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Effects of Climate Change and Heat Waves on Low Income Urban Workers: Evidence from India[1]

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Introduction

A heat wave is an extended period of hot and humid weather measured relative to the normal weather pattern of an area (Meehl and Tebaldi 2004). The frequency and duration of heat waves have gone up with climate change, and the world is facing hot days, hot nights, and heat waves more frequently (IPCC 2007a). Heat waves are a health hazard as they slow the evaporation of perspiration, which cools the human body. The human skin temperature is strongly regulated to remain at 350 C or below, under normal conditions (Sherwood and Huber 2009). The skin temperature has to be lower than the core body temperature (370 C) for metabolic heat to be transmitted to the skin. Sustained skin temperature above 350 C due to heat waves elevates the core body temperature, causes tiredness, nausea, body ache, etc., and thus, reduces the person's work efficiency.[2] High temperatures can pose serious threats to all individuals, not necessarily the old and the unwell; hence every possible effort should be made to maintain one's skin temperature at around 350 C (Mehnert *et al.* 2000; Bynum *et al.* 1978). Heat waves are being experienced with increasing frequency in different parts of the world (Das and Smith 2012; IPCC 2007b, 2014) and people are resorting to various adaptive measures to reduce the adverse effect on health. The present paper discusses some such measures adopted by poor urban informal sector workers and accounts for the loss suffered and costs incurred by them in some parts of India.

Heat Waves and Urban Labour Market

There is seasonality in the rural work pattern, which may help rural workers by reducing their exposure to extreme heat during heat waves. But urban workers in secondary or tertiary sector activities – which are little influenced by weather, continue yearlong, and occur in poor and exposed environments – are more vulnerable to weather-related hazards like heat waves that continue for a few days. Other than the health implications on the working poor, such climatic changes may impact labour supply and productivity, particularly in labour-intensive activities.

There is much discussion in the labour economics literature on the labour-leisure model of unemployment. Using micro-data, the inter-temporal labour-leisure elasticity of substitution is estimated to be 0.2 (McCurdy 1981). Labour substitutes labour for leisure usually under external stress, like the presence of consumption commitments (for example, expenditure associated with children such as food and schooling). Short-run wage declines also motivate workers to increase short-run market hours to maintain cash flow (Dau Schmidt 1984). Now, the question arises: how is this income induced labour-leisure substitution being affected by exogenous stress from heat waves, which may impose multiple constraints on the worker (like low-income due to both less availability of work and low productivity due to heat effect on health, high expenditure to adapt to extreme heat, etc.)?

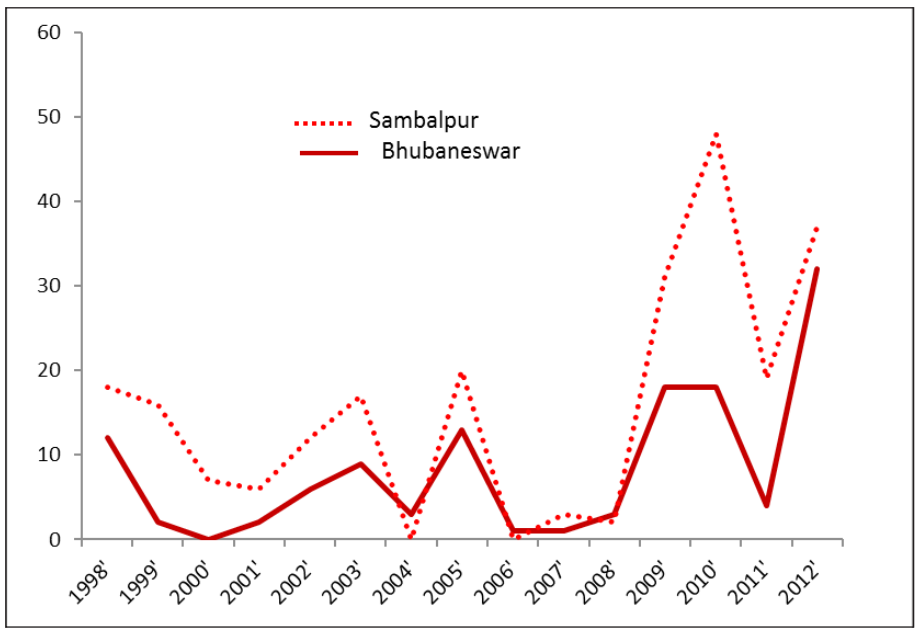
During the peak hot hours of heat wave days, workers may withdraw from the market, or there may be fewer customers than usual; therefore, workers may earn less. To offset this loss, workers may like to work longer, but may not be able to do this if the type of work provides little scope for such substitution,[3] or the thermal stress is strong enough to force him/her to rest more. Poor health reduces the capacity to work and has significant effects on wages (Currie and Madrian 1999). In this light, one may presume that heat-affected workers may not be able to work longer, and, therefore, might earn less. If income recovery is not possible, then the person is forced to remain at a lower level of wellbeing. The loss of income and the additional expenditure, if any, to cope with the extreme heat can be a measure of private adaptation cost, especially for self-employed people or informal sector workers. Many of the developing countries, especially in South Asia, are poised for faster growth, which involves large-scale construction and other exposure-based activities. If the present trends in temperature continue, this may involve large increases in private and public expenditure on adaptation, more provision of electricity, change in technology and work environment, etc. There is little research on these issues, though the research findings are likely to have strong policy implications.

Focus of the Study

In this paper, an attempt is made to find out the burden in terms of working hour loss, loss in family work time, and monetary cost incurred by low-income urban

informal workers because of severe heat waves in two cities of Eastern Indian state of Odisha – Bhubaneswar and Sambalpur. These two cities, along with most of the rest of the state, have been witnessing severe heat waves since 1998, and both the people and the government have been adopting various strategies to cope.[4] The heat wave management efforts of the government have recorded some success in terms of reducing mortality (Das and Smith 2012; Das 2014). Based on daily maximum temperature recorded with the local meteorology stations, Das and Smith (2012) measured the yearly heat wave days for different areas of the state, including these two cities, for the period 1998 to 2012 (Figure 1). Clearly, heat wave days are increasing over years and, on average, it calculates 12 heat wave days per year for these two cities.

Figure 9.1: Annual Counts of Heat Wave Days in Bhubaneswar and Sambalpur, Odisha



Source: Das and Smith, 2012.

Most workers in this study who are exposed to heat are in a sense, own-account enterprises in trade, transport and services activities and who, unlike the service class, make their own independent labour allocation decision to maximise utility. Gronau (1987) provides an excellent review of studies on home production. Work at home is said to be a close substitute to work in the market in terms of the direct utility these activities generate. However, to understand these issues at the household level, time budget data are required, which this study attempts to collect through a questionnaire survey.

A primary survey based on purposive random sampling was pursued in these areas, to get responses to the questionnaire. An attempt was made to find out the time allocation of people to different activities during a day (7 am to 11 pm) and other queries like if people suffered from any type of heat attack, changed their occupation because of heat, know of the government's heat wave awareness campaign, their expenditure to cope with extreme hot temperature, and so on. This is an exploratory study to find out the prevalence of the problem and its effect, if any, on labour supply. Therefore, most questions on labour allocation were phrased to be indirect, such as 'What do you do during 7 am to 9 am now (i.e. yesterday)?' and not 'What do you do during 7 am to 9 am during a heat wave day?' The interview was conducted during peak summer (not heat wave), and the area had experienced a heat wave two weeks before, so incorrect reporting for heat wave days are supposedly low. The sample survey section describes in detail the procedure followed to collect the time allocation data.

The sections below present some theoretical literature on heat stress and labour supply issues followed by the sample survey, the descriptive statistics of the sample, the results and then the adaptation cost estimates. The last section concludes.

Heat Stress and Labour Supply

The effect of climate change on labour supply has been discussed in terms of labour availability constraints in vulnerable regions because of the migration of labour from vulnerable areas to less vulnerable areas.[5] Regular heat waves may have no effect on total labour availability in a region; as such phenomena do not induce migration, but are likely to constrain labour productivity by restricting the individual's ability to work efficiently due to unbearable weather. Heat stress may alter the marginal productivity of labour or the marginal cost of supplying labour to activities where the individual is exposed to heat. Thus, under a heat wave scenario, one expects change in workers' decision regarding the allocation of time from labour to rest, especially in exposed sectors, such as agriculture, construction, manufacturing, etc. (Zivin and Neidell 2010). Studies show that marginal productivity of labour gets impacted by lower endurance, fatigue (Gonzalez-Alonso *et al.* 1999; Galloway and Maughan 1997; Nielsen *et al.* 1993), and cognitive performance (Epstein *et al.* 1980; Ramsey 1995; Hancock *et al.* 2007; Pilcher *et al.* 2002), etc., and heat stress can cause all such health effects. Studies under ergonomics have also established a strong association between productivity loss and rise in temperature (Niemelä *et al.* 2002; Lan et. al. 2010; Mahamed and Srinavin 2005).[6] Simultaneously, the marginal utility from leisure activities may go up during peak heat (Ma *et al.* 2006; Pivarnik *et al.* 2003; US Department of Health and Human Services 1996; Eisenberg and Okeke 2008) triggering the leisure-work substitution. This may have serious welfare implication for people, especially for low-income workers for whom every hour of work matters. The link between external shock from heat waves and the

wellbeing of poor labour class is yet to be explored in detail, though there are plenty of studies on the effect of heat waves on human health, especially in epidemiology (Kovats and Hajat 2008). Based on an aggregative analysis on temperature and labour supply at the level of counties, a careful analysis by Zivin and Neidell (2010) showed large reductions in labour supply in climate-exposed industries in the US as the temperature rose over 85° F. Secondly, at higher temperatures, unemployed people reduced outdoor leisure activity; this shows their preference to stay indoors during heat waves. Effective labour supply – defined as a composite of labour hours, task performance, and effort – is found to decrease during temperature deviations from the biological optimum, according to a study that uses country-level panel data on population-weighted average temperature and income (1950–2005) to illustrate the potential magnitude of this effect (Heal and Park 2014). The present paper uses individual level questionnaires survey data and is based on a developing region where the effect could be much stronger. Thus, the present findings are likely to provide complementarities to the evidence found from developed economies.

Beyond labour-leisure substitution, another setback could be a longer absence from home on heat wave days. This could take one of the three forms: (1) leave home earlier than usual; (2) return home late to avoid travelling in the scorching sun; or (3) work overtime in the evening or at night to recoup the loss in income during the usual working hours. This means being unable to help in housework. Such absence may be very high, especially for those who live far from work, and their family members may suffer more compared to others because of heat waves. The effect of heat waves on family work is less talked about, as it is usually considered a part of leisure activities in labour allocation studies. This study accounts for the time explicitly allocated to house. The study focuses on very poor self-employed workers whose family do all household related works manually because of low income and family members help each other. If a member is away from home for long, other members of the household are likely to be over-burdened. While losing time for housework may not reduce income, it may have utility implications, as the utility from housework is different from the utility from rest.

The labour class reallocates time between labour and leisure to maximise welfare because of the income effect. During heat waves, a reversal of such allocation may occur because either leisure provides more utility, or because the likely health effect of working long hours under heat wave conditions will be too adverse, and require a lot of medical expenditure, which may have serious economic implications. Therefore, during heat waves, workers allocate time to different activities to minimise the negative impacts of heat stress on health. Thus, the choice of activity and location, i.e. whether to work at home or at work (place) or spend time under a shady tree (rest), as happens in underdeveloped countries, is undertaken rationally to minimise the negative impact of temperature by reducing the exposure to hot weather. I take the hypothesis that workers reallocate time between work, rest and time spent on housework to minimise the negative impact of heat waves on health.

Any marginal change in time required for rest will impact the time allocated to housework or outside work depending on the seriousness of the heat wave. The income effect of outside work being very strong for poor people, the individual will first reallocate time from housework to rest, but ultimately may reduce outside work time, as the scope of reducing housework may not be great. As, usual, housework takes a few hours every day, and some of it (like cooking or helping in cooking, buying groceries, etc.) is important and cannot be ignored, the individual will be forced to allocate more time from economic work to rest if heat stress requires more rest. On a heat wave day, the primary objective of the worker is to minimise the negative health effect of the heat wave; therefore, rest assumes utmost importance, and work at home and outdoors is adjusted to ensure enough rest. The temperature anomaly determines the hours of rest needed and thus determines the labour allocation decision on the heat wave day.

Sampling and Survey

A purposive random sampling was conducted in Bhubaneswar and Sambalpur – two cities in Odisha affected repeatedly by heat waves – to collect information on adaptation to heat stress by poor urban workers. Ten types of urban workers from the low economic strata who work mostly in the open environment were chosen: vegetable/fruit sellers, cobbler, construction workers, porters, rickshaw/trolley driver, auto rickshaw driver, taxi driver, mobile marketing and sales executive/representative, vendors (mobile sellers of household items in trolleys), and owner and workers in open-air retail enterprises (temporary stall owners).

The sample was taken from comparatively crowded and backward market areas of the cities, like areas close to railway station, bus stop etc., as workers in these areas are poorer. The sample was drawn randomly by picking 15 workers from each of these 10 categories. The questionnaire-based survey was conducted simultaneously in both cities in 2013 between 25 April and 20 May, when the temperature was around 42–430 C in Sambalpur and 400 C in Bhubaneswar, but it was not a heat wave period. It is considered a heat wave when the temperature is around 450 C in Sambalpur and 420 C in Bhubaneswar, which occurs many times during the summer and occurred around 15 April 2013 also. As reported before, answers to most of the questions on time allocation to different activities for a heat wave day were elicited through recall. The temperature was already high, and people were asked what they did in each two-hour period (7–9 am, 9–11 am, etc. going up to 9–11 pm) the previous day and what they did on the heat wave day (using the local name for heat waves) they experienced around 15th April that year; therefore, it is hoped that people's answers were mostly accurate. The survey listed workers' activities during each two-hour period between 7 am and 11 pm for these two days (the day before the interview date (a normal summer day) and the heat wave day two weeks before), and then grouped the activities into 'rest', 'house work', and

'outside work'. Next, the hours spent on each of these three groups of activity were counted to measure the time allocation on a normal summer day and on a heat wave day. Along with time allocation, work related and biographical information, the survey also collected information on purchase of consumer durables and other expenditures to cope with heat stress and differences in regular day-to-day expenditures between heat wave days and normal summer days.

Sample Features

The sample comprised mainly middle-aged people and was dominated by men. In the study area, occupations surveyed are usually undertaken by males, so the sample had just 6 per cent female respondents. There was a mix of different education levels in the sample; most respondents were educated up to Class 10. Most of the uneducated respondents were either cobblers, or rickshaw drivers, or retail sellers; whereas mobile marketing and sales executives were graduates with one or two degrees. Only 4 per cent of the sample had some technical education like motor garage work, driving, electrical training, and so on.

On social class distribution, 18 per cent belonged to the general class, 43 per cent were backward classes, 30 per cent belonged to the scheduled caste, and 9 per cent to scheduled tribes. The family size was 5.17 members on average, although some families had as many as 18 members. On average, most families had 3.5 dependents. Most respondents were migrants; only 29.3 per cent were born in these cities. Around 75 per cent of the respondents were household heads.

Table 1 shows the distribution of different occupation class in the sample based on annual income range. The modal annual income of respondents was between INR 50,000[7] and INR 100,000, which includes the incomes of 52 per cent of the respondents. Some were very poor (1 per cent), with an annual income of less than INR 10,000, and some were relatively well-off (1 per cent), with an annual income of more than INR 300,000.

The cobblers were the poorest – 45 per cent made less than INR 20,000 annually – followed by porters or manual labourers in transport and other sectors. Mobile marketing and sales executives made INR 50,000–100,000 annually at the least and were the richest in the sample; 80 per cent of them made INR100, 000–300,000 annually.

Health Problems from Heat Waves

Some workers reported that heat waves caused them many health problems, like fever (15 per cent), tiredness (12 per cent), respiratory problems (8 per cent), losing consciousness (5 per cent), blurred vision (8 per cent), feeling of nausea (10.3 per cent), and body ache (4 per cent), etc., though most of them had no prior history of health problems. Of the respondents who reported health problems, most were cobblers, porters, rickshaw pullers, or auto drivers; there were few marketing and

sales executives. Hospitalisation due to heat attack was reported by 15 per cent of workers, of which 50 per cent were either porters (18 per cent), or rickshaw pullers (16 per cent) or cobblers (13 per cent), and the rest from other categories. This clearly indicates that the major victims of heat attack are in the lowest income categories having more exposed occupations from among the low-income workers. Only 2.3 per cent of the respondents reported changing their occupation, in fact their mode of working, because of heat. They reported to have changed their work from mobile vending to stall vending at roadside like 'from selling eggs or other products at door step to selling tea or sugar cane juice at a fixed place'.

Table 9.1: Distribution (per cent) of the Sample According to Occupation and Income Class

Occupation	Annual Income Class (in INR)					
	Less than 10000	10000 - 20000	20000 - 50000	50000 - 100000	100000 - 30000	Above 300000
Vegetable/Fruit Seller	0.03	0	0.43	0.47	0.07	0
Cobbler	0.10	0.35	0.13	0.29	0.13	0
Construction Worker	0	0.03	0.63	0.33	0	0
Porters (Manual Labour in Transport or Other sectors)	0	0	0.38	0.62	0	0
Rickshaw/Trolley Drivers	0	0	0.53	0.43	0.03	0
Auto Driver	0	0	0.13	0.55	0.32	0
Taxi Driver	0	0	0.13	0.73	0.13	0
Mobile marketing and Sales executive	0	0	0	0.13	0.80	0.07
Vendors (Mobile sellers of HH items in trolleys)	0	0	0.04	0.93	0.04	0
Owners & workers in open retail enterprises	0	0.06	0	0.74	0.19	0
Total	0.01	0.05	0.24	0.52	0.17	0.01

Effect of Awareness Programmes on People

Since 2003, the Government of Odisha has been conducting an awareness programme on what to do during heat waves and the things to avoid (see Appendix for detail). When asked if they knew of the programme, find it useful, and if they have taken the advice, around 99 per cent said they knew of the programme. The source of information was radio (63 per cent), newspaper (64 per cent), television (73 per cent), pamphlets (31 per cent), volunteers (18 per cent), neighbours (14 per cent), and NGOs (12 per cent), etc. Most had received the information from multiple sources; 83 per cent from maximum three sources[8] (either radio, or television, or newspaper or pamphlets), 13 per cent from two sources and only 4 per cent from only one source.

Around 93 per cent of the respondents found the government campaign very helpful and 99 per cent reported to have changed some of their habits during heat waves because of the campaign. On average, it was found that during heat waves, 73 per cent of respondents drink water and 65 per cent eat cucumber and onion before leaving home; 63 per cent carry a water bottle; 64 per cent carry an umbrella, 26 per cent wear light-colour cotton clothes; 21 per cent do not walk barefoot; and 33 per cent do not work during noon hours. Though the behavioural changes because of the campaign seem high, one does find a lower response rate for the ones involving more expenditure. It may be that poor economic condition restricts people from buying cotton clothes, walking slippers, or skip work during noon. Thus, the sample seemed to be a mixture of people who had experienced and suffered heat waves and who had taken some precautions to avoid health problems from subsequent experience due to awareness campaign. The impact of heat waves on labour supply of this informed and adapted working class is net of adaptation and thus, should be more useful for policymaking.

Results

Summary Statistics on Time Allocation

Workers allocate time differently on a heat wave day than on a normal summer day, and because of heat stress, they lose time (Table 2). It shows that workers have rested longer and spent less time on both outdoors work and housework, which, perhaps, is the first finding from the real life experience of poor workers in a very poor and deprived part of the world. On average, 1.19 hours of work time and 0.46 hours of family time were lost per heat wave day, as workers reallocated these hours to rest because of heat stress.

Table 9.2: Change in Time Allocation and Work Time Loss on Low-income Category Working Class Because of Heat Waves

Occupation	Change in average time allocation during a heat wave day compared to normal summer day (in hours)		
	Regular outside work	House work	Rest
Vegetable/Fruit Seller	-0.73	-0.22	0.95
Cobbler	-1.23	-0.47	1.70
Construction Worker	-1.54	-0.38	1.93
Porters (Manual Labour in Transport or Other sectors)	-1.62	-1.02	2.64
Rickshaw/Trolley Drivers	-1.65	-0.52	2.17
Auto Driver	-1.06	-0.21	1.28
Taxi Driver	-1.52	-0.68	2.2
Mobile marketing and Sales executive	-0.74	-0.37	1.1

Vendors (Mobile sellers of Household items in trolleys)	-1.26	-0.18	1.44
Owners & workers in open retail enterprises (Temp Stall)	-053	-0.58	1.11
Average change	-1.19	-0.46	1.65

This has very serious implications for poor workers who live from hand to mouth. Rickshaw drivers lost the most work time (1.65 hours), followed by porters (1.62 hours), construction workers (1.54 hours), taxi drivers (1.52 hours), etc., but the time lost is less for temporary stall owners (0.53 hours), vegetable sellers (0.73 hours), and sales executives (0.74 hours). This could be because temporary stall owners and vegetable sellers work either in the morning or late in the afternoon, and sales executives, who are comparatively well off, probably take better precautions so that they do not lose more work time. As expected, time loss from housework is low, as these activities require some minimum amount of time and such time required cannot be changed much, as explained before.

One may expect these people to compensate such loss by working longer other days, but the possibility of such adjustments are low due to many reasons. First of all, this extra rest is to neutralise the negative effect of heat on human body and these people have no luxury at home to recover quickly from such stress. Many reported 'not being able to sleep at night', 'feeling tired', 'irritated', 'having low motivation to work due to stress' etc. as other side effects of heat waves. So, over-exerting, as they all do manual job, to compensate for this loss of work time is difficult.

Cost of Adaptation

Next, private cost of adaptation is measured as income loss due to work time loss plus extra expenditures made to cope with the heat waves. As discussed above almost every respondent was aware of the awareness programme of the government and many had reported to have changed their behaviour, food, etc. and thus loss of work time is after the possible adaptations that each worker has undertaken. So loss of income from work time loss was added to extra expenditures. Extra expenditures information was collected on two heads: (i) on regular items like food, electricity, water, transport (either own or children's transport to school) etc. and (ii) on consumer durables like purchase of ceiling fan, water coolers, etc. made to cope with high temperature.

Expenditures on Non-durable Regular Items

Nobody could recollect the exact extra amount spent on regular items on heat waves days, but could report the approximate increase in expenditures on these heads in the month when heat waves were experienced. Hence using monthly expenditure differences, I calculate increase in expenditure on consumer non-

durable goods per heat wave day. Table 3 shows these extra expenditures for different worker categories. All categories of workers are spending more on regular items in months with heat wave days compared to months with no heat waves, the average extra expenditure being INR 600, varying in between INR339 to INR810 for different groups. These extra expenditures constitute 4 to 15 per cent of the monthly income for different category of workers who earn approximately INR 85833 per annum or INR 7152 per month (approximately US$119). Spending 15 per cent of income by some workers to cope to heat waves in a month is too high a burden. As heat waves are felt during two months (mid-April to mid-June) in Odisha, the average numbers of heat wave days in a month are taken to be 6 (see section 1.2 above) and this calculates the extra expenditure on consumer non-durable goods to be INR 100 per heat wave day, which is 1.4 per cent of the monthly income.

Table 9.3: Economic Burden in Terms of Extra Monthly Expenditure on Food and Other Routine Items by Low-income Working Class Because of Heat Waves

Occupation	Average approximate annual income (in INR)a	Average increase in monthly routine expenditure due to heat wave days (in INR)b
Vegetable/Fruit Seller	63667	810 (0.15)
Cobbler	57903	597 (0.12)
Construction Worker	47667	450 (0.11)
Coolie (Manual Labour in Transport or Other sectors)	59828	597 (0.12)
Rickshaw/Trolley Drivers	57833	557 (0.12)
Auto Driver	110161	694 (0.08)
Taxi Driver	86333	612 (0.09)
Mobile marketing and Sales executive	200000	693 (0.04)
Vendors (Mobile sellers of Household items in trolleys)	78036	339 (0.05)
Owners & workers in open retail enterprises (Temp Stall)	95323	639 (0.08)
Average for all groups	85833	601 (0.08)
Average extra expenditure per heat wave day		100 (0.014)

a. Annual income was measured from mid values of income categories to which each worker belonged to.

b. Figures in parenthesis are the proportion of monthly income.

Expenditures on Consumer Durable Items

Regarding purchase of consumer durables, I use those purchases as adaptive expenditures where the respondent reported regular heat waves as the most important reason for such purchase.[9] Moreover, the source of money was stated as 'saving plus borrowing' by almost everybody who made such purchases due to heat waves and the year of purchase was either 2006 or afterwards. After 1998 heat waves, the state witnessed very intense heat waves during 2005 when more than 500 people died (Das and Smith 2012 and Figure 1) and this incident seems to have triggered these purchases. The costs of these durable consumer goods were annualised using the equivalent annual cost (EAC) method as shown below:

$$Annual\ Cost = \frac{P_i}{\frac{1-[\frac{1}{(1+r)^n}]}{r}}$$

where Pi is the price of the ith consumer durable, n is the possible life span of the commodity and r is the rate of interest which is the cost of borrowing. I used 8 per cent rate of interest to annualise the expenditures, though it could be much higher as people could be borrowing money from private sources. Thus, the annualised costs are the underestimates of actual costs. The information on life spans of these goods were also asked from the workers, but these information for some of the globally used goods like ceiling fans, refrigerators etc. also match the standard life expectancy chart of household goods reported by different home inspection experts.[10] Table 4 shows these calculations. As the proportion of the sample undertaking such activities varied widely from activity to activity, a weighted average of the annualised average cost was calculated using sample proportions as the weights to get this estimate for a representative worker.

Table 4 shows the annual averted expenditure on consumer durables to be INR 592 per sample household in a year, which works out to INR 49 per heat wave day. Adding extra expenditure on both durable and non-durables, the adaptation cost calculates to INR 149 per heat wave day or INR 1788 per year, as there are approximately 12 heat wave days in a year in the state. Using the approximate annual income and the number of hours worked during normal summer, the average hourly income was calculated to be INR 38 and loss of income per heat wave day as INR 46. Thus, the private adaptation cost of a low-income informal sector worker measures to INR 195 per heat wave day or INR 2340 per annum of which 51 per cent consists of extra expenditure on food, electricity bills etc., 25 per cent on consumer durable goods and 24 per cent is income loss due to requirement of more rest.

Table 9.4: Annualised Averted Expenditures on Consumer Durable Goods Due to Heat Waves

Type of heat wave averted activities at home	Sample proportion who reported to have undertaken these changes due to heat waves	Average cost of the activity or the materials used (in INR) (Alphabets in parenthesis are sources of money)	Possible life span used	Annual average cost of the activity using Eq. 10 (in INR)
Wipe floor repeatedly using cooling ingredients	0.33	320 (S)	One Years	320
Put thick layers of paddy straw on roof to stop transmission of heat	0.54	482 (S+B)	One Years	482
Use thick curtains	0.14	503 (S+B)	5 years	126
Insulate walls with paint, mud	0.017	1020 (S)	10 years	152
Purchase fans	0.92	1295 (S+B)	15 years	151.29
Purchase Air/water cooler	0.05	4233 (S+B)	10 years	631
Purchase fridge	0.04	7162 (S+B)	20 years	729.47
Purchase Air Conditioner	0.003	18000 (B)	20 years	1833.34
Weighted annual average for a sample household				592

Note: S: Saving; B: Borrowing

Conclusion

One form of increased temperature due to climate change is a heat wave, which is a continual spell of hot and humid weather for two or three days, and can be lethal (Basu and Jonathan 2002). High temperature impacts economic output through various channels like effect on health, labour productivity, productivity of crops, labour supply, etc. This paper looked into how heat waves affected time allocation between work and rest by altering the marginal utility from time spent on these activities to workers in occupations that expose them to extreme weather. Low-income category urban workers were surveyed in two different cities of eastern Indian state of Odisha, Bhubaneswar, and Sambalpur, where heat waves have occurred regularly during the summer since 1998. The results show that the working class has been seriously impacted by heat waves; they are not able to work as long as they do on a normal summer day and have to spend more on food, electricity, etc. Other health effects have necessitated hospitalisation in some cases.

The results show that workers work 1.19 hours less and spend 0.46 hours less at home, and they rest 1.65 hours longer on average on a heat wave day than on a normal summer day. Work time loss is more for people doing manual work. Other than work time loss, people are found to be spending extra on routine items like food, electricity bills, etc. and undertaking other adaptive measures to cool floor and roof of the house, using thick curtains made of locally grown grasses, buying fans, water coolers, etc. Annualising this expenditure and adding the extra expenditure on routine goods and income loss due to work time loss, per head private adaptation cost of low-income informal sector urban worker is calculated to be INR195 per heat wave day or INR2340 per annum which constitutes 2.7 per cent of their income. Of this amount, 51 per cent is due to extra expenditure on food, electricity bills etc., 25 per cent due to annualised consumer durable expenditures and 24 per cent due to income loss from more rest. As per Government of India estimates, there were 644000 urban informal sector non-agricultural workers in Odisha in the year 2004-05of which nearly 128000 (20 per cent) work in construction, trade and transport sectors to which the present sample mostly belonged to.[11] Extrapolating the private adaptation cost for this group, it estimates to be INR25.12 million per heat wave day or INR3.01billion per annum at 2012-13 prices for the state of Odisha. Using a simple linear extrapolation, one finds the number of heat wave days to increase 2.5 times by 2020 and 3.5 times by 2030, which will put heavy burden on these people. This also means that, in general, labour markets in low-income countries are likely to be seriously affected in terms of both labour supply and wellbeing of the labour class. As more than 50 per cent of the adaptation cost is on food and other routine expenditure, government intervention – in the form of income supplements, subsidised ration, provision of subsidised electricity or increased wages in summer – can help workers cope better with such climate stress.

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Notes

1. JEL classification: J22, J28, Q54, Q58 A more theoretical and extended version of the paper has been published in Climate Change Economics Journal (Das, S, 'Temperature increase, labour supply and cost of adaptation in developing economies: Evidence on urban workers in informal sectors' Climate Change Economics, Vol. 6, No. 2 (2015) 1550007 (24 pages)).
2. Hyperthermia is caused if the core body temperature attains lethal values like 42–43° C.
3. Certain activities are constrained to work within a certain time frame; for example, after the market shuts in the evening, petty traders cannot operate.
4. http://www.osdma.org/ViewDetails.aspx?vchglinkid=GL002&vchplinkid=PL008, and http://www.osdma.org/ViewDetails.aspx?vchglinkid=GL003&vchplinkid=PL013&vchslinkid=SL005&vchtlinkid=TL003, both accessed on 21st April 2014.
5. For details, see the IOM website: http://www.iom.int/cms/envmig; ADB paper: http://www.adb.org/sites/default/files/pub/2012/addressing-climate-change-migration.pdf (accessed on 21st April 2014); UNESCO paper: http://www.unesco.org/new/en/social-and-human-sciences/themes/sv/news/migration_and_climate_change_a_unesco_publication_on_one_of_the_greatest_challenges_facing_our_time/#.UhXh0NKBl6o (accessed on 22nd April 2014)
6. Other comprehensive studies and meta-analyses examine the ergonomics and physiology of thermal stress in humans (Pilcher *et al*. 2002; Hancock and Vasmatzidis 2003; Hancock *et al*. 2007).
7. The exchange rate was US$1 = INR60 during the survey period, i.e. during April-May 2013.
8. Nobody reported receiving information from more than three sources.
9. Many reported different causes for having consumer durables like they had money to buy, received these as gift, received as dowry from in-laws, etc.
10. http://www.nachi.org/life-expectancy.htm, accessed on 12th January 2015
11. http://dcmsme.gov.in/Report_Statistical_Issues_Informal_Economy.pdf, accessed on 10th February 2014.

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Appendix

Dos and Don'ts of Heat Wave Awareness Programme of Odisha Government

Precautions to avoid heat stroke

- Eat enough food and drink enough water before going out.
- Consume different types of liquids like water rice, *belapana, sarbat* (locally available sweet drinks), curd water, ORT solution, watermelon, cucumber etc.
- Carry required amount of water if going out.
- Wear light coloured cotton cloths
- Either avoiding travel during noon or use umbrella, cap, turban, wet towel, shoes and if possible, goggles when walking in the sun.
- If too hot, reschedule your work so as to work more during morning and afternoon and less during noon.
- Remain alert for children, elderly, fat people, pregnant women and persons with high blood pressure, diabetes or epilepsy.
- Do not give water if the person faints due to heat attack.
- Do not take alcoholic drinks.
- Please consult doctor if feeling uncomfortable due to heat.

Symptoms of heat stroke (take the person to a hospital if any of these symptoms are found)

- Feeling of tired.
- Headache, body ache and vomiting.
- Dry throat.
- Blink vision
- Abnormal increase in body temperature.
- Increased palpitation
- Being unconscious