# Heat wave disaster in Bangladesh Classic Case

# I. HEAT WAVE INTRODUCTION

## 1. WHAT IS A HEAT WAVE?

A heat wave is a period of excessively hot weather, which may be accompanied by high humidity, especially in oceanic climate countries. While definitions vary, a heat wave is usually measured relative to the usual weather in the area and relative to normal temperatures for the season. Temperatures that people from a hotter climate consider normal can be termed a heat wave in a cooler area if they are outside the normal climate pattern for that area.

## 2. HEAT INDEX

The heat index (HI) or humiture is an index that combines air temperature and relative humidity, in shaded areas, to posit a human-perceived equivalent temperature, as how hot it would feel if the humidity were some other value in the shade. The result is also known as the "felt air temperature", "apparent temperature", "real feel" or "feels like". For example, when the temperature is 32 °C (90 °F) with 70% relative humidity, the heat index is 41 °C (106 °F). This heat index temperature has an implied (unstated) humidity of 20%. This is the value of relative humidity for which the heat index number equals the actual air temperature.

Heat index has become a matter of concern in the context of Bangladesh climatology along with most other countries. The heat index from 1961-2010 in Bangladesh portrays the significant augment of both temperature and relative humidity in past 20 years. It is obvious that the global warming is responsible for the remarkable increase of maximum and mean temperature during summer. Besides

adverse climatic condition, environmental pollution and the abatement and inconsistency of rainfall results in noticeably rising trend of humidity in north-west, central and eastern region. Evaluating the discomfort and health threat purpose it must be emphasized that both heat and moisture content play significant role in elevated heat index factor of Bangladesh. Mean heat index value ranges from 42-50℃ in different parts of the country in summer.

## 3. IMPACTS OF HEAT WAVE

The impact of heat wave is multifaceted, and the main effects as follows:

- It endangers human health and makes the human body cannot adapt the environment, so this will causes the occurrence or aggravation of the disease, even death.
- Straining the city's water and electricity supplies.
- Affecting plant growth and reduce crop yields.
- Exacerbating droughts.
- Heat wave often makes people agitated, and even may appear the phenomenon of mental disorder. What’s worse, it’s easy to cause public disorder, accident casualties and poisoning, fire and other events.

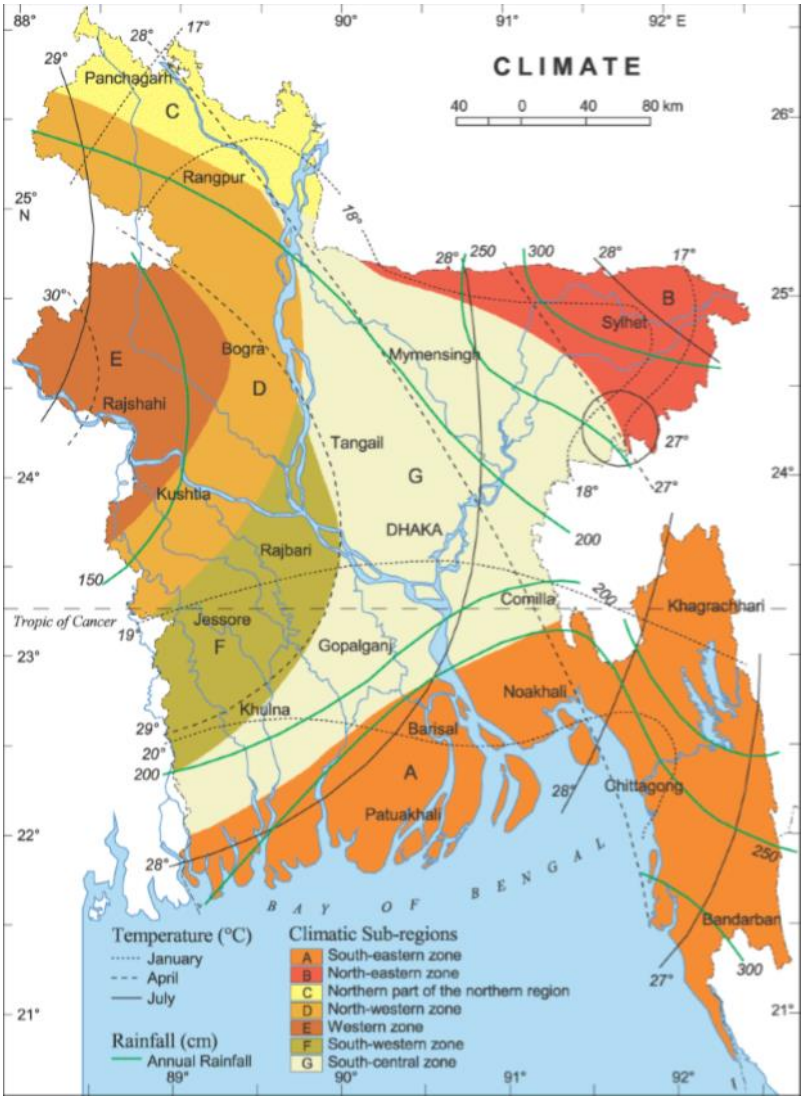
# II. HEAT WAVE IN BANGLADESH

## 1.CLIMATE CONDITIONS IN BANGLADESH

Bangladesh has a tropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures, and high humidity. Regional climatic differences in this flat country are minor. Three seasons are generally recognized: a hot, muggy summer from March to June; a hot, humid and rainy monsoon season from

June to November; and a warm-hot, dry winter from December to February.In general, maximum summer temperatures range between 38 and 41 °C. April is the hottest month in most parts of the country. January is the coolest month, when the average temperature for most of the country is 16–20 °C during the day and around 10 °C at night. Winds are mostly from the north and northwest in the winter, blowing gently at 1 to 3 kilometers per hour in northern and central areas and 3 to 6 kilometers per hour near the coast. From March to May, violent thunderstorms, called northwesters by local English speakers, produce winds of up to 60 kilometers per hour . During the intense storms of the early summer and late monsoon season, southerly winds of more than 160 kilometers per hour cause waves to crest as high as 6 meters in the Bay of Bengal, which brings disastrous flooding to coastal areas. The annual rainfall is about 1,600 mm, most parts of the country receive at least 2,300 mm of rainfall per year. About 80% of Bangladesh's rain falls during the monsoon season. The climatic conditions of Bangladesh are shown in figure 1

**Figure 1**




## 2.HEAT WAVE IN BANGLADESH

The temperature observation data from 2001 to 2017 which come from meteorological stations 419070, 419230 and 419360 in Bangladesh were used to show the general situation of heat wave in Bangladesh in recent years，because these three sites have less data missing.

Statistics of heat wave frequency from 2001 to 2017 which come from station 419070, 419230 and 419360 are shown in figure 2, 3 and 4（The blank is the missing value）。Although the original temperature data exist missing value, statistical figure does not fully reflect the number of heat waves, but it can be seen from the general

trend of the statistical figure that the number of heat waves tends to increase. The number of heat waves observed at the three station in 2010 was very prominent in the adjacent years, indicating that abnormal heat wave weather occurred in 2010.

**Figure 2**

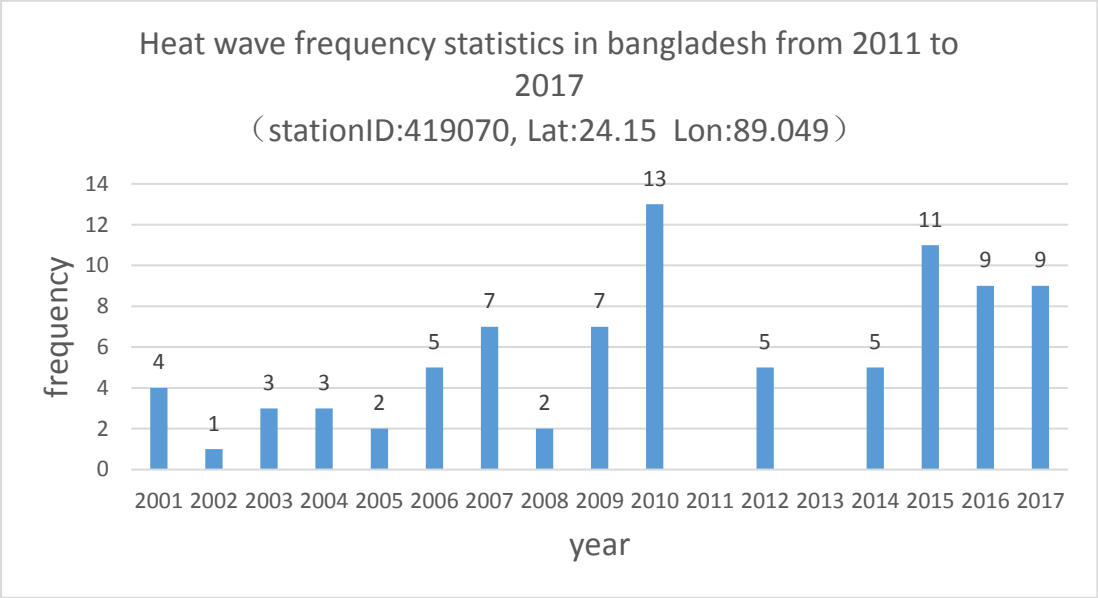



**Figure 3**

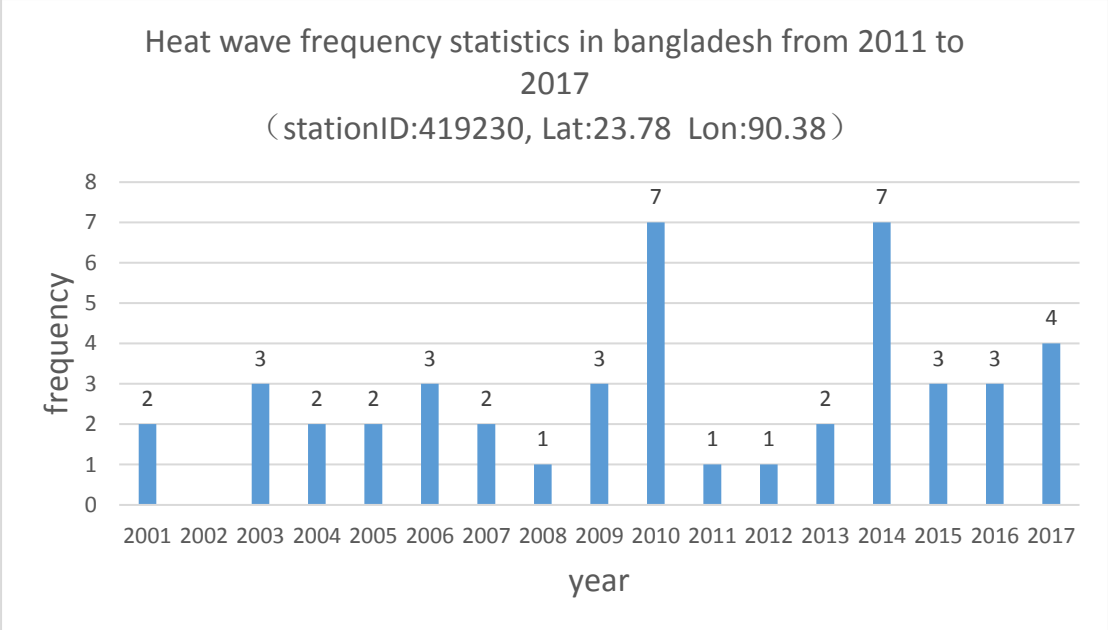
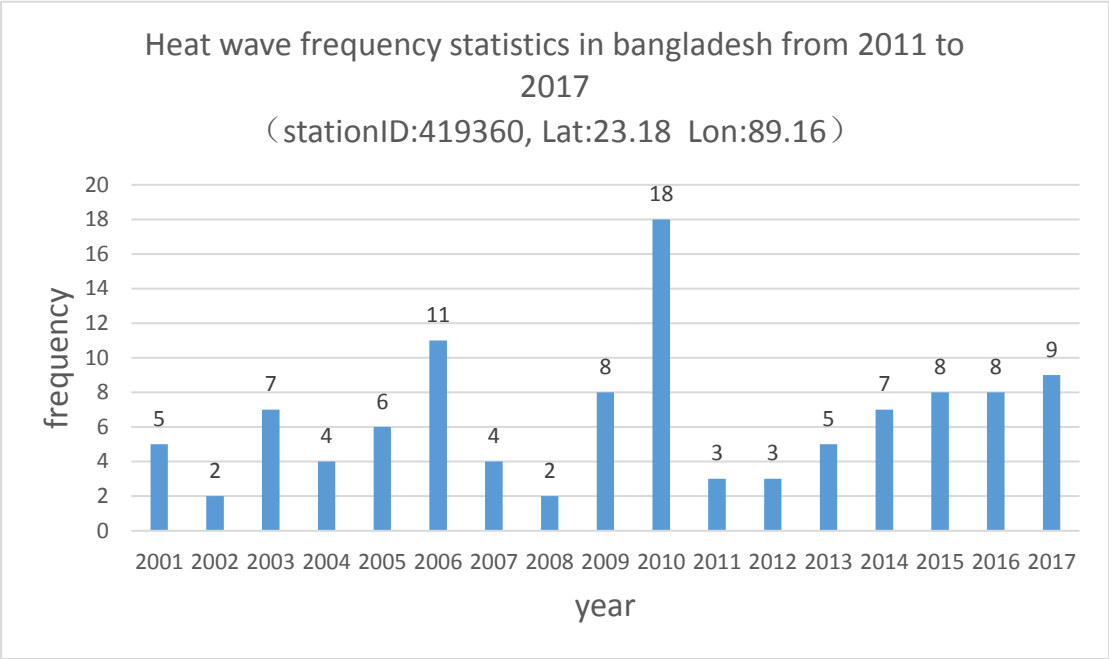


**Figure 4**




One of the main reasons for the increased frequency of heat waves is global warming.Over most land areas since the 1950s, it is very likely that there have been fewer or warmer cold days and nights. Hot days and nights have also very likely become warmer or more frequent. Human activities have very likely contributed to these trends. Global warming boosts the probability of extreme weather events, like heat waves, far more than it boosts more moderate events. In the last 30 40 years, heat waves with high humidity have became more frequent and severe. Extremely hot nights have doubled in frequency. The area in which extremely hot summers are observed, has increased 50-100 fold. These changes are not explained by natural variability, and attributed by climate scientists to the influence of anthropogenic climate change.

## 3.TYPICAL HEAT WAVE EVENT

A heat wave swept bangladesh in June 2005.It swept over Dhaka, Khulna, Rajshahi and Chittagong divisions and regions of Chandpur, Patuakhali, and Noakhalihas and claimed nearly 100 lives ,as the mercury soared over 40 degrees

Celsius.

The heat wave was caused in large part by sparser pre-monsoon season showers, which brought less moisture than normal to the area, leaving large parts of Bangladesh arid and dry. The sudden end of pre-monsoon rain showers, an uncommon trend in Bangladesh, has contributed to the heat waves. Additionally, the monsoon season is later and further south than the normal trend. This weather pattern, coupled with the El Niño effect, which often increases temperatures in Asia, combined to create the record high temperatures. High humidity compounded the effects of the temperatures on residents. Moreover, widespread failures of the electrical grid left many locations without working air-conditioners, fans, or water pumps, adding further to the death toll.

The government of bangladesh announced financial compensation to the next of kin of people killed in the heatwave in the state. Drinking water, oral rehydration salts and intravenous fluids were made available at public places like railway stations and bus stations. Emergency medical camps are set up across the state. An awareness campaign was launched advising citizens to not leave their homes at noon unless absolutely necessary.

This heat wave event reflects many of Bangladesh's problems with its ability to cope with high temperatures. The most obvious problem is that most homes lack refrigeration. When heat waves hit, families living in slums do not have cooling equipment and are exposed to high temperatures for a long time. The overall power supply capacity of Bangladesh is weak. Power failure often occurs during peak summer power consumption, which seriously affects the rescue work of hospitals and other relevant institutions. In addition, the lack of public places to cool down in the summer and the poor living environment, especially the slum environment, lead to the spreading of disease is difficult to control. All of problems increase the mortality rate.

The problems in Bangladesh's ability to prevent high temperature disasters are fundamentally caused by the backward development of the country, so the most effective measures include the following two aspects： First of all, considering the

current situation of Bangladesh, it is unrealistic for every family to have air conditioning, but the government can build large summer shelters, which can effectively relieve the pressure caused by the high temperature. Secondly, it is necessary to study cheap and effective personal cooling measures. For example, a charity in Bangladesh has developed a cheap cooler made of cardboard and beverage bottles and it lowered the indoor temperature by 5 degrees. Therefore, in the context of economic backwater, it is undoubtedly the most effective to study such cheap cooling measures.

# III. CAUSES OF BANGLADESH HEAT WAVE

## 1. CLIMATE IN BANGLADESH

Bangladesh has a tropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures, and high humidity. Regional climatic differences in this flat country are minor. Three seasons are generally recognized: a hot, muggy summer from March to June; a hot, humid and rainy monsoon season from June to November; and a warm-hot, dry winter from December to February. In general, maximum summer temperatures range between 38 and 41 °C (100.4 and 105.8 °F). April is the hottest month in most parts of the country. January is the coolest month, when the average temperature for most of the country is 16–20 °C (61–68 °F) during the day and around 10 °C (50 °F) at night.

## 2. URBAN HEAT ISLAND (UHI) EFFECT—TAKE DHAKA FOR INSTANCE

### A. UHI in DHAKA

Whoever has experienced the sweltering summer days of Dhaka will agree that average temperature of Dhaka City has increased over the decades. The scorching heat during daytime and hot, see thing nights coupled with load shedding are the bane of

the city dweller's life. The answer of why the temperature is so high can be attributed to a unique feature of the urban climate known as Urban Heat Island (UHI) Effect. The urban heat island phenomenon was first discovered in the early 1800s in London. But it is not clear yet whether it is related to global warming.

A UHI is a metropolitan area which is significantly warmer than its surrounding rural areas. The temperature difference usually is larger at night than during the daytime and larger in winter than in summer, and is most apparent when winds are weak. The main cause of the urban heat island is modification of the land surface by urban development; waste heat generated by energy usage is a secondary contributor. Since people have covered most of the land surface of Dhaka with concrete and asphalt pavements, the city has become an oven with millions of people in it.

Though the UHI air temperature is generally most apparent at night, urban heat islands exhibit significant and somewhat paradoxical diurnal behavior. The UHI air temperature is large at night and small during the day, while the opposite is true for the UHI surface temperature. Throughout the daytime, particularly when the skies are free of clouds, urban surfaces are warmed by the absorption of solar radiation. As described above, the surfaces in the urban areas tend to warm faster than those of the surrounding rural areas. By virtue of their high heat capacities, these urban surfaces act as a giant reservoir of heat energy. (For example, concrete can hold roughly 2000 times as much heat as an equivalent volume of air). This daytime heating creates convective winds that minimize the surface temperature to a great extent. At night, however, the situation reverses. The absence of solar heating causes the atmospheric convection to decrease. This traps the urban air near the surface, and allows it to heat from the still-warm urban surfaces, forming the nighttime UHI air temperature.

## B. CAUSE OF UHI

Poor urban design is the biggest cause of heat island in our city. Heat islands are

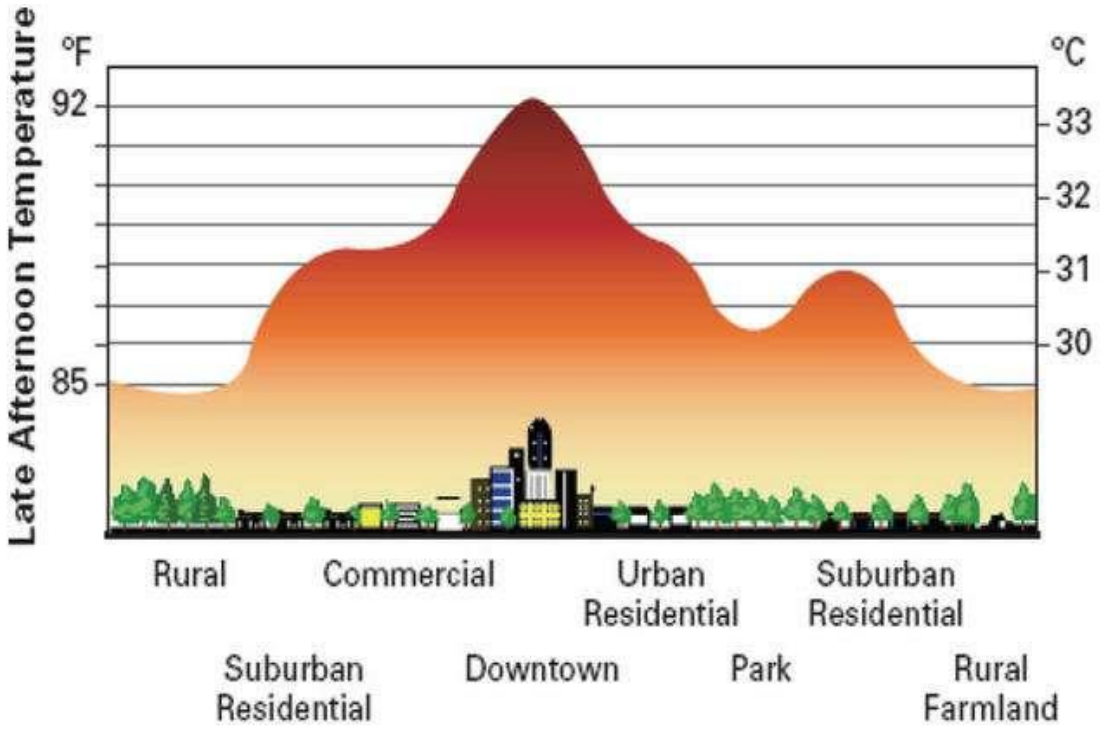
created when city growth alters the urban fabric by manmade asphalt roads and tar roofs and other features substituting forest growth. These surfaces absorb - rather than reflect - the sun's heat, causing surface temperatures and overall ambient temperatures to rise.

The principal reason for the night-time warming is (comparatively warm) buildings blocking the view to the (relatively cold) night sky. Two other reasons are changes in the thermal properties of surface materials and lack of evapotranspiration in urban areas. Evapotranspiration (ET) is a term used to describe the sum of evaporation and plant transpiration from the earth's land surface to atmosphere. Materials commonly used in urban areas, such as concrete and asphalt, have significantly different thermal bulk properties (including heat capacity and thermal conductivity) and surface radiative properties than the surrounding rural areas. This causes a change in the energy balance of the urban area, often leading to higher temperatures than surrounding rural areas. But that's not the only thing that causes the urban heat island effect. Scientists believe that vegetation plays a large part in keeping an area cool through a process called evaporative cooling. Plants take in water through their roots and depend on it to live.

But after the plant is done with it, dry air absorbs that water by turning it into gaseous water vapor. The air provides the heat that drives this process, so during the process, the air loses heat and becomes cooler. Because building a city means replacing vegetation with structures, the city loses the evaporative cooling advantages of vegetation.

Other causes of a UHI are due to geometric effects. The tall buildings within many urban areas provide multiple surfaces for the reflection and absorption of sunlight, increasing the efficiency with which urban areas are heated. This is called the "canyon effect". Meanwhile, tall buildings and narrow streets can heat the air trapped between them and reduce airflow. Waste heat from automobiles, air conditioning, industry, and other sources also contributes to the UHI. High levels of pollution in urban areas can also increase the UHI, as many forms of pollution change the radiative properties of

the atmosphere.




# IV. HEALTH RELATED HAZARDS OF HEAT WAVES

## 1. Heat related diseases for human health

Heat edema presents as a transient swelling of the hands, feet, and ankles and is generally secondary to increased aldosterone secretion, which enhances water retention. When combined with peripheral vasodilation and venous stasis, the excess fluid accumulates in the dependent areas of the extremities. The heat edema usually resolves within several days after the patient becomes acclimated to the warmer environment. No treatment is required, although wearing support stockings and elevating the affected legs will help minimize the edema.

Heat rash, also known as prickly heat, is a maculopapular rash accompanied by acute inflammation and blocked sweat ducts. The sweat ducts may become dilated

and may eventually rupture, producing small pruritic vesicles on an erythematous base. Heat rash affects areas of the body covered by tight clothing. If this continues for a duration of time it can lead to the development of chronic dermatitis or a secondary bacterial infection. Prevention is the best therapy. It is also advised to wear loose-fitting clothing in the heat. However, once heat rash has developed, the initial treatment involves the application of chlorhexidine lotion to remove any desquamated skin. The associated itching may be treated with topical or systemic antihistamines. If infection occurs a regimen of antibiotics is required.

Heat cramps are painful, often severe, involuntary spasms of the large muscle groups used in strenuous exercise. Heat cramps tend to occur after intense exertion. They usually develop in people performing heavy exercise while sweating profusely and replenishing fluid loss with non-electrolyte containing water. This is believed to lead to hyponatremia that induces cramping in stressed muscles. Rehydration with salt-containing fluids provides rapid relief. Patients with mild cramps can be given oral .2% salt solutions, while those with severe cramps require IV isotonic fluids. The many sport drinks on the market are a good source of electrolytes and are readily accessible.

Heat syncope is related to heat exposure that produces orthostatic hypotension. This hypotension can precipitate a near-syncopal episode. Heat syncope is believed to result from intense sweating, which leads to dehydration, followed by peripheral vasodilation and reduced venous blood return in the face of decreased vasomotor control. Management of heat syncope consists of cooling and rehydration of the patient using oral rehydration therapy (sport drinks) or isotonic IV fluids. People who experience heat syncope should avoid standing in the heat for long periods of time. They should move to a cooler environment and lie down if they recognize the initial symptoms. Wearing support stockings and engaging in deep knee-bending movements can help promote venous blood return.

Heat exhaustion is considered by experts to be the forerunner of heat stroke (hyperthermia). It may even resemble heat stroke, with the difference being that the

neurologic function remains intact. Heat exhaustion is marked by excessive dehydration and electrolyte depletion. Symptoms may include diarrhea, headache, nausea and vomiting, dizziness, tachycardia, malaise, and myalgia. Definitive therapy includes removing patients from the heat and replenishing their fluids. Most patients will require fluid replacement with IV isotonic fluids at first. The salt content is adjusted as necessary once the electrolyte levels are known. After discharge from the hospital, patients are instructed to rest, drink plenty of fluids for 2–3 hours, and avoid the heat for several days. If this advice is not followed it may then lead to heat stroke.

## 2. INDIVIDUALS ACTIONS when facing heat waves

- Staying hydrated by drinking plenty of fluids even if they do not feel thirsty and avoiding drinks with caffeine or alcohol.
- Listening to the radio for updates and staying aware of the changing conditions.
- Eating small meals and eat more often.
- Avoiding extreme temperature changes.
- Wearing loose-fitting, lightweight, light-colored clothing.

• Slowing down, staying indoors and avoiding strenuous exercise during the hottest part of the day.

• Using a buddy system when working in excessive heat.

• Taking frequent breaks if outdoor work is unavoidable.

• Wearing sunscreen with a high SPF, since sunburned skin reduces the body's ability to cool itself.

• Closing windows and shutters during the day, especially those facing the sun, and opening windows and shutters at night when the outside temperature is lower, if safe to do so.

• Being cautious in relying on electric fans to provide relief; above 35 °C fans may not prevent heat related illness.

• Moving to the coolest room in the home, especially at night.

• Being aware of family and friends who may need extra help.

• Checking in with heat-vulnerable family and friends to ensure they are following cooling tips.

• Recognizing symptoms of overexposure to heat in family and friends and alleviating the symptoms.

Outdoor labors are at high risk of occupational heat illness, but there is a lot they can do to protect themselves during heat events:

• Adapting work schedules so that the worker can start early, take frequent breaks and complete the most intensive tasks in the early morning or late afternoon134

• Wearing light, loose, clothing and hats, drinking lightly-salted water regardless of thirst135

• Adjusting expectations based on direct exposure to sunshine. For example, for outdoor work in direct sunlight between the hours of 10 am. and 5 pm, adding 1 to 2 °C to the humidex measurement136.

By pursuing the activities listed below, individuals can take action to prepare for the

upcoming heat season and any potential heatwaves:139

- Knowing where the nearest cooling centers are.
- Keeping informed on weather conditions via television, radio, newspapers and other print media.
- Maintaining awareness of potential response actions by government and non-government agencies that could affect day-to-day life.

# V. PROTECT CROPS

## 1. SHORT-TERM EMERGENCY MEASURES

- Dryland crops are cultivated to loosen the soil and cover the ground to achieve the purpose of cutting off the soil capillary and reducing water evaporation.
- Paddy fields should be irrigated in water-saving irrigation according to the requirements of water during development timely.
- Before the occurrence of the highest daily temperature (before 14 o'clock), the canopy of the crop should be sprinkled to increase the relative humidity of the air around canopy, reduce the temperature, and improve the field microclimate.
- Carrying out artificial precipitation enhancement actively in all favorable weather.

## 2. LONG-TERM DEFENSE MEASURES

- Analyzing the spatial and temporal distribution of local high temperature and drought disasters to adjust the agricultural layout. Change water farming to dry farming according to the season and regional characteristics of high temperature and drought disasters.
- Choosing a variety suitable for local high temperature and drought, and adjust the sowing period appropriately, so that the period of high temperature and

drought is in the growth period of crops against high temperature and drought.

- Sprinkler irrigation facilities, drip irrigation facilities, and shade nets should be placed in high-yield farming areas to achieve the role of drought resistance and cooling.

# VI. WAY FORWARD FOR FUTURE

## 1. Long-term defense planning

On the one hand, long-term measures should focus on disaster reduction in response to typical extreme weather disasters such as heat wave， such as the reduction of urban heat generation and the weakening of urban heat island effect; On the other hand, long-term measures should focus on disaster prevention: starting from improving the climate adaptability of urban and architectural design.

### A. Energy conservation and emission reduction

The large amount of emissions of greenhouse gas is the direct cause of global warming, which is the background of the increasingly frequent occurrence of high-temperature disasters around the world. Therefore, from the perspective of the overall urban planning, formulating planning to reduce carbon emissions and use green energy, vigorously developing public transport, and effectively reducing urban carbon emissions and heat, which is suitable measures for cities to cope with climate change and extreme climate disasters.

### B. Cut the urban heat island effect

The heat island effect makes the urban climate more hot, and in extreme heat,

the intensity of the urban heat island effect at night is significantly higher than the sustained heat during the day, which exacerbates the damage to human health. The heat island effect is caused by the difference in reflectivity of the underlying surface of the city. Therefore, the most direct and effective way to reduce the heat island effect is to build the urban green infrastructure and increase the quantity and quality of green space, especially in the upwind area of the city. The research shows that the areas with high vegetation coverage have lower cooling rate than those with low vegetation coverage, so the planning should give priority to areas with low greening level in urban green space construction. In addition, the mosaic-like dense and frequent small green space improves the urban thermal environment better than the large concentrated green space.

## C. Disaster prevention publicity and education

Different from traditional urban disasters such as fire, earthquake and flood, people can largely reduce the impact of disasters through self-help and mutual assistance during high-temperature disasters. Therefore, public publicity of education is an important way to form a bottom-up disaster prevention system. First of all, the disaster information exchange mechanism with clear powers and responsibilities should be established. For example, in the high-temperature planning in the UK, detailed provisions are made on the objects, timing, methods and methods of high-temperature and health information exchanging, and protective guidelines should be provided for different types of vulnerable groups. Secondly, the government should make full use of online media and social channels to disseminate the knowledge of high-temperature disaster and defense measures to the public. In addition, the existing grass-roots organization structure of neighborhood committees can be utilized to directly publicize disaster prevention methods to the public, and focus on helping the elderly living alone and vulnerable people suffering from long-term physical and mental diseases.

## 2. Short-term emergency measures

### A. Urban high temperature warning system

High temperature disaster is predictable, so the establishment of high temperature warning system is an important guarantee for the implementation of high temperature emergency planning. The government department can implement the high-temperature monitoring and warning system in summer, and implement different levels of prevention by issuing different warning levels, so that the departments can cooperate with each other to carry out emergency response actions better. Monitoring and warning of heat wave should not only focus on temperature, but also on health. In the future, the city should have a perfect high-temperature warning system, which should be included in the urban emergency planning. In addition, the high-temperature emergency mechanism which is participated by the meteorological department, social security department, medical institutions, social groups and other subjects should be improved.

### B. Passive cooling

When high temperature disaster occurs, using air conditioning to cool down is the most rapid and effective disaster prevention measure. But in the long run, residents' over-reliance on a lot of heat-producing mechanical cooling equipment will further raise urban temperatures, creating a vicious cycle. Therefore, reducing the use of mechanical refrigeration and encouraging the spread of passive cooling planning are of double significance for disaster reduction and prevention in extreme high temperature climate，for example, better insulation materials and more reflective surface materials can be used, or building structures can be modified to enhance ventilation capacity. For major urban construction projects, the energy saving and

climate adaptability of the project design scheme should be strictly controlled and audited.

## C. Public places to avoiding High temperature

Places to cool the heat should be provided for vulnerable groups who live in poor conditions without cooling conditions or are exposed to the outdoors for a long time, and It can be divided into two categories: indoor and outdoor. The choice of indoor shelters should make use of existing public resources, such as community activity center, library, large shopping center and so on. Outdoor shelters are mainly designed for the long-term exposed floating population, generally including parks, squares or important traffic hub stations and other densely populated public Spaces. For example, the spray cooling device can be installed at the bus station during the hot summer.