



STUDY OF BIO-CLIMATIC INDICES OVER BIHAR REGION

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Abstract: *In a changing scenario of weather and climate pattern there is a need to provide more insight in summer and winter seasons by supplying the information of heat stress wind chill index to the public. In this paper efforts have been made to compute the heat index and wind chill index for Bihar region during summer and winter times using national weather service formulae. The results obtained from operational India Meteorological Department (IMD) wind chill effective temperature (WCTn) are more realistic than National Weather Service (NWS) based wind chill temperature index (WCTI) during winter time. The preliminary results obtained from the four stations of Bihar show that it needs more extensive analysis of public responses before standardize in public domain.*

Key words: *Heat index, wind chill temperature index and climate*

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INTRODUCTION

Weather or climate affects the living organisms and exposure depends on the thermoregulatory mechanism of their body. The normal criterion of assessing the heat wave or cold wave is depends on the departure from temperature. But in reality, discomfort is more in humid conditions even if the temperature is not so high. Similarly, during winter time the wind speed increases the chillness and affects the lives of the people badly. Although the wind chill effective temperature (WCTn) used in India Meteorological Department (IMD) currently is very useful. But to make it more meaningful to the public more work needs to be done by analyzing the responses or feedback from the public. In this way, this study is useful to prepare a thermoregulatory response table in a given strata, so that the preventive measures can be taken in a due course of time. This information will be very useful for medical professionals to provide the preventive medication and awareness to the people. This will help in planning the socio-economic budget over the area. The adaptation and rehabilitation are of great concern nowadays as the gradual increase of all the heat/cold indices almost linearly. It will also help in new construction planning and shifting the population over new area by monitoring the response table. In this way new planning, new initiative, medical facilities or necessary living facilities can be provided timely. Hence this type of research have great potential in providing the advise for rehabilitation or migration and new construction companies so they can provide the necessary facilities to the people. The time series of these indices will provide the clue of climate change over Bihar region and projective climate trend of future. This will be very important information for government or non governmental institutions. Several studies have done on heat stress and its impacts in recent past by (Dash and Kjellstrom, 2011, Balakrishnan, et al, 2010, Nag & Nag, 2009 and Kjellstrom, 2000) in various sectors (work place, labor, and factory) and parts of India. The inter-annual variation of these indices is the indicator of human activities and their affect in adapting the climate. The indication of monotonic increase or decrease of indices alarms the future about the extreme weather events. The winter months have pronounced effect on human health if chilling is more. Studies by several authors (De et al, 2005, Lakshmanan, 1984 and Deosthali, Vrishli., 1999) reported the impact of winter chilling in a rapidly changing urbanization or anthropogenic activities. Thus by doing operationalization of heat or cold indices regulatory guidelines can be made in our country to determine the maximum limit of exposure of the workers. The available international guidelines need to be validated against our background facts.



DATA AND METHODOLOGY

The surface observational data of temperature (maximum and minimum), humidity (average of maximum and minimum), and wind speed is taken from meteorological centre Patna. Current classification of heat wave or cold wave is based on departure from normal temperature is not sufficient to justify all the cases and go unnoticed. During summer time humidity and in winter wind speed play an eminent role in thermoregulatory responses of the humans. The computation of heat stress or temperature heat index (THI) and wind chill temperature index (WCTI) is taken same as national weather service, regression analysis formula. The results were obtained in degree Fahrenheit from the formulae and later converted into degree centigrade to make it more convenient in Indian scenario. THI is also called the apparent temperature of the humid day and calculated from the following formula:

$$T_{HI} = 16.923 + 1.85212 \cdot 10^{-1} \cdot T + 5.37941 \cdot RH - 1.00254 \cdot 10^{-1} \cdot T \cdot RH + 9.41695 \cdot 10^{-3} \cdot T^2 + 7.28898 \cdot 10^{-3} \cdot RH^2 + 3.45372 \cdot 10^{-4} \cdot T^2 \cdot RH - 8.14971 \cdot 10^{-4} \cdot T \cdot RH^2 + 1.02102 \cdot 10^{-5} \cdot T^2 \cdot RH^2 - 3.8646 \cdot 10^{-5} \cdot T^3 + 2.91583 \cdot 10^{-5} \cdot RH^3 + 1.42721 \cdot 10^{-6} \cdot T^3 \cdot RH + 1.97483 \cdot 10^{-7} \cdot T \cdot RH^3 - 2.18429 \cdot 10^{-8} \cdot T^3 \cdot RH^2 + 8.43296 \cdot 10^{-10} \cdot T^2 \cdot RH^3 - 4.81975 \cdot 10^{-11} \cdot T^3 \cdot RH^3$$

Where,

T = temperature in degrees Fahrenheit [°F]

RH = relative humidity in percent [%]

The effects of high heat index values are given in table 1 below as per the national weather service, USA guidelines.

Table 1: Temperature heat index categories

Category	Classification	HI [°F]	HI [°C]	General Affect on People at High Risk
I	Extremely Hot	130°F or Higher	55°C or Higher	Heat or Sunstroke highly likely with continued exposure
II	Very Hot	105°F - 130°F	40 °C - 55°C	Sunstroke, heat cramps, or heat exhaustion likely, and heatstroke possible with prolonged exposure and/or physical activity
III	Hot	90°F - 105°F	32°C - 40°C	Sunstroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
IV	Very Warm	80°F - 90°F	27°C - 32°C	Fatigue possible with prolonged exposure and/or physical activity



Similarly, Wind chill temperature index (WCTI) is given by the following formula:

$$WCTI = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T temperature in degrees Fahrenheit [°F] and V wind speed in miles per hour (mph).

The results were obtained in degree Fahrenheit and later converted into degree centigrade. For WCTI the temperature of the station should be less than 10 °C and wind speed greater than 4.8 kmph. The results obtained from heat index and wind chill index are preliminary over Bihar region and need extensive analysis of exposure of winds during winter and humidity in summer to standardize it.

RESULTS AND DISCUSSION

The data of four departmental observatories of Bihar region (Patna, Gaya, Bhagalpur and Purnea) from the year 20011 to 2014 have been analysed for THI and WCTI computation. It is well known that the moisture is variable in time and space and its concentration in the atmosphere modified by the anthropogenic activities. The concentration or forcing produced by the trace gases is changed which significantly varies the moisture distribution. The transport of various types of cloud condensation nuclei affects the weather activities or climate in the long term over the area. The thermoregulatory mechanism of the body of each individual is different in reactive responses and adaptation. In this regard the moisture inception by the body during summer times generates more discomfort feeling than dry conditions. During winter time, exposure of cold is more effective and cause discomfort if the winds are strong. The chilling effect is more vulnerable than the cold wave or cold days. The computed values of THI for all the stations of Bihar show that maximum THI values have been falling in second category followed by first, third and fourth category (figures 1 to 4). During winter time the winds induced chilling effect and affect the lives of the people badly for few days. In this work, both the criterion, India Meteorological Department (IMD) wind chill effective temperature (WCTn) and National Weather Service (NWS), USA based WCTI computed and compared for four years of data. The results brought out from the analysis show both the methods captured the winter time cold events. The results obtained from IMD operational WCTn are more realistic than WCTI for all the four stations of Bihar (figures 5 to 8). The appreciable increase of heat stress and winter chill events may be due to modern urban development which can add can add several degrees to local temperatures through heat absorption in concrete buildings, road tar-seal, etc. the 'urban heat island



effect' The fact is accepted globally and reported in third assessment report of Intergovernmental Panel on Climate Change (IPCC) that global warming during last fifty years are anthropogenic in nature.

CONCLUDING REMARKS

The preliminary bio-climatic study over Bihar region by computing the THI and WCTI is more realistic than the current traditional trends. Some of the main highlights of the study are given below:

1. This study is linking to the real exposure of the public of Bihar region and helps to determine how small shift in temperature and heat /cold exposure due to the change in weather can cause health risks.
2. It helps to provide the adaptation or local needs of local communities by providing the heat or cold forecast over the specified area.
3. The temperature heat index (THI) values will be available throughout the year except winter season. The maximum THI values are falling in second, category followed by first, third and fourth category.
4. The results obtained from WCTn operational criteria of IMD were more realistic than WCTI of NWS.
5. This study is useful to make regulatory guidelines in our country to determine the maximum limit of exposure of the workers.

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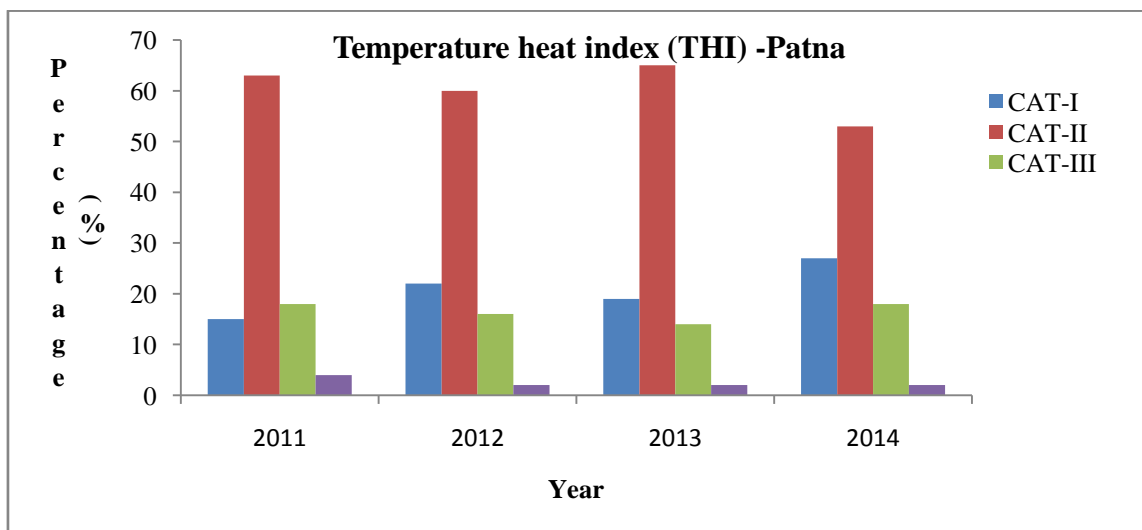


Figure 1: THI for Patna (March to September)

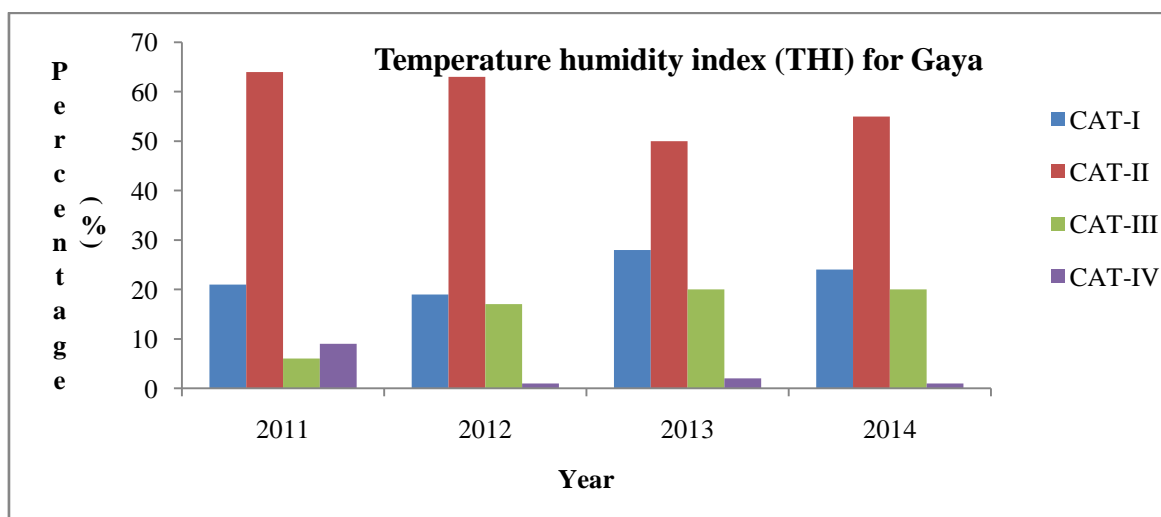


Figure 2: THI for Gaya (March to September)

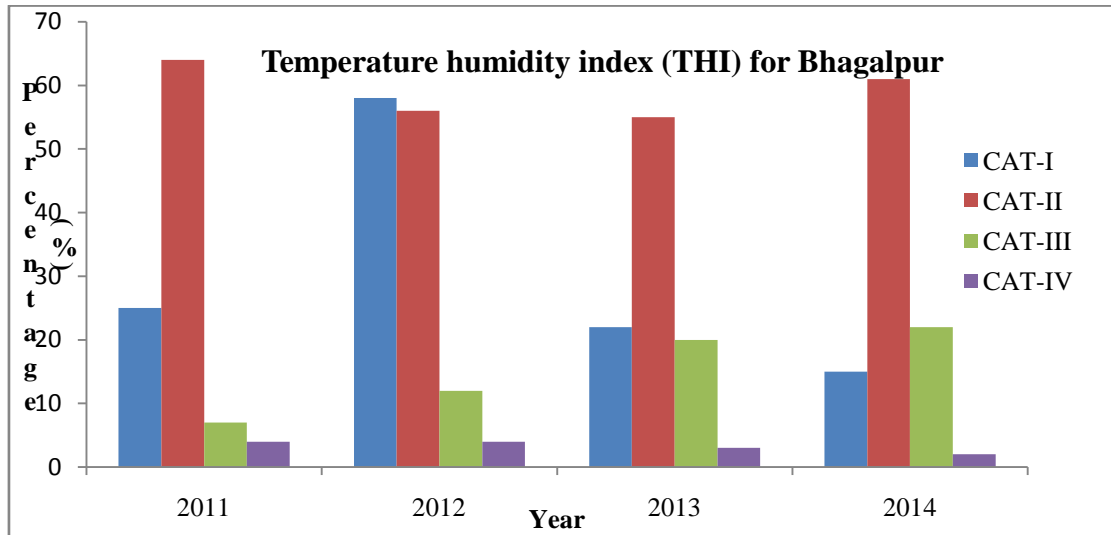


Figure 3: THI for Bhagalpur (March to September)

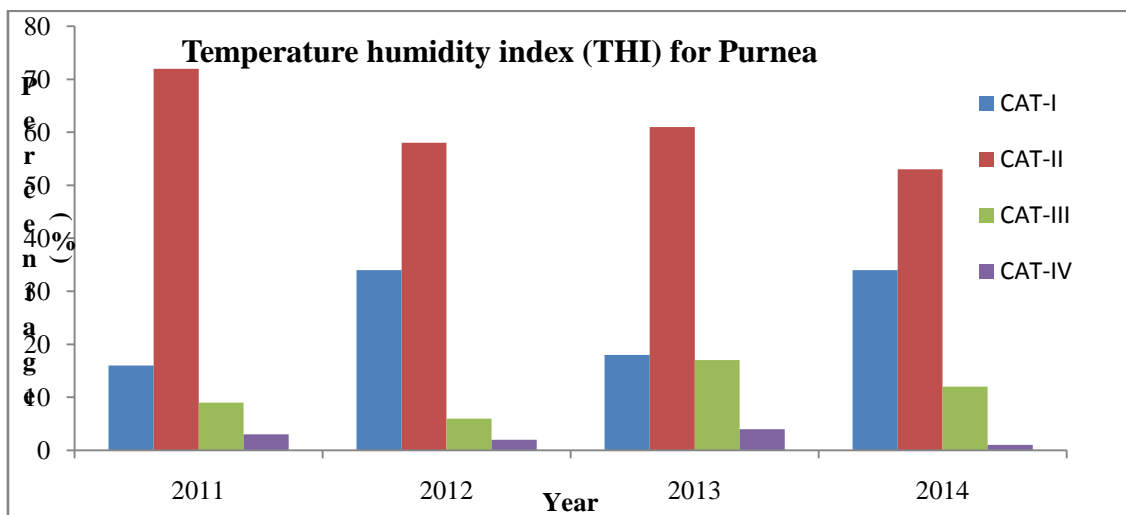


Figure 4: THI for Purnea (March to September)

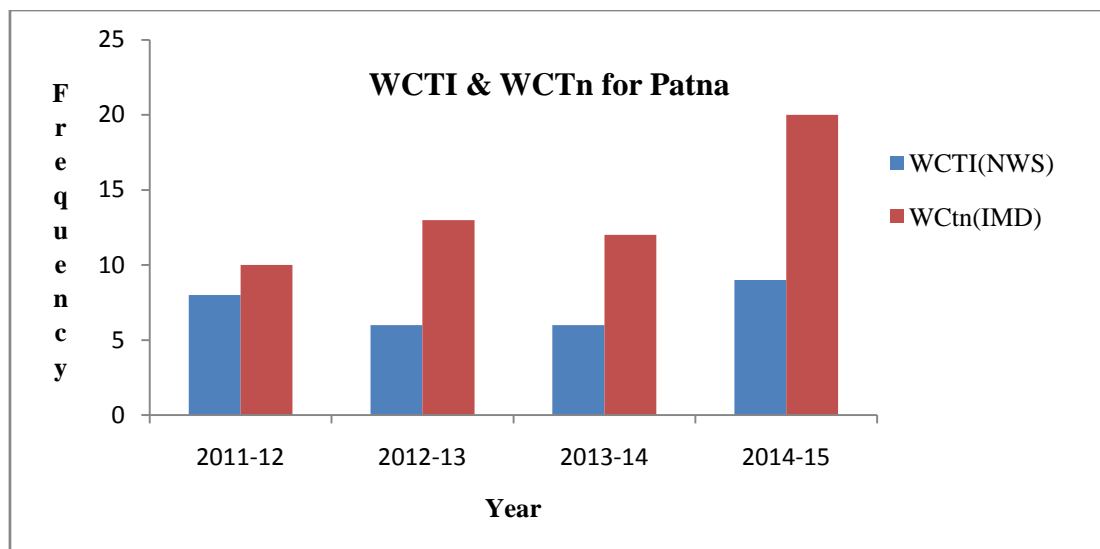


Figure 5 : WCTI and WCTn for Patna

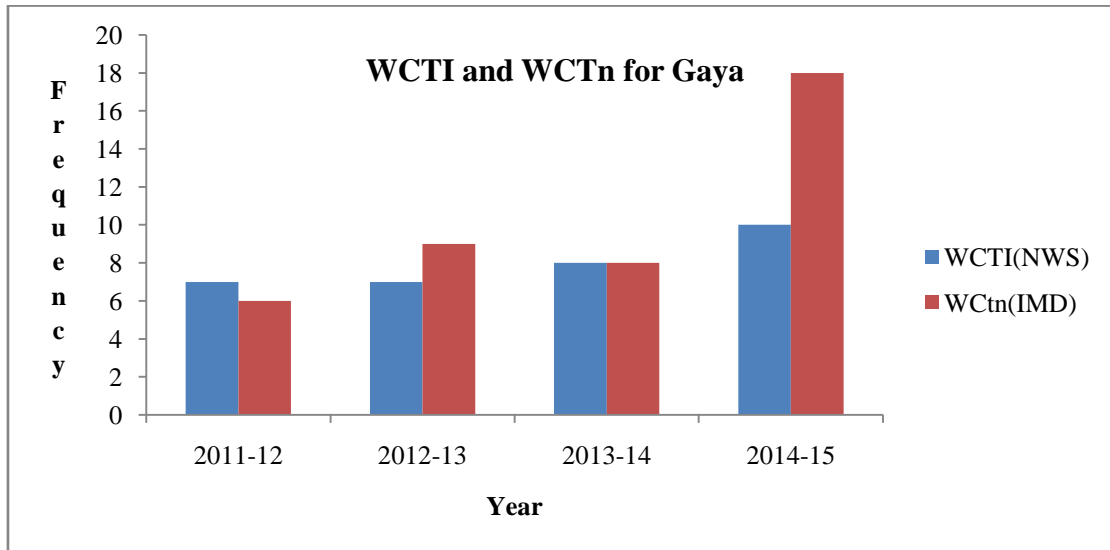


Figure 6 : WCTI and WCTn for Gaya

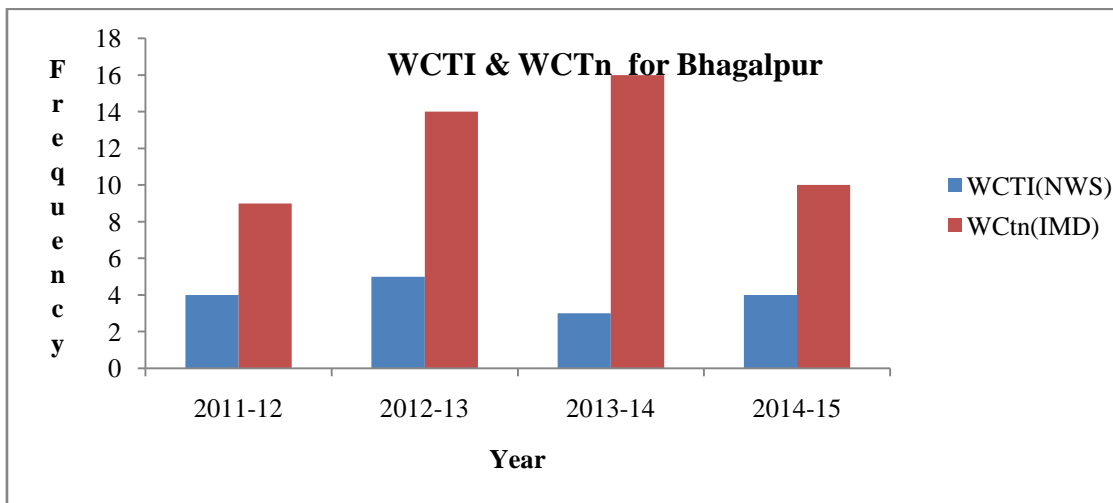


Figure 7 : WCTI and WCTn for Bhagalpur

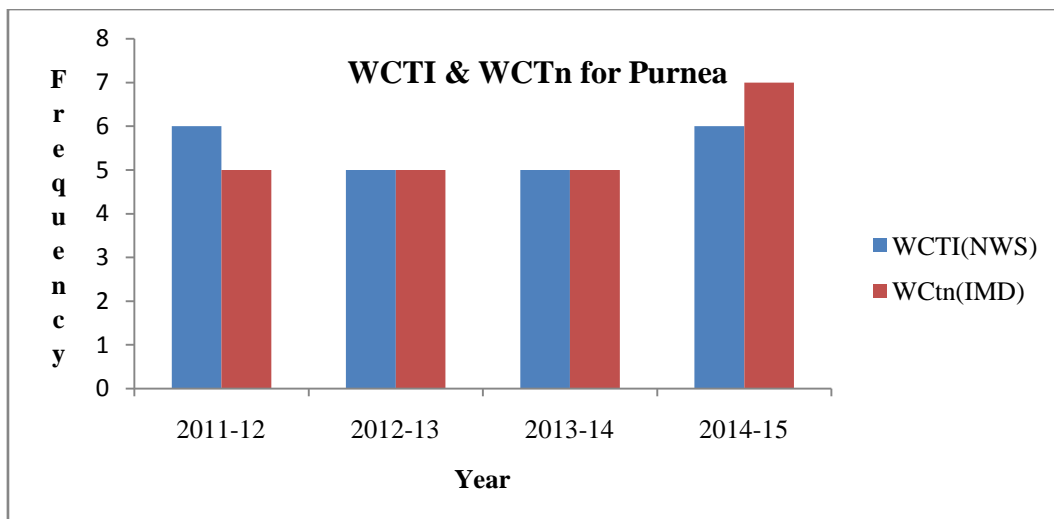


Figure 8 : WCTI and WCTn for Purnea