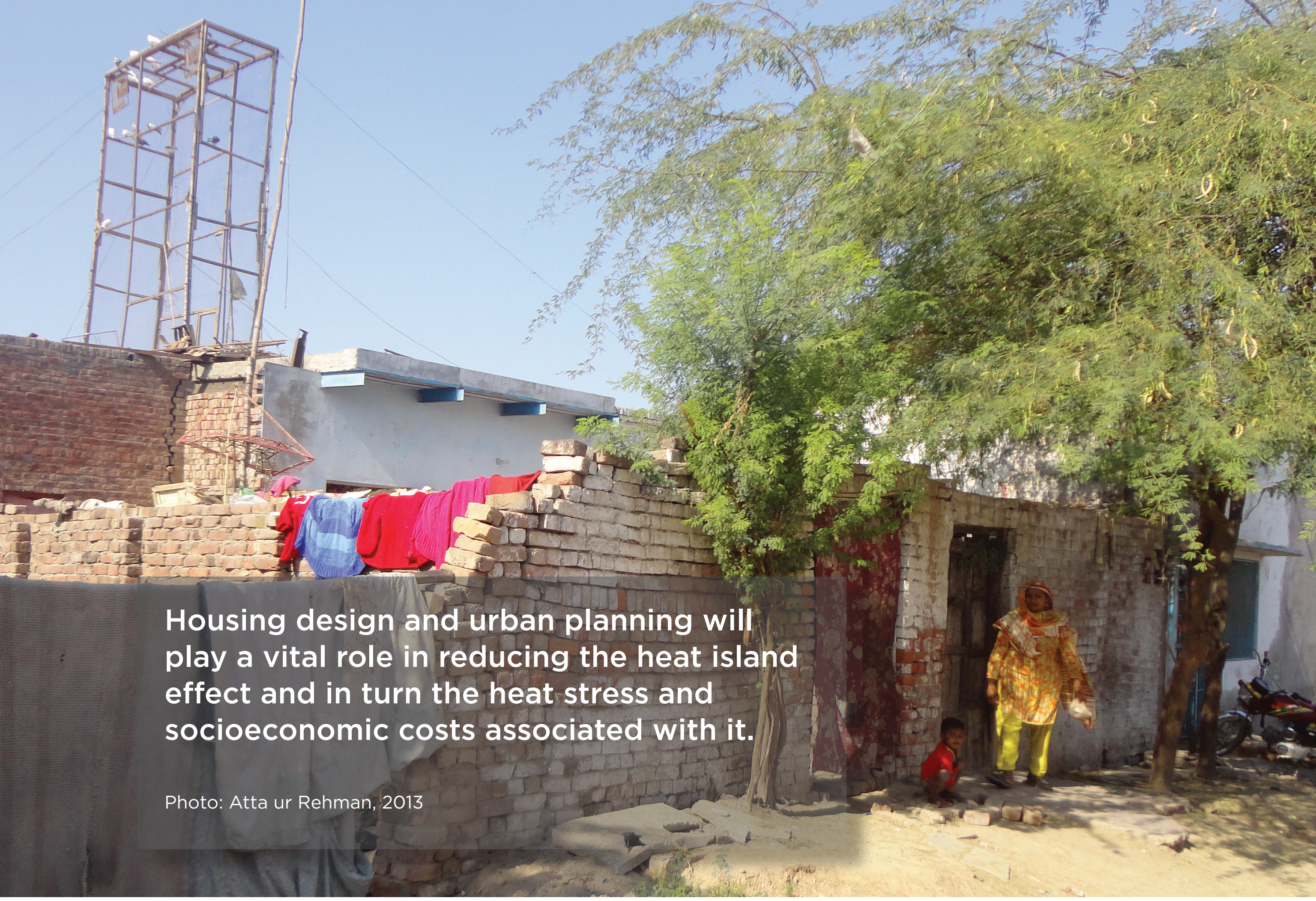
The analysis has been conducted in four specific locations, and it is expected that the nature of heat-related impacts could be much different in different socioeconomic and geographic conditions. However, we already see some emerging trends that are common to most areas, such as the cascading effects of failure of services and governance issues pertaining to planning. These emanate from the inability to include rapidly growing peri-urban areas into cities and plan for services provision and revenue collection. Where responses to changes in heat are concerned, we did not evaluate the factors that enable or block local residents from adopting them. For example, we did not consider tenure as a factor determining investment decisions despite the fact that a large portion of urban dwellers may be renting.

Even with reliable data availability and analysis, the attribution to each degree of temperature, wind speed, and percent humidity to certain diseases, lack of productivity, and other impacts is still a difficult task in terms of accurate economic evaluation. Collection and analysis of epidemiological data will greatly help in setting prevention and response priorities. Nevertheless, some of the policy implications from this limited analysis are clear and imminent.

The impact of heat indexes constantly rising above the human body's threshold of 37°C cannot be reduced with the passive cooling technologies available at the moment.

4.2 Policy Implications

Housing design and urban planning will play a vital role in reducing the heat island effect and in turn the heat stress and socioeconomic costs associated with it. Although there are national policies to promote climate resilient shelters, implementation is a challenge.



Housing design and urban planning will play a vital role in reducing the heat island effect and in turn the heat stress and socioeconomic costs associated with it.

Photo: Atta ur Rehman, 2013

Implications at the National to Regional Level

The cost of the sustained high temperature and heat index periods projected as a consequence of climate change is likely to be very high. Unlike floods and earthquakes, heat is a very slow-onset disaster in the making. Development pathways are often irreversible, and lack of central planning (or decisions to make large investments) may make these problems insurmountable. Therefore, it would be more sensible to prevent such a disaster by implementing long-term planning and investing in empowering and building the capacity of lower tiers of government to tackle problems locally with the help of communities and the private sector.

Linkages and Roles of Other Agents

Changes in shelter design cannot be predicated through formal policy mechanisms coming "from above." Therefore, it is imperative to initiate changes "from the bottom up" through innovation, experimentation, awareness, and capacity building. Universities and research organizations in the public, private, and nonprofit sectors can be mobilized to undertake this challenge. Including people like masons, contractors, and home owners will be essential to deal with a problem of this scale.

In addition, because changes in shelter design alone cannot reduce the impact of sustained increases in the heat index, alternative avenues for responding, such as the establishment of public cooling centers and heat emergency response capabilities, will need to be explored. Such alternatives have been proposed in other parts of South Asia. Development of them at scale would require the involvement of numerous actors from communities, the private sector, the medical and emergency response community, and the government.

Implications at the City or State Level

To reduce the impact of heat in shelters, technologies will have to be developed through the private sector and adequate supply chains established. At the same time, the cost of services for the poor (the health burden) and lack of open spaces (the heat island effect) cannot be addressed through shelter design. The cascading effects of poor water, sanitation, and urban planning will have to be reconsidered as major driving factors in compounding the impacts of increased temperature and humidity.

Addressing the projected increases in temperature will require substantial innovation with respect to shelter design, energy, and behavior if mass remigration is to be avoided.

Photo: Atta ur Rehman, 2013

Therefore, action at the city and the provincial/state level will be most important in bringing about the needed policy-oriented changes. This will include town planning capacities and enforcement abilities. Providing basic water and sanitation services and charging for them will always remain a challenge as long as the provinces and higher tiers of government wish to control the delivery of such basic services.

Preventive and curative health measures, heat emergency plans, and infrastructure will have to become part of the disaster risk reduction strategies, just as for earthquake and flood planning. Since all of these strategies have historically been developed retrospectively, a large population will have to suffer before they become a reality.

Mass Remigration and Energy

Given that certain areas of South Asia will become too expensive to live in with increased heat, there is a possibility that the newly urbanized poor may have to remigrate in search of environmentally and economically viable locations. Although more detailed estimates are needed regarding the scale of such heat vulnerable populations, it may well affect about half a billion people in South Asia. Their current locations will become simply unlivable without active cooling. At present, however, active cooling (i.e., air-conditioning) is expensive and unaffordable for most households. The energy required to run it also exacerbates warming, both within cities as heat is pumped out of buildings and globally by contributing to climate change. As a result, addressing the projected increases in temperature will require substantial innovation with respect to shelter design, energy, and behavior if mass remigration is to be avoided.

5. CONCLUSIONS

This study concludes with a focus on a large portion of new housing in the fast urbanizing cities of Pakistan where heat stress will have a significant economic and social impact on the development of the Pakistani economy. The results show that shelter design modifications to reduce the impact of heat are likely to have positive economic returns at the household level under current conditions in cities like Multan—, and for most cities with projected climate change. This is due to an increase in the heat losses experience by the households rather than an increase in efficiency of the technologies, and hence, affordability of technologies still remains an issue.

The changes that can be achieved through improvements in materials and shelter design without active cooling can be effective only to a certain limit (i.e., a heat index of 37°C). Increases in nighttime minima and a heat index beyond that limit will have major impacts on health unless mechanisms can be identified to keep in-house temperatures below ambient nighttime minima. At present, the primary mechanism available to do this is air-conditioning.

The results are as valid for similar or hotter climate zones throughout South Asia. Populations still suffer considerable losses to heat and attribute it to nature and intensive urbanization and industrialization at the local level, which is supported by the literature. Predictions of cost increases with climate change show that they may be beyond the capacity of most urbanizing families. These estimates are based on more investment and intensive use of current strategies, which may have limitations under climate regimes expected in the future.

Melting ice and rising sea levels have been the hallmarks of climate change impacts as popularized by scientists and the media alike. Reduction of habitat for polar bears and loss of biodiversity and glaciers in colder areas have been causes of great concern. From this study, we see that increased humidity (coupled with raised minimum temperatures inside shelters) may threaten the livelihoods of millions of people who are under considerable stress from the economic impacts of heat. More research is needed to identify areas where such threats to human existence are imminent and may start exhibiting impact within the next 15 years.

Predictions of cost increases with climate change show that they may be beyond the capacity of most urbanizing families.

Therefore, more resources need to go into material and shelter design research for temperature resilience. Data and knowledge sharing can go a long way in predicting and planning for these changes in climatic conditions. Knowledge generation and dissemination at the local level may be the best place to start, which may also pave the way for sharing it across boundaries.

With a lack of financing and insurance mechanisms in the housing sector, which are a reflection of the inability to enforce property rights, the state and national levels of government cannot be expected to play a significant role in either incentivizing or enforcing climate resilient designs. However, provision of services such as electricity, water, and sanitation could greatly alleviate the burden of heat stress in the medium term. Unplanned settlements, when assimilated into municipal boundaries, lack basic services such as water and sanitation, as well as open areas. These deficiencies already impact the health of millions of people, and the situation will only be exacerbated by the expected climate change.

It has already been shown that in Pakistan the most common cause for families to fall into poverty is repeated health shocks (Heltberg & Lund, 2008). Improvement in health services now may generate the resources needed by poor households to deal with heat stress better in the future. Conversely, relief from temperature stress may help households better deal with health problems. However, in the longer term, more radical adaptation strategies may be needed to cope with a disaster of this scale.

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APPENDIX 1: POLICY LANDSCAPE MAP

Key Actors in the Housi

INTERNATIONAL

World Bank
Financial and policy assistance, among various other sectors, in housing, house financing, housing reconstruction and urban development.

Asian Development Bank (ADB)
Financial and policy assistance, among various other sectors, in housing reconstruction and urban development.

United Nations Development Programme (UNDP)
Apex UN agencies dealing with, among others issues, emergencies, early recovery, environment, climate adaptation and housing reconstruction.

United Nations Habitat (UN Habitat)
Dedicated UN agency for shelter and housing.

NATIONAL

Planning Commission
Apex national level body that provides policy guidance and directions, approve and allocate resources, among other sectors, for housing and physical planning. All development plan, annual, five-year, ten year or more, are prepared by the Commission.

Ministry of Housing and Works
The custodian of National Housing Policy 2001, deal with the housing needs of the federal government employees, coordination and collaboration with the provincial governments for addressing housing interventions, particularly for low income groups. National Housing Authority and Pakistan Housing Authority are its subsidiaries.

State Bank of Pakistan
Provide policy guidance and directions regarding house financing, particularly for low income groups.

Housing Building Finance Corporation (HBFC)
The dedicated state institution to provide house financing; provides a range of house financing products, such as construction, purchase of house, and repair of house.

NATIONAL

The Climate Change Division
The custodian of National Climate Change Policy 2012 and mandated to deal with issues and subjects related to climate adaptation and mitigation.

National Disaster Management Authority (NDMA)
An apex federal body to deal with entire spectrum of disaster management, in concert with its provincial and district level disaster management entities, such as PDMAs and DDMAs.

Earthquake Reconstruction and Rehabilitation Authority (ERRA)
A national level body to deal with reconstruction and rehabilitation of earthquake affected areas.

The National Energy Conservation Centre (ENERCON)
Serves as the focal point for energy conservation/efficiency activities, from different sectors to domestic level. Activities includes technology demonstration, pilot projects, training, education and development of plans and policies.

PROVINCIAL

Ministry of Housing and Physical Planning
The Ministry deals with shelter and housing issues along with urban development. Collaboration and coordination with the federal and provincial governments.

Planning and Development Departments (PP&D)
Principle planning organization at the provincial level, mandated to formulate, approve, coordinate and monitor development programmes across the departments, including housing and physical planning.

Housing and Physical Planning Departments
Providing shelter and dealing with housing issues in addition to matters related to urban development and safe drinking water.

Cooperative Departments
Promote and regulate cooperatives, including housing cooperatives societies.

DISTRICT

Tehsil (Town) Municipal Administration (TMA)
The second tier of the district government, is responsible for implementing the spatial planning, building bylaws and development planning.

Development Authorities
Development authorities in selected districts, responsible for planning, designing and implements the urban development project including residential colonies, such as Peshawar Development Authority, Lahore Development Authority or Karachi Development Authority.

District Disaster Management Authorities (DDMA)
Responsible to deal with disaster and emergencies at the district level, which include, among others, housing reconstruction and rehabilitation.

PRIVATE SECTOR

The Association of Builders and Developers (ABAD)
Representative forum of leading developers and builders in Pakistan, aims to promote and contribute towards housing industry and protect the interests of the member companies.

Institute of Architects, Pakistan (IAP)
IAP is a representative forum of architects to promote architecture and town planning as well as looks after the interests of professionals in the field.

Cooperative Housing Societies
The cooperative housing societies, with over two thousand registered with the Government, are the major source of providing housing units/serviced plots in Pakistan.

Masons and Construction
Contractors The masons and local small scale contractors in housing sector, majority falls within informal construction services, and mainly cater to middle and low income groups.

REPRESENTATIVE NGOs

Saiban
Involved in incremental housing programmes for low-income segments of society, known as Khuda ki Bastis (literally God's Colony)

Orangi Pilot Project (OPP)
Initiated a Low Cost Housing Programme, intended to bring improvements in building components and construction techniques, provides housing support services to communities and technical training to youths and masons to become community architects.

Heritage Foundation of Pakistan
Involved in conservation of heritage buildings, designing and construction of DRR resistant/climate compatible shelter using vernacular methodologies.

Pakistan Straw Bale and Appropriate Building
Offers seismic and heat resistant housing, using local labour and local renewable material for permanent housing. Developed unique straw bale building methods.

ng Arena

Other UN agencies/INGOs
Other UN agencies and numerous international NGOs partly or fully dealing with climate resilient housing, DRM, recovery and reconstruction.

Donors
Donors, such as DFID, USAID, European Union, AusAid, GTZ, CIDA etc.

The Council for Works and Housing Research (CWHR)
A research-based organization with the main aim to research and provide guidance on civil engineering works, with special focus on affordable housing.

Pakistan Council of Architects and Town Planners (PCATP)
A statutory regulating body for recognition and protection of architect and town planning professionals and assist the government and relevant institutions through reviewing and advising on issues related to professionalism and the education of architects and town planners.

National Engineering Services Pakistan (NESPAK)
A state-owned company,that provides a broad spectrum of consultancy services, including housing, urban planning and area development.

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Agencies for Squatter Settlements
Agencies are in place to deal with squatter settlements in terms of their regulation and improvement, Directorate of Kachi Abadis in Punjab and Sindh Kachi Abadi Authority.

Bodies of Special Housing Scheme
The provincial governments launched various affordable housing schemes, which are implemented through different implementation arrangements, such as Punjab Land Company, Khyber Pakhtunkhwa Housing Authority in KPK, People Housing Cell in Sindh.

Defense Housing Authorities
Defense Housing Authorities The semi-autonomous authorities in Karachi, Lahore and Rawalpindi, are part of Ministry of Defense. Primarily established to provide serviced plots/housing units to in-service/ex-service men, now mainly caters to clients from upper and upper middle classes.

Bahria Town
With numerous private real estate developers across Pakistan, Bahria Town establishment is the representative of these entities, being the largest in Pakistan. With thousands of serviced plots to built homes, Bahria Town mainly caters to clients looking for high-end living in big cities like Karachi, Lahore and Rawalpindi.

Sheltering From a Gathering Storm Publications

Additional materials can be found at **i-s-e-t.org/SHELTER**
These materials include:

SUMMARY REPORT

- Sheltering From A Gathering Storm: The Costs and Benefits of Climate Resilient Shelter

CASE STUDIES

- Sheltering From a Gathering Storm: Typhoon Resilience in Vietnam
- Sheltering From a Gathering Storm: Flood Resilience in India
- Sheltering From a Gathering Storm: Temperature Resilience in Pakistan

SHELTERING SERIES

- Review of Housing Vulnerability: Implications for Climate Resilient Houses
- Qualitative Insights into the Costs and Benefits of Housing
- Indian Housing Policy Landscape: A Review of Indian Actors in the Housing Arena
- Temperature Impacts on Health, Productivity, and Infrastructure in the Urban Setting, and Options for Adaptation
- Potentials to Build Disaster Resilience for Housing: Lessons Learnt from the Resilient Housing Design Competition 2013
- Climate Resilient Housing: An Overview of the Policy Landscape in Pakistan
- Situation Analysis Gorakhpur, India: Climate Change, Flooding and Vulnerability
- Community Based Evaluation of the Costs and Benefits of Resilient Housing Options: Gorakhpur, India

TEMPERATURE BRIEFINGS

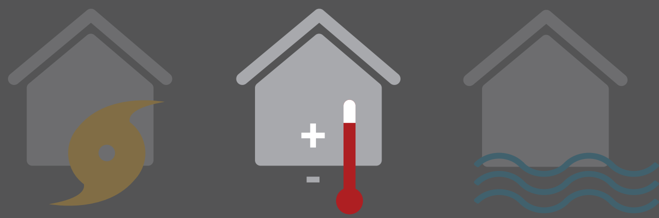
- Projecting the likely rise of future heat impacts under climate change for selected urban locations in South and Southeast Asia.

POLICY BRIEFS

- Gorakhpur: Extreme Rainfall, Climate Change, and Flooding
- Da Nang: Extreme Rainfall, Climate Change, and Flooding
- Da Nang: Typhoon Intensity and Climate Change

TECHNICAL REPORT

- Gorakhpur: Extreme Rainfall, Climate Change, and Flooding
- Da Nang: Extreme Rainfall and Climate Change



Sheltering From a Gathering Storm aims to improve understanding of the costs and benefits of climate resilient shelter designs and contribute to the transformative changes necessary to make communities more resilient to future disasters.

This case study, one of three in the project, focuses on key issues related to temperature in Pakistan, and provides insights into the economic and nonfinancial returns of adaptive, resilient shelter designs that take into consideration hazards such as typhoons, flooding, and temperature increases.

This document is an output from a project funded by the UK Department for International Development (DFID) and the Netherlands Directorate-General for International Cooperation (DGIS) for the benefit of developing countries. However, the views expressed and information contained in it are not necessarily those of or endorsed by DFID, DGIS, or the entities managing the delivery of the Climate and Development Knowledge Network, which can accept no responsibility or liability for such views, completeness or accuracy of the information, or any reliance placed on them.

This report was produced by The Institute for Social and Environmental Transition-International in partnership with The Institute for Social and Environmental Transition-Pakistan.

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For more information, please see:
www.i-s-e-t.org/SHELTER