Abstract

Climate change and urbanization are continuously increasing their impacts on human society by acting synergistically to increase heat exposure, especially in urban societies. The climate change projection and the urbanization projection predicted that both of these phenomena will keep on increasing in the next coming decades. Like many other countries of the world, Pakistan is also in a tight grip of climate change. Urban growth is expanding in the major cities of Pakistan. Among different provinces of Pakistan, Punjab is the most populous province. The economic growth in Punjab works like a magnet which strongly influences the push and pull factors of urbanization in this province. To conduct the heat vulnerability assessment on firm grounds a deep understanding of vulnerable causing factors is very essential. This research has probed deeply into the extreme heat exposure of the populations in Lahore, Multan & Murree. It has developed a time series of the historical heat exposure in these regions by defining the extreme heat exposure as the daily average temperature ≥ 90th percentile of the yearly temperature. The maximum and minimum temperatures were also explored to get uniformity in understanding the historical heat exposure. The time series generated in this research clarified that extreme heat exposure of all three study sites has increased as compared to the heat exposure in the past 30 years.

The focus of this thesis was the determination of the heat vulnerability index (HVI) for Lahore, Multan and Murree which represent different climatic conditions in Punjab. While synthesizing the heat vulnerability index a careful exploration of vulnerability causing situations, selection of vulnerability framework and selection of vulnerability indicators were done sequentially. The principal component analysis with orthogonal rotation resulted in the respective principal components of vulnerability in Lahore, Multan and Murree which were then extracted to the specific polygons of each region. The vulnerability in Lahore generated two Principal components named as S*ocio-economic & Environmental component* (43.02% variance) and the *Sociodemographic & minority* (27.04% variance) both of them resulted in a 70.40% variance. Multan also resulted in two components named as *Environmental & Urban component* (43.62% variance) and the *Socio-demographic* component (30.85 % variance) with total variance explained as 74.47% variance. Just like the number of extracted components in Lahore and Multan, Muree also resulted in 2 components of vulnerability named as *Sociodemographic & Urban component* (50.05 % variance) and the second component was *Environmental & demographic* (22.84 % variance) with total variance explained as 72.89% variance. The ArcGis 10.22 was used to generate the spatial display of principal components and the heat vulnerability indexes. The heat vulnerability indexes developed for Lahore, Multan and Murree indicated that highly vulnerable communities were centrally configured and the less vulnerable populations were present around the periphery of the study areas. The social components were found more responsible for manifesting vulnerability. While addressing the public health-related heat interventions, especially in the resource deficient countries the targeted approach is needed to respond to the emergent heat exposure-related situations. The targeted approach is needed to ensure that populations who are under extremely vulnerable conditions can get more benefits. The hot spot analysis in conjunction with HV-Index provides a statistically driven geospatial distribution of extremely vulnerable populations under various scenarios of vulnerability causing indicators. This research has explored the hotspot analysis along the overlay analysis to spotlight those populations which are more deserving for heatrelated

health interventions. The indicators specified overlays of hotspots and high classes of vulnerability were also mapped.

To understand the heat-related health concerns the incidence of kidney stone patients all around the year (Jan-Dec) for five years was statistically checked for correlation with various environmental parameters. It was found that temperature was the most highly responsible factor in explaining the incidence of kidney stone patients in selected hospital records of Lahore Multan and Murree. To further elaborate on the environment heat exposure and health-related outcomes, the urological examinations of calcium stone patients before and after the heat stress period in both males and females were conducted. The urological health conditions were found more distressing during heat stress periods (June) as compared to the non-heat stress periods of the year (February).

As this research has grasped the environmental heat-related multiple aspects at a broader scale and has tackled them refinery by integrating various datasets and literature driven statistical procedures so this research can be very helpful in different fields of life. It can put forward various useful policy options and it may pave the way for further elaboration of the heat vulnerability index in various provinces and cities of Pakistan especially concerning public health and policy options.