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ORIGINAL ARTICLE

Exposure, Impacts, and Responses to Heat Stress: A Comparison Between Rural and Peri-urban Poor Population

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Abstract

This study is an attempt to understand the differences in exposure, impacts, and responses to heat stress between peri-urban and rural population. Furthermore, it explores how crucial a role heat stress plays in impacting migration decisions. Based on the analysis of an ensemble of regional climate models, it is found that the studied region is projected to undergo an increase in the frequency of heat waves under RCP 8.5 scenario. Afterwards, a randomly selected household survey was carried out at rural as well as peri-urban areas of Faisalabad. At both areas, the available economic opportunities were analyzed to understand how economic well-being and type of occupation are associated with thermal discomfort. It was found that people involved in outdoor activities are highly vulnerable to heat stress. Poverty is one of the prime barriers to adapt to heat stress. People's livelihoods, in terms of labor productivity and decline in agriculture production, are reported to be affected by the heat stress. This study found that peri-urban respondents came from the rural areas of the district and other cities across the providence to improve their level of income and reduce their vulnerabilities but due to the low level of education and skills, they have only been able to improve their livelihoods to a limited extent. As a result, there is very little improvement in their standard of living as well as their thermal discomfort/exposure to heat stress.

Keywords Migration · Climate change · Heat stress · Poverty

1 Introduction

Pakistan is among the countries in the world which are worst affected by climate change (Kreft et al. 2016). Besides many other factors making the country susceptible, heat waves/stress stands out as one of the most crucial artifacts of changing climate (Saeed and Suleri 2015). It affects attitude, health, and performance of individuals (Zahid and Rasul 2010). Pakistan has experienced severe incidents of heat stress/wave in recent years which resulted in large-scale mortality and morbidity (Saeed and Suleri 2015). Future projections of climate change scenario reveal that incidence of heat wave/stress is likely to increase during this century (Saeed et al. 2017).

Heat-wave situation occurs when exposure to direct sunlight or place of excessive heat exceeds certain threshold levels which may result in physiological discomfort, stress, and other heat-related illnesses or even death (Smith et al. 2014; Opitz-Stapleton et al. 2016; Hajizadeh et al. 2015). Type of occupation and working environment contribute in exposure to heat stress. People who work under direct sunlight (agriculture work), or place of excessive heat (industrial work), and are involved in heavy physical work are more vulnerable to heat stress (Kjellstrom et al. 2009; Lin and Chan 2009; Venugopal et al. 2015). Lack of safety protocols, cooling facilities, and heavy pace of work causes increased risk of heat stress for the farm as well as non-farm workers in rural and urban areas, respectively (Lundgren et al. 2013). Many developing countries face decline in workers' productivity as a result of exposure to heat stress (Kjellstrom et al. 2016). Decline in productivity

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may motivate workers to alter their profession or even opt to migrate (Majid and Zahir 2013; Saeed et al. 2016).

Rural-to-urban (internal) migration, under normal circumstances, is considered as an adaptation strategy, where a migrant moves to urban localities for better livelihood and living standards (Tacoli 2009). Socio-economic factors are generally regarded as the main determinants of internal migration which can be broadly classified under two categories: push factors and pull factors. Push factors are generally related to the place of origin (e.g., poverty, illiteracy, limited economic opportunities, etc.), whereas pull factors are related to the place of the migrant's destination, attracting people to certain locations (e.g., better livelihood opportunities, education, health, and living conditions).

For most developing countries, the problem of migration is compounded by the challenge of urbanization that seems to couple with it (ADB 2013). While most of the people living in rural areas are associated with agriculture; therefore, once they migrate, they lack the skills required at the urban centers. Mostly, the rural poor migrates for work and lives in peri-urban areas because of the low cost of living compared to urban centers (Smith and Saywell 1998; Nicodemus and Ness 2010).

Pakistan has a high pace of urbanization where the net rural-to-urban migration accounts for one-fifth of the annual rise in urban population (Hussain 2014; Saeed et al. 2016). With an urbanization rate of 3% per annum (Kugelman 2014), many Pakistani cities have informally grown into large agglomerations with about 35–50% of the urban population reportedly living in informal settlements (WB 2014; Kugelman 2014). Government projections suggest that, by 2030, more than half of Pakistan's population will be residing in urban areas (GoP 2014), increasing the vulnerability even further due to urban heat island effect. Combining the increasing trend of urbanization with the future increase in heat waves, a gloomy picture comes out, especially in terms of thermal comfort levels available at home as well as at work place.

In this study, we attempt to understand the differences in exposure, impacts, and responses to heat stress between peri-urban (migrant) and rural (non-migrant) population. We have also tried to figure out how crucial a role heat stress plays in impacting migration decisions by altering the above-mentioned thermal comfort levels. Moreover, the future-projected increase in heat waves over the studied region is also estimated using state-of-the-art climate modeling technique to understand the susceptibility of the region to future global warming.

The rest of the study has been structured as follows; Sect. 2 explains the methodology, Sect. 3 states the results, Sect. 4 discusses the results, and Sect. 5 draws conclusion.

2 Methodology

We selected the district Faisalabad (Punjab Province) which is climatically semi-arid and has an agro-based economy (Fig. 1). Faisalabad city, the hub of industrial and agricultural activities, is the third largest city of Pakistan; with around 7600 large-to-small-scale industrial units. The importance of the region can be gauged from the fact that it covers around 25% of the country's total export (Batool et al. 2008). District-level economic statistics show that the agriculture sector provides 30.09% employment in the district, whereas the share of the industry and services sector in employment is 34.4% and 34.7%, respectively (GoP 2011). About 52% of its total population is living in rural areas and the majority of them are engaged in agricultural activities. Majority of the urban population is daily-wage labor workers in various cotton and chemical industries, while others are involved in the services sector. It has been found that only textile and associated industries provide livelihood to around 10 million families. Therefore, it attracts potential rural labor force not only from adjacent areas, but also from different parts of the country (Batool et al. 2008). It is evident that the working environment does not comply with the safety and environmental standards; the prevalence of various health hazards and injuries at workplaces is often due to humidity, excessive heat, noise, and improper lighting arrangements (Shah et al. 2015; Khan et al. 2015).

Today, climate models are considered as the state-of-the-art tools to carry out future projections of climate under different scenarios. Global climate models (GCMs), with a typical resolution of approximately 200 km, are considered insufficient to study climate change impacts at regional or national scale. Therefore, regional climate models (RCMs) are usually employed to downscale the information generated by GCMs. For this study, we used the data of three RCMs which are forced by three GCMs at a resolution of 44° (~ 50 km) as presented in Table 1. The models' simulations were performed under CORDEX (Coordinated Regional Climate Downscaling Experiment) initiative for South Asia (Jacob et al. 2012). Here, we used RCP 8.5 scenario which is considered as business-as-usual scenario. Moreover, we used the methodology presented by Saeed et al. (2017), which defines a heat wave when the daily maximum temperature remains at 45 °C or above continuously for 5 days. This definition was applied on all the RCMs, while the results were analyzed for the region (72.5°N–74°N and 30.5°S–32°S) focused on the Faisalabad district. Moreover, the analysis was conducted for three sub-periods which are 2026–2050, 2051–2075, and 2076–2100.

To understand the differences in exposure, impacts, and responses to heat stress between peri-urban (migrant) and

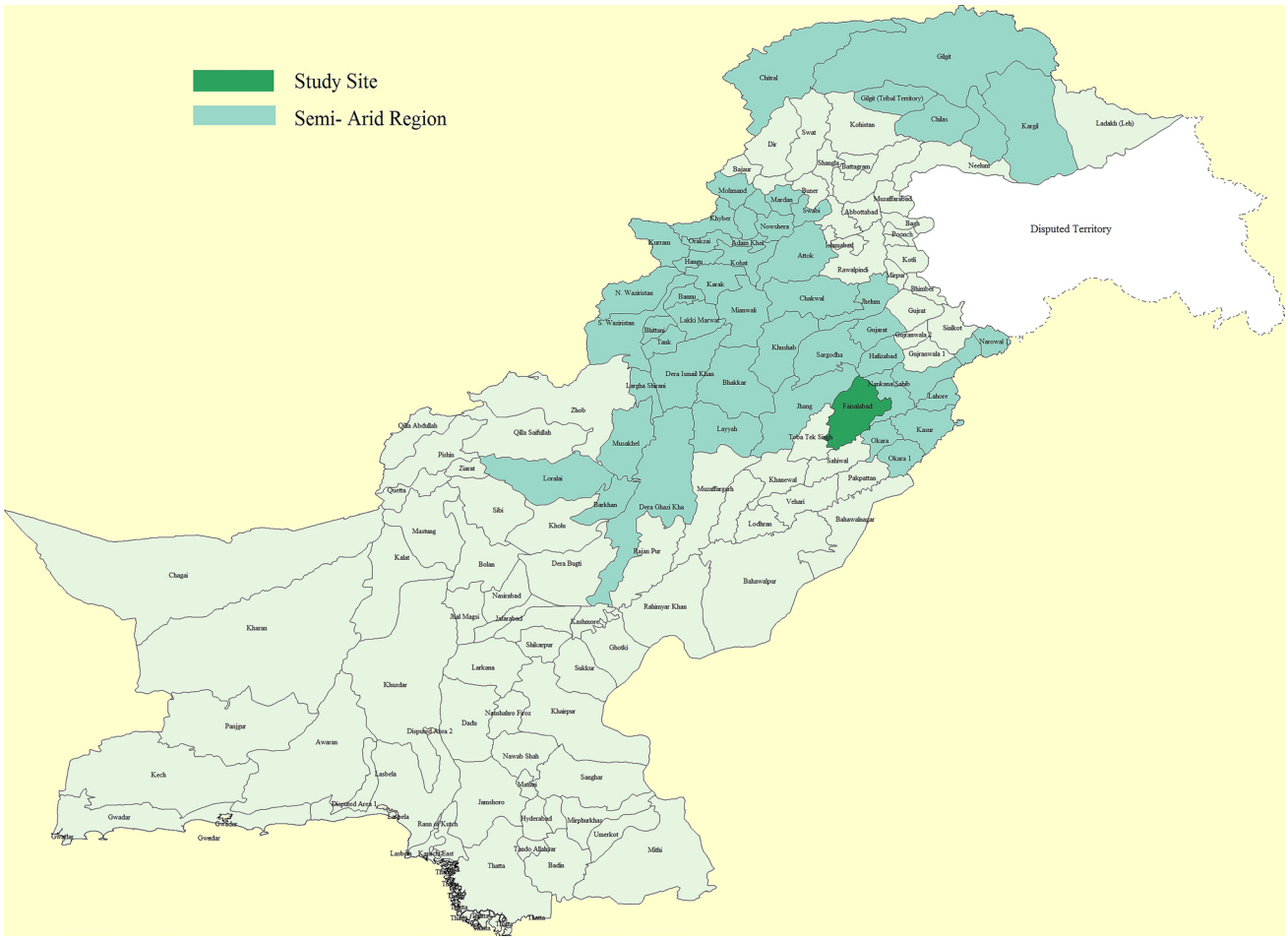

Fig. 1 Study site

Table 1 Matrix showing names of regional climate models (RCMs) and its forcing global climate models (GCMs) along with their respective institutes

RCM	RCM's Institute	GCM	GCM's Institute
REMO_2009	Climate Service Center, Germany	MPI-ESM	Max Planck Institute for Meteorology, Germany
CSIRO	CSIRO, Australia	CCSM4	NCAR, USA
RCA4	Rossby Centre, Sweden	EC-EARTH	Rossby Centre, Sweden

rural (non-migrant) population, we used a quantitative approach to measure the perception of these groups with regard to living and workplace conditions (Garbarino and Holland 2009). In this regard, a comparison of two study groups, i.e., (1) rural residents of Faisalabad district, and (2) peri-urban residents of Faisalabad city, was drawn. For both of the groups, the available economic opportunities (see Sect. 3.2) were analyzed along with the role of education and skills in the selection of a job/work (Khan et al. 2013). It was then assessed along with the type of work exposed the most to heat. Finally, we explored how economic well-being, household income, and financial assets (Lewin and Stier 2003), as well as thermal comfort level of the peri-urban respondents have been changed after they moved to peri-urban areas.

Data collected through a survey using structured questionnaire could be considered as an effective approach to understand the perception and behavior of the respondents (Rubin et al. 2014). By following this approach, we conducted a household survey to understand people's perception regarding their exposure to heat stress at home as well as at workplace for both rural and peri-urban areas. A total number of 80 households were randomly selected for interviews out of which 40 households were selected from rural areas (non-migrant families) and 40 from peri-urban areas (full family migrant). The survey questionnaire was

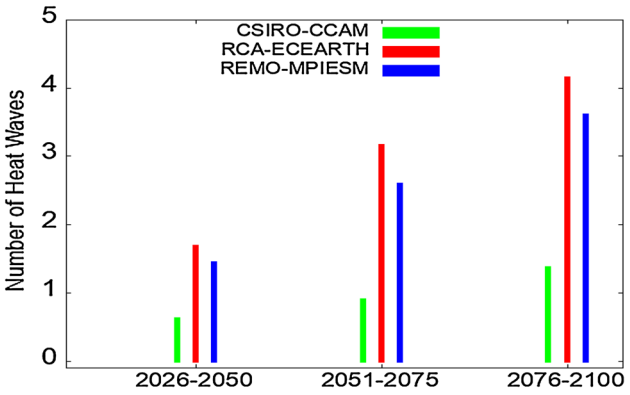

Fig. 2 Annual averaged difference in the number of heat waves for each future sub-period as compared to the historical period (1976–2000) from the three RCMs

pre-tested and modified according to local needs before going into the field.

3 Results

3.1 Future Projection of Heat Waves

Figure 2 shows the results of the different heat waves among historical (1976–2000) and each future sub-periods for all the three RCMs. All three RCMs show an increase in future heat waves; however, difference in the magnitude among the RCMs can be noticed. CSIRO-CCAM shows much less increase as compared to the rest of the two RCMs, while RCA–EC-EARTH shows the highest increase. For example: averaged over the whole sub-period of 2076–2100, CSIRO-CCAM shows an increase of 1 heat wave per year. Whereas, REMO-MPISM and RCA–EC-EARTH show an increase of more than 3.5 and 4 heat waves per year, respectively. Although there are differences among the RCMs, however, it is important to note that the trend in all the three models is towards the increase in the number of heat-wave events as we move towards the end of the century. Despite these differences, these results point towards a robust increase in heat waves over the region. Hence, these results point towards a potential increase in the vulnerability of the people living in Faisalabad district to heat waves in future.

3.2 Socio-Economic Profile of Respondents and Their Households

Table 2 indicates that majority of the rural respondents were aged between 26 and 45 years. The level of education among rural respondents has a mixed trend; only 31% have a secondary or above level of education, while around 37% are uneducated. Rural communities are mostly dependent upon agriculture for their livelihood (Rehman et al. 2017), while around 77% of our rural respondents mentioned agriculture as their main source of income (Table 2). The average monthly income of the rural household ranges from Rs 2500 to 100,000 and around 55% of the households have average income above the poverty line (poverty line is defined as the cost of basic needs per adult equivalent to Rs 3030 per month).[1]

Table 2 Characteristics of the respondents

Characteristics of the respondents	Peri-urban (%)	Rural (%)
Age in years		
Less than 26	22.5	15.0
26–35	27.5	27.5
36–45	17.5	25.0
46 and above	32.5	32.5
Level of education		
Uneducated	43	37
Middle	51	31
Secondary and above	5	31
Occupation		
Farming/livestock	0	62.5
Casual labor (daily wage) on farm	7.5	15.0
Casual labor (daily wage) non-farm	40.0	7.5
Business/transport/shop/construction	25.0	10.0
Skilled labor	2.5	2.5
Salaried/job holder (government or private)	25.0	2.5
Poverty line		
Below the poverty line	72.50	45.00

On the other hand, people living in the peri-urban areas are comparatively poor. Around 28% of the household have income above the poverty line. Data show that their average monthly income ranges from Rs 3000 to 30,000 per month per household. Majority of the peri-urban respondents (72%) came from different rural areas of Faisalabad and 28% from other cities across the province. Results show that peri-urban respondents migrated for a better livelihood opportunity. Majority of the respondent's (83%) livelihood activities were affected by climate change at their previous locations (see Fig. 4). We found that poor people who migrated from rural areas are involved in daily-wage labor activities. They were found to be uneducated or having a middle level of education (Table 2), which clearly depicts that, in urban/peri-urban areas, type of occupation chosen depends upon the level of education and skills. Similar to Khan et al. (2013), we found that only a small fraction of the total sample (5.4%) has a

[1] Economic Survey of Pakistan (2015–2016), Ministry of Finance, Pakistan.

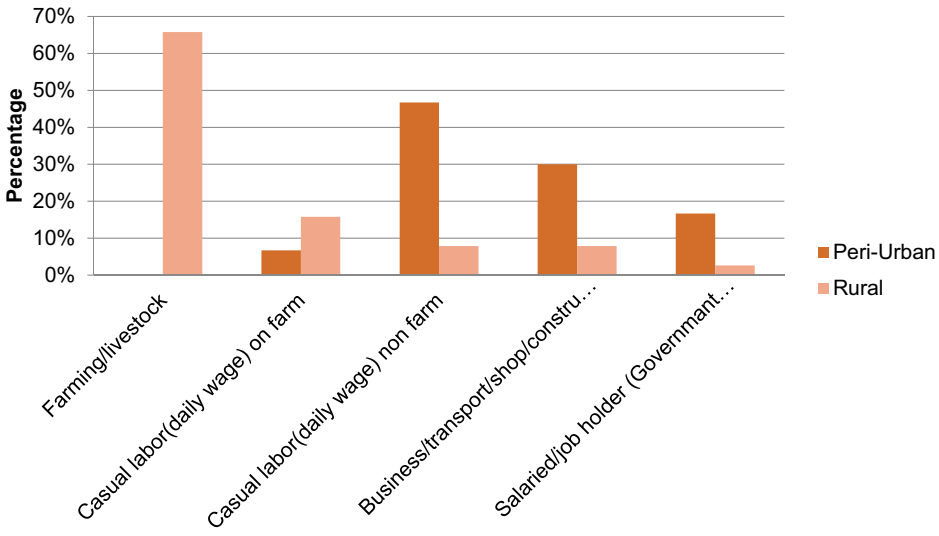

Fig. 3 Percentage of respondents working under direct sunlight or place of excessive heat. These results are significantly different among rural and peri-urban areas at ($p < 0.01$) level of significance

Note: These results are significantly different among rural and peri-urban areas at ($p<0.01$) level of significance.

secondary or above level of education and has a job in public or private sector. Owing to this, only a small fraction of peri-urban respondents (35%) had been able to secure income above 10,000 per month.

3.3 Exposure to Heat Stress

3.3.1 At the Place of Work

As per our respondents' data, majority of the rural population largely depends on agriculture for their livelihoods and most of the agriculture activities take place in open fields. That is why, almost all the rural respondents engaged in agriculture are vulnerable to heat stress during the summer season, as they have to work under direct sunlight or place of excessive heat exposure (Fig. 3). Almost all types of working opportunities in the rural community expose workers to heat, as was mentioned by around 98% of the rural workers. We found that people usually rest in shade and cover their head with a piece of cloth to prevent heat stress during fieldwork. Owing to this heat exposure and lack of preventive measures, almost all of the rural workers claimed that their productivity decreases in summer, because their exposure to heat makes it difficult to work at full capacity during the daytime.

Our results show that, in peri-urban areas, diversified livelihood opportunities (such as: daily-wage labor work in industries and construction sector, public/private jobs and more opportunities to set own business, etc.) are available, but the majority of people (around 40%) fail to avail these diverse opportunities and get involved mainly in daily-wage labor activities. Since the type of occupation chosen is highly dependent on education and skills (Khan et al. 2013), results show that only 25% are salaried-job holders, while others have their own small business or involved in construction and transport services. It was evident that the workers involved in outdoor activities and working under the place of excessive heat are more vulnerable to heat stress during summer. Daily-wage labor workers and business/transport/construction workers are reported to be more exposed to heat stress in peri-urban areas (Fig. 3). To cope with the issue of excessive heat at workplace, various measures are taken such as, cooling equipment, i.e., fans and air conditioners and other safety measures (like a cap, a hat, and a piece of cloth to cover head). Around 40% respondents said that equipments are provided by the employers. Although the very basic cooling facilities are available to some extent, 38% of the respondents still feel tiresome during work and approximately 55% think that it is difficult to work.

3.3.2 At the Place of Residence

In our study area, almost all of the rural respondents have their own residences comprising of two or more than two rooms. Rural residences have unique characteristics; around 75% of the houses are constructed with brick walls and t-iron roofs covered with a layer of soil. Along with this, around 85% houses have windows for a better ventilation. Use of electric fan to avoid heat stress or cooling homes is widely common among rural community; only a small fraction of the rural respondents 2.3% and 4.7% have an air conditioner and air cooler, respectively. More than half of the rural respondents (58%) are of the view that available cooling equipment is sufficient to fulfill their needs if continuous electricity supply is ensured. Majority of the respondents mentioned facing problems like reduction in sleep quality and time with heavy sweating during nighttime, on the days with excessive heat (Fig. 4).

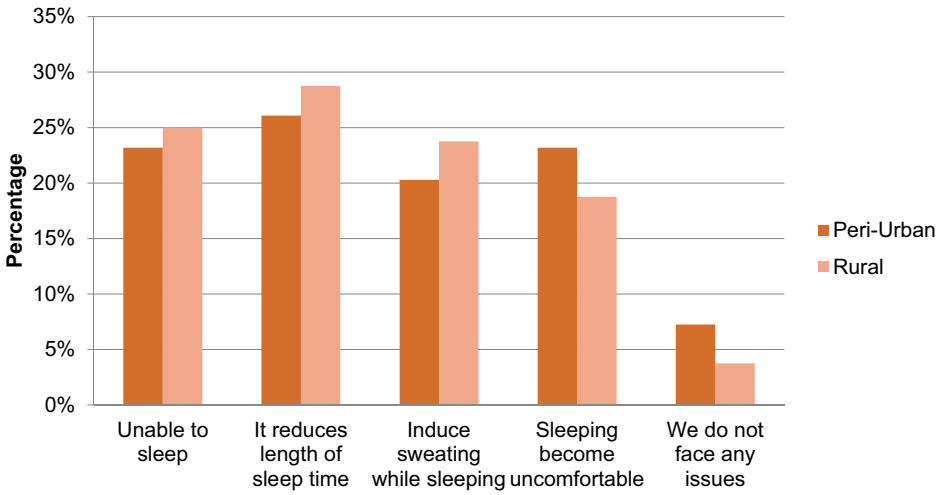

Fig. 4 Change in sleeping quality during excessive heat. These results are significantly different among rural and peri-urban areas at ($p < 0.01$) level of significance

Note: These results are significantly different among rural and peri-urban areas at (p<0.01) level of significance.

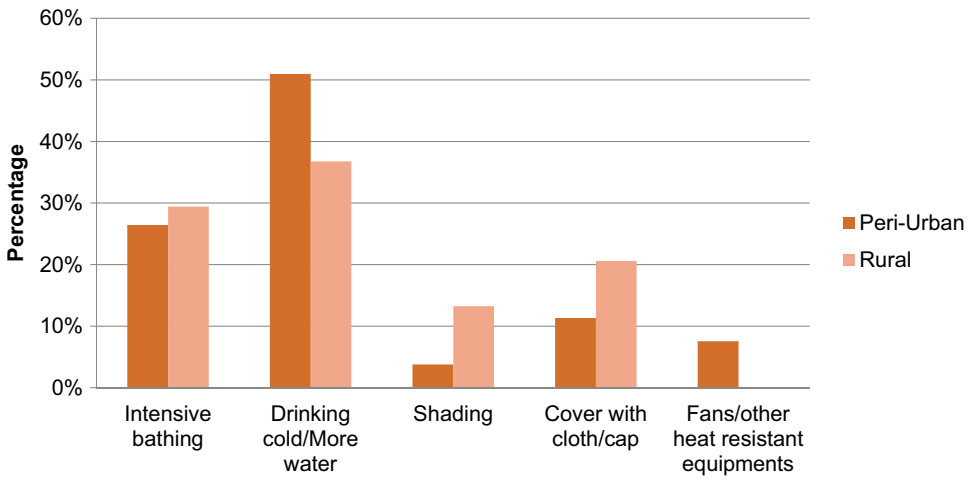

Fig. 5 Most common strategies to prevent heat stress

On the other hand, most of the peri-urban residents came from the rural areas of Faisalabad (72%) and across the country (28%); majority of them (63%) live in rented houses. Most of the houses are small, having two or less number of rooms with limited ventilation facilities. Similar to the rural areas, almost all the respondents reported that fan is the only available cooling equipment at their residences. For the survival from heat stress in their small and less ventilated houses, around 60% respondents think that available cooling equipments are sufficient. Results show that around 45% of the total peri-urban respondents reported being uncomfortable due to a high indoor temperature in less spacious houses along with fewer ventilation facilities (see S 1) (Fig. 4). Thermal discomfort at home in urban/peri-urban areas has increased because of the release of heat stored in buildings during daytime and high outdoor temperature due to less green spaces (Franck et al. 2013). Furthermore, people become more vulnerable as they have limited access to better infrastructure and service due to their low level of income and high prices in peri-urban/urban areas (Hatcher 2017).

Our results show that respondents are aware of some extra measures to prevent themselves from heat stress. The most common measures reported by the respondents are drinking a large amount of cold water and other local and traditional beverages. Lower economic status of peri-urban respondents reduces their access to other preventive measures such as cooling facilities (air cooler or air conditioner). Along with the above-mentioned measures, frequent bathing is also a very common preventive measure among both rural and peri-urban respondents (see Fig. 5 for details).

3.4 Impact of Heat Stress on Health

Exposure to heat stress affects not only the productivity but increases also the risk of health vulnerabilities (Kjellstrom et al. 2016). At our study sites, people were more concerned about the health impacts of ambient temperature rise during

the summer season. Around 98% of the rural respondents were of the view that their health can be affected by this rise in ambient temperature. Since poor health conditions affect the productivity of workers, around 78% of the respondents were much worried about heat stress and its health effects. The most common symptoms of heat-related impacts are: intense thrust (among 16% of the respondents), headache (13%), low blood pressure (12%), and urine of abnormal color (11%). Approximately 46% respondents reported feeling at least one of the symptoms twice a month.

Our results show that, due to hot working environment along with shortage of electric supply, heat-related health hazards increase among workers. Almost 93% of the peri-urban respondents were concerned about the impact of heat stress on health. The most common symptoms of heat stress reported in the peri-urban settings are headache (17%), abnormal color of urine (26%), intense thirst (13%), and heavy sweating (11%). The rate of occurrence of these symptoms is high among peri-urban respondents than rural respondents because of their low socio-economic status and housing structure. Talking about numbers, around 33% of the respondents feel at least one of those symptoms twice a month, whereas 26% of the respondents suffer from any of these health-related conditions four-to-five times a month. The trend of visiting any government or private health facility (clinic, quack, and hospital) is most common among peri-urban respondents (around 95%) if such symptoms occur. Furthermore, the quantity of solid food intake is found to be compromised due to excessive use of water during hot conditions. Around 90% of peri-urban and 82% of rural respondents have reported a decline in their solid food intake as a result of heat stress.

4 Discussion

People involved in outdoor work-related activities feel that they are exposed to heat stress during summer season (Opitz-Stapleton et al. 2016). Farmers and daily-wage workers are working under direct sunlight and place of excessive heat (Venugopal et al. 2015; Kjellstrom 2016). Their vulnerabilities to heat stress increase if proper preventive measures are not available at workplace (Venugopal et al. 2015). A study reveals that people involved in informal activities are usually responsible to arrange for their own preventive instruments. Whereas, in formal sector (industrial and service sector), safety protocols including cold drinking water, cooling facilities, and shades are provided by the employer in our study area. Our research is consistent with Park et al. (2015) in concluding that these available safety measures are insufficient to reduce heat stress at workplace. This further leads to decline in the productivity of the workers in the hot working environment.

People who live in peri-urban areas are more vulnerable to heat stress compared to the rural areas (Depietri et al. 2013). Their thermal comfort level is being compromised because of the higher indoor temperature due to housing structure (Franck et al. 2013) (see S 1) and unavailability of cooling equipments. While, in rural areas, although people have comparatively large houses with more than three rooms and a proper ventilation system, they still face discomfort because of the more unscheduled electricity load shedding than urban areas during summer.[2] Due to these reasons, people from both sites usually feel discomfort while sleeping at night during summer. In addition, the use of excessive amount of drinking water and frequent bathing are the most common practices at both sites to prevent heat stress.

Beside that, low-income communities have to work continuously for the whole day without break to secure their income (Khan et al. 2013). In addition to this, the coping measures provided by the employer are insufficient (Park et al. 2015). None of the employees is provided with health insurance policy or first-aid health facility to immediately respond to heat stress at the workplace.

People of Faisalabad district are aware of heat stress and its impacts on livelihoods. More specifically, around half of the respondents from both sites reported that their livelihoods were affected by heat stress (Garg et al. 2017). Farming community reported that self-assessment and information broadcast by electronic media are the most common sources of information about coping with heat stress. While talking about the preventive measures, people usually adopt the traditional measures (Gao et al. 2018); they do not have the proper knowledge and economic resources to adopt new technologies and tools to prevent heat stress. Increase in temperature, decline in precipitation, increase in humidity, increase in the frequency of heat stress, and extreme-climate events as a result of climate change affect the livelihood of the people (Adhikari et al. 2015). Poor people are the most vulnerable to any climatic and socio-economic stresses (Hope 2009). Migration is considered as an adaptation strategy to reduce the livelihood (economic) vulnerabilities of climate change (Salik et al. 2017). Around 83% of peri-urban respondents reported that livelihood opportunities have shrunken at their previous location. Climate change impacts on agriculture production could be one of the reasons behind the shrinking of livelihoods (see Fig. 6). It is evident from the literature that benefits of migration outweigh its costs (Mueller et al. 2014; Scheffran et al. 2012). People become able to improve their level of income as they migrate from deprived rural areas to urban areas (Farooq et al. 2005).

[2] Unscheduled load shedding taking toll on public in Faisalabad, can online be accessed at: https://nation.com.pk/10-Aug-2017/unscheduled-loadshedding-taking-its-toll-on-the-public-in-faisalabad.

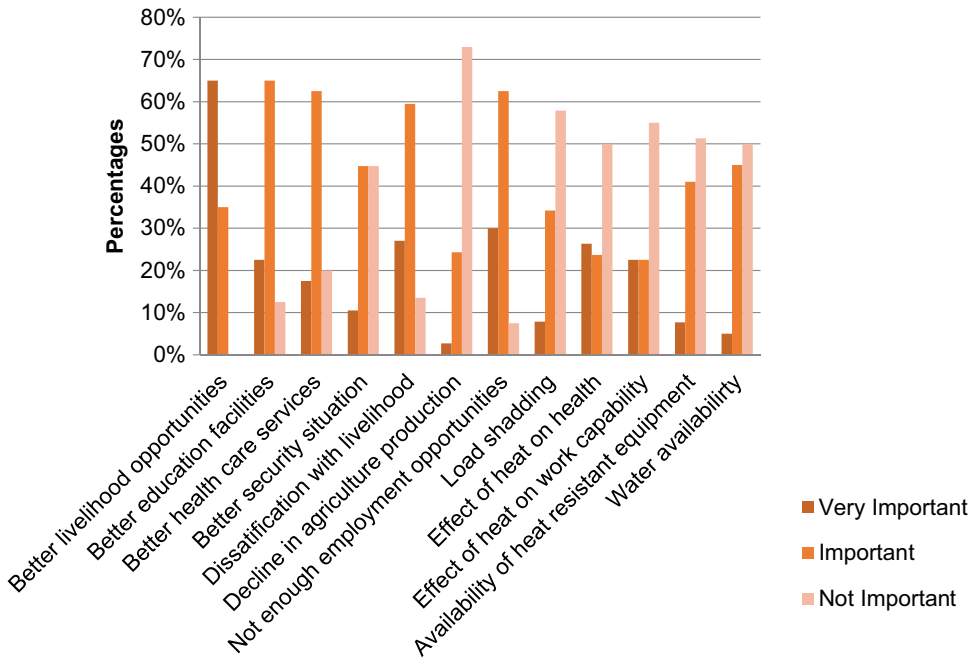

Fig. 6 How important the following reasons are in migration decision (peri-urban)

Although migration provides an opportunity to improve the level of income of the migrants, however, in urban/peri-urban areas, access to better livelihood opportunities is highly dependent upon level of education and skills (Khan et al. 2013). Our results show that the rural poor having a low level of education and skills have only been able to improve their livelihoods to a limited extent (De Haas 2010). Owing to this, majority of the rural labor migrants have low-income status and lives in peri-urban areas because of the high cost of living in urban centers (Sect. 3.2). As a result, they become more exposed to heat stress at their workplaces as well as at home, because they face high indoor temperature in less spacious houses and less green areas (Franck et al. 2013).

5 Conclusion

This study demonstrated that the numbers of heat-wave events are very likely to increase in future under the business-as-usual scenario. As a consequence, the people's vulnerability to heat stress would increase. They become more exposed to heat in terms of physical stress as well as its impact on livelihood. Poverty is found to be one of the key barriers to adaptation to heat stress. People have to work continuously in a hot environment to earn a livable income, as a result of which their productivity reportedly declined. Furthermore, lack of professional skills and education reduces the workers' ability to find a profitable and environmentally secure profession.

In the absence of an appropriate skill set, peri-urban labor force becomes more vulnerable to heat stress because of their lower living standard in peri-urban areas. Furthermore, we have found that improvement in thermal comfort level is highly dependent on the level of income, type of work, and availability of heat-resistant equipments.

On the basis of our findings, this study proposed the following policy measures:

- As we found in this study, improvement in thermal comfort is dependent on the level of income. Level of education and professional skills are the key to improve livelihood and level of income. For this reason, there is a need to invest in human capital of rural as well as of urban poor (to improve their skill, education, capacities, etc.) for better and effective labor productivity and professional development.
- There is a need to ensure the implementation of the labor laws to reduce their vulnerability and to provide them a safe and secure working environment. Furthermore, as we found that rural migrants are only able to improve their income to a limited extent, there is a need to enforce minimum wage rate, thus enabling them to earn more and to become resilient to heat stress at both home as well as at work place.
- Due to budgetary constraints, this study focused only on 80 households (40 from rural and 40 from peri-urban) to understand the differences in exposure, impacts, and responses to heat stress. To get more into the subject, it would be appreciative to do similar work with more number of household participation in the survey as well as the

use of scientific tools to measure indoor and outdoor temperature.

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Compliance with Ethical Standards

Conflict of Interest Statement On behalf of all authors, the corresponding author states that there is no conflict of interest.

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