Impact of Heat Stress on Animal Health Using Temperature Humidity Index over India

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ABSTRACT

The thermal stress on animals has been observed all over the India. Temperature-Humidity Index (THI) is an indicator used to measure degree of heat stress on the animals. For the present study monthly mean THI was calculated from 1980 to 2015. The thermal stress is categorized as No Stress (below 70), Mild Stress (71-75), Semi Moderate Stress (76-80), Moderate Stress (81-85) and Severe Stress (85-90). During monsoon season, the thermal stress is the combination of semi moderate and severe stress conditions, whereas in the winter season it is the combination of mild and semi moderate stress conditions. During pre-monsoon season the thermal stress is the combination of semi moderate and severe stress conditions and in the post-monsoon season it is the combination of no stress condition and mild stress conditions observed over India. Over Jammu and Kashmir only the mild stress condition has been observed from June to August months while rest of the year it shows no stress condition. The thermal stress conditions in the form of mild, semi moderate or severe stress is always located over Tamil Nadu state throughout the year. Therefore, mitigation practices can be followed according to the season for recovering the animal from the thermal stress during mild, semi moderate and severe stress condition across the country which will be of more helpful. Heat stress negatively affects cow comfort, dry fodder intake and ultimately the dairy production in India. The appropriate management practices must be applied in counter environmental conditions that can lead to reduce the productivity of animals. Finally, heat stress control practices should also be adopted according to the environmental, topographical and intensity of stress condition and applied carefully as one method proves successful in one place, it does not guarantee that it will be successful elsewhere in India. Therefore, in this study the monthly mean THI maps and seasonal maps were prepared accordingly and with the help of these maps required heat stress mitigation practices must be followed.

***Key words**: Temperature Humidity Index, thermal Stress, fodder*

1. Introduction

Animal Husbandry, Dairying and Fisheries activities, along with agriculture, continue to be an integral part of human life and are the best insurance against the vagaries of nature like drought, famine and other natural calamities (Madhu Suman *et al*, 2012). They supplement family income and generate gainful self-employment, particularly for landless labourers, small and marginal farmers and women (Birthal, 2008).

India has a unique climatic regime with two monsoon seasons and two cyclone seasons. The hot weather season is characterized by the severe thunderstorms and heat waves where as the cold weather season with violent snowstorms in the Himalayan regions and cold waves. Heavy to very heavy rainfall during the monsoon season often cause floods over many parts of the country.

Climate change has complex impacts on domestic animal production system affecting feed supply, challenging thermoregulatory mechanism resulting thermal stress, emerging new diseases due to change in epidemiology of diseases and causing many other indirect impacts (Xiaoxu Wu *et al*, 2015). Global warming has two way effects on animal production system.

In one hand it directly affects the health, reproduction, nutrition of the animals resulting in poor performance, inferior product quality, and outbreak of novel diseases while on the other hand there are indirect effects on animal production due to change in soil fertility, decrease in preferred vegetation, rangeland degradation, desertification

and decrease in production of feed stuffs (Bajagai, 2011).

Dairy cattle are particularly more susceptible to increased ambient temperature. The effects of thermal stress vary among individuals are according to breeds and production level (Bernabucci *et al*., 2010). The intensification of thermal stress and more frequent occurrence of this problem is probably the most obvious consequence of global climate change in dairy cattle which is attributable to increased atmospheric temperature.

Thermal stress is one of the greatest climatic challenges faced by the domestic animals and the possibility that the problem of thermal stress to become more prominent with increased atmospheric temperature may further aggravate the condition and even provoke new episode of thermal stress condition. The focus of this paper is on temperature humidity index representing the influence of thermal environments on farm animal response and application of this index for environmental management of livestock.

2. Materials and Methods

The daily dry bulb temperature and relative humidity data from 300 stations from the year 1980 to 2015 were analyzed to obtain the monthly mean values of dry bulb temperature (°C) and relative humidity and from them the THI was calculated. The monthly THI maps were plotted in arc- GIS software.

Classification of THI

There are different formulae to estimate the thermal stress, THI, being one of them. Different conditions are classified below:

$$THI = (0.8 \times T_{db}) + [(RH/100) \times (T_{db} - 14.4)] + 46.4,$$

T_{db} - dry bulb temperature in degrees Celsius, RH - relative humidity

No	Category	THI values
1	No stress	Below 70
2	Mild stress	70-75
3	Semi moderate stress	76-80
4	Moderate stress	81-85
5	Severe stress	85-90

3. Results and Discussion

Temperature-Humidity Index, combines ambient temperature and relative humidity to express an indicator of the degree of heat stress.

3.1 Monthly Mean THI

Monthly mean THI was calculated and plotted month wise during the period from 1980 to 2015 in Figure 1. In January (Fig1.1) semi moderate stress was observed over few places of coastal Tamil Nadu and southern Kerala. In the month of February (Fig1.2), north and north-east India showed No stress condition. The semi moderate stress was observed over Andhra Pradesh, thick coastal region of Tamil Nadu and southern Kerala. During March (Fig1.3) the semi moderate stress was creeping entirely over the Orissa, Andhra Pradesh, Kerala, south Chhattisgarh, Konkan and Vidharbha region of Maharashtra, north and middle Karnataka and major part of Tamil Nadu. The severe stress condition was located over the scattered parts of Tamil Nadu and Andhra Pradesh. In April (Fig1.4) the semi moderate stress condition was dominant over the entire country except Jammu& Kashmir, Assam, Punjab, Uttarakhand and North East India. The semi moderate stress condition of March got converted into the severe stress condition and was significantly located over Telangana, south Chhattisgarh, eastern Vidharbha region of Maharashtra and eastern coastal states of India. Oceanic feature and topography of eastern coast played important role for the generation of severe stress condition in the April month. There was no severe stress over the western coast of India. During May (Fig1.5), the semi moderate stress condition got converted into severe stress condition and dominantly observed over the entire India. The semi moderate stress condition was

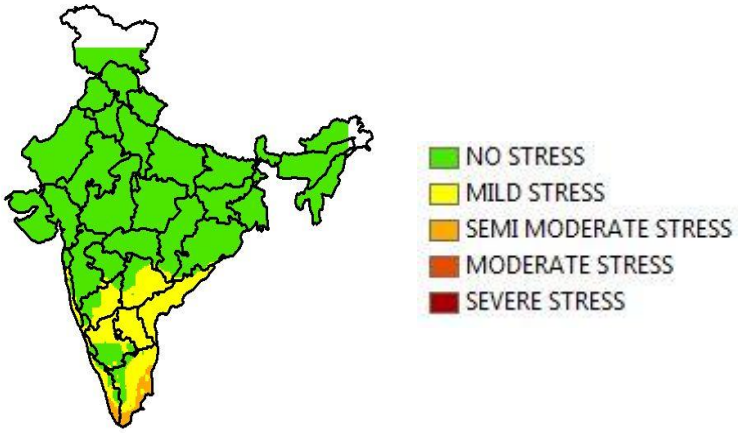

Figure 1.1 January month mean THI

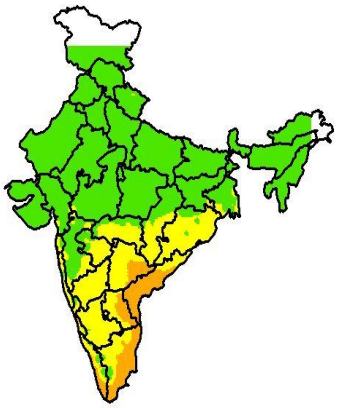

Figure 1.2 February month mean THI

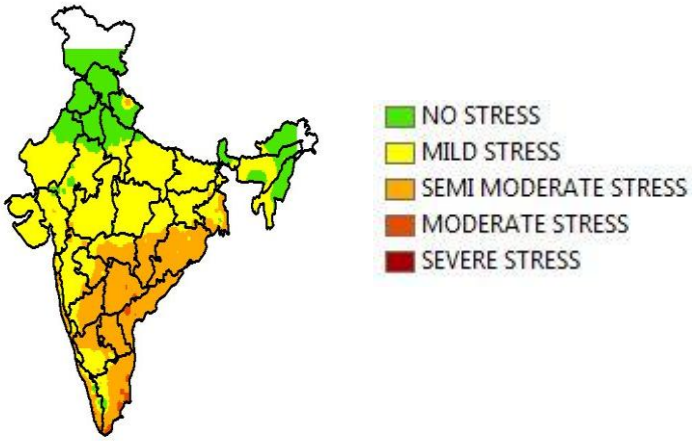

Figure 1.3 March month mean THI

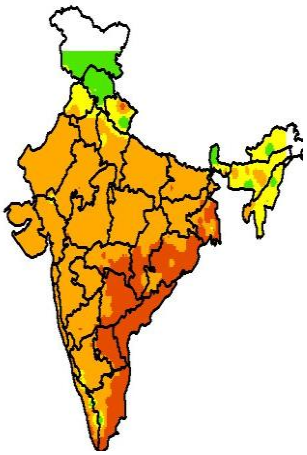

Figure 1.4 April month mean THI

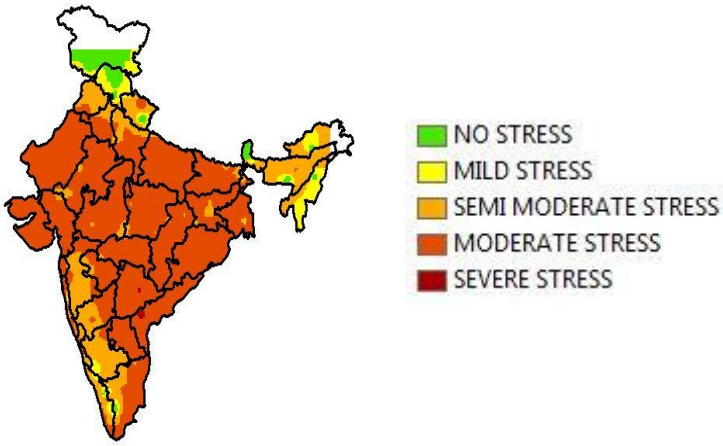

Figure 1.5 May month mean THI

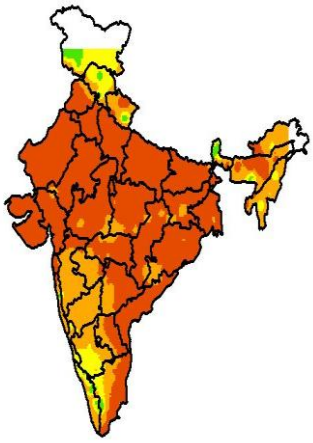

Figure 1.6 June month mean THI

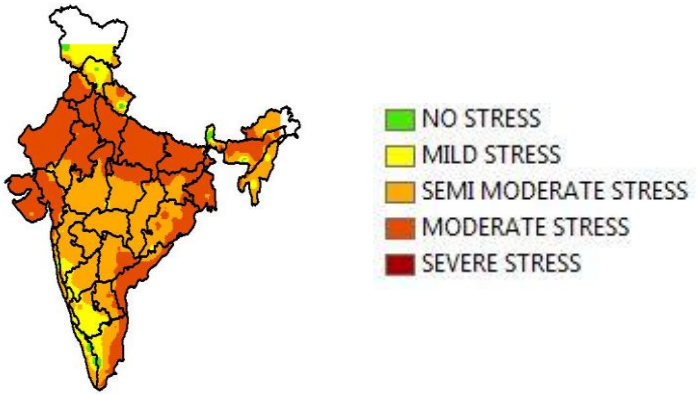

Figure 1.7 July month mean THI

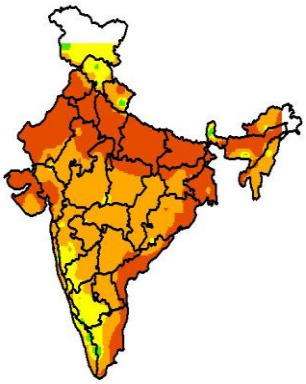

Figure 1.8 August month mean THI

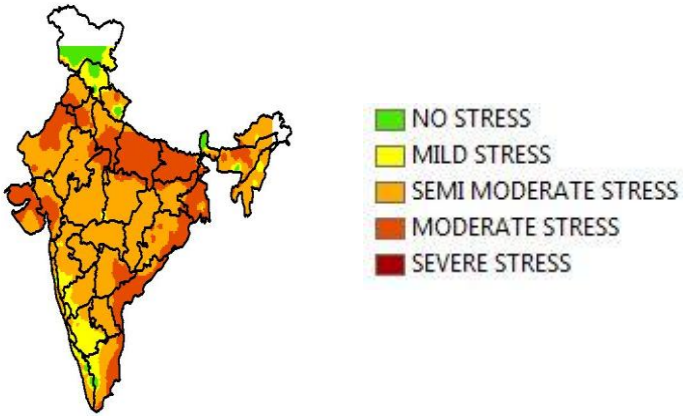

Figure 1.9 September month mean THI

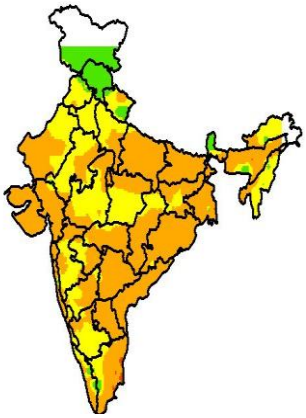

Figure 1.10 October month mean THI

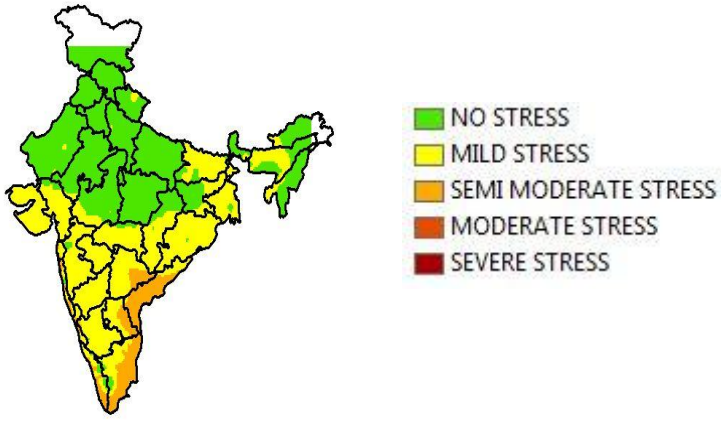

Figure 1.11 November month mean THI

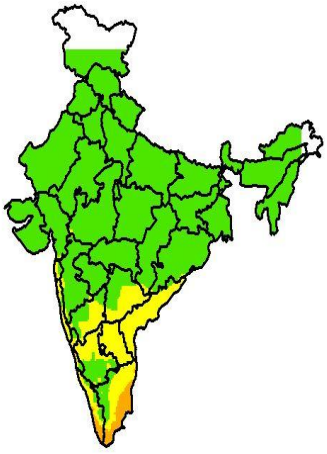

Figure 1.12 December month mean THI

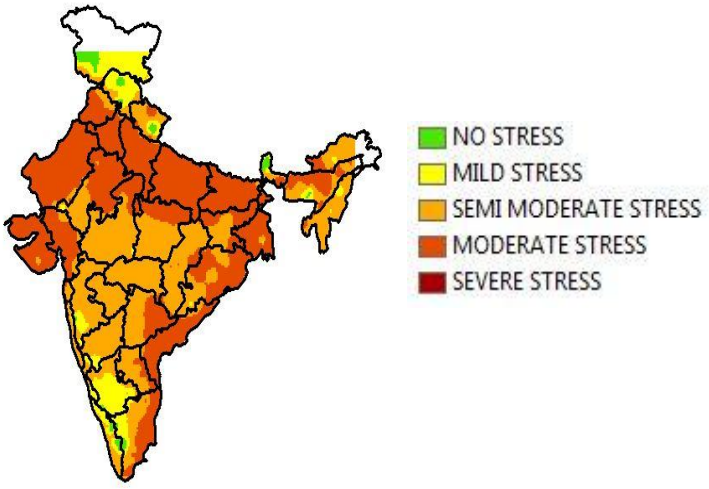

Figure 2.1 Monsoon season mean THI

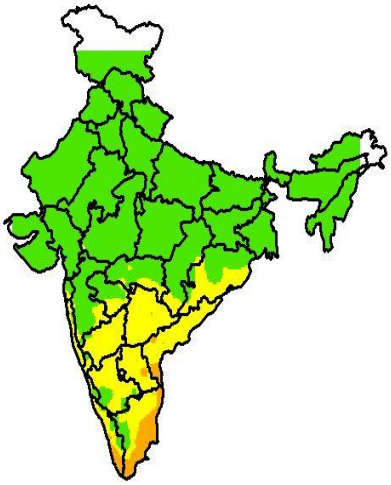

Figure 2.2 Winter season mean THI

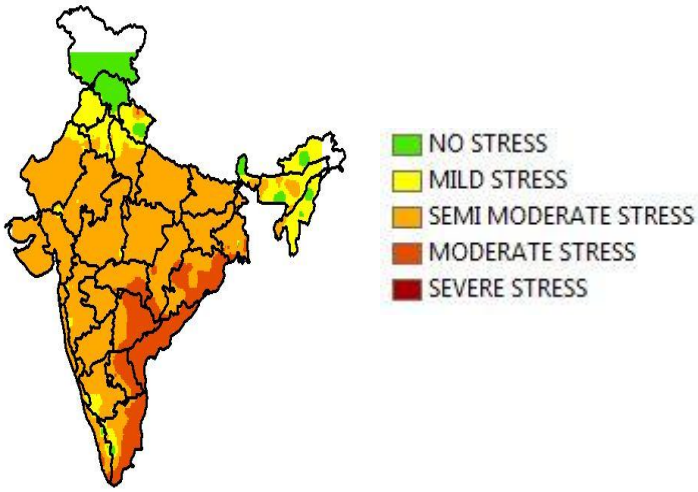

Figure 2.3 PreMonsoon season mean THI

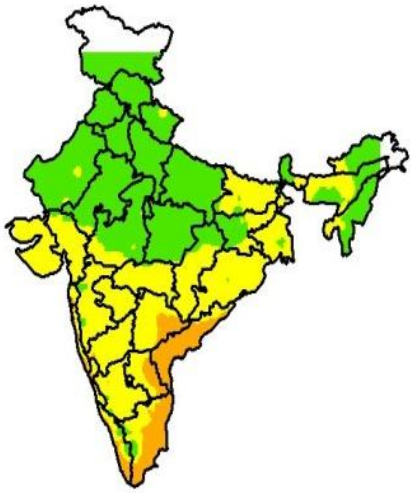

Figure 2.4 PostMonsoon seasons mean THI

located over Punjab, Uttarakhand, Kerala, major part of Karnataka, western plains of Maharashtra, Assam, Meghalaya and Tripura. Over the western coast Gujarat, Konkan region of Maharashtra showing severe stress condition. The Western Ghats distinguishes the stress condition between the coastal region and the plain region. June month (Fig1.6), the severe stress condition over the India significantly decreased but the creeping was towards Punjab, Jammu and Kashmir region. Occurrence of monsoon and moisture availability reduced the severe stress over the western and central Maharashtra, Karnataka and Kerala region. July (Fig1.7) and August month (Fig1.8), the severe stress condition sharply decreased over the central part of the country. Gujarat, Punjab, Rajasthan, Uttar Pradesh, Bihar, Assam and eastern coast showed severe stress condition. The mild stress condition was only located over the Jammu and Kashmir in July and August. During September (Fig1.9) the severe stress condition was reduced over Gujarat, Punjab and Haryana region. In October (Fig1.10), further the semi mild stress condition got converted into mild stress condition and significantly observed over the western Maharashtra, southern Karnataka and major parts of Madhya Pradesh. The severe stress was entirely converted into semi moderate stress especially over the eastern coast. During November (Fig1.11), Semi moderate stress was located over Andhra Pradesh, coastal Tamil Nadu, southern Kerala and Konkan region of Maharashtra. In December (Fig1.12) No stress condition was observed over the entire country except in Andhra Pradesh, coastal Tamil Nadu and southern Kerala.

3.2 Seasonal Mean THI

Pre-monsoon season

The pre-monsoon season map (Fig 2.3) consists of March April and May, was the combination of the semi moderate stress conditions and severe stress conditions. The semi moderate stress condition was located over Punjab, Uttarakhand, Kerala, major part of Karnataka, western plains of Maharashtra, Assam, Meghalaya and Tripura. Over the western coast Gujarat, Konkan region of Maharashtra showed severe stress condition.

Monsoon season

In Monsoon season map (Fig 2.1) the semi moderate stress condition was located over the Maharashtra, northern Karnataka, Arunachal Pradesh, Nagaland Manipur and Mizoram. The severe stress was located over the Rajasthan, Punjab, Uttar Pradesh, Bihar, Bengal, Andhra Pradesh, Orissa, major Assam and coastal belt of Tamil Nadu.

Post-monsoon

In Post-monsoon season map (Fig. 2.4) No stress condition was observed over the north and north-west part of the India, north-east including, Arunachal Pradesh, Nagaland, Manipur and Mizoram. Semi moderate stress was located over Andhra Pradesh, major part of Tamil Nadu, southern Kerala and Konkan region of Maharashtra. After the monsoon season, there was no severe stress condition located over the country. In monsoon season, severe stress condition over the east coast got converted into the semi moderate stress condition during the post monsoon season.

Winter season

During winter season No stress condition was observed over North and north-east India. The southern part of India was showed mild stress including southern part of Orissa, Andhra Pradesh, Telangana, and northern Kerala. Semi moderate stress was observed over few places of coastal Tamil Nadu and southern Kerala. In winter season, No stress condition get strengthened over the northern and central part of India.

4. Conclusions

The temperature-humidity index is an indicator of the degree of heat stress on the animals. In April severe stress condition was located only over the Telangana, Rayalseema, southern Chhattisgarh and east coastal states of India. In May, severe stress condition was located over entire country. During June month the Severe stress condition starts reducing over the country from the Western coastal states of India and completely removed in the October month. In the October month, the No stress condition was moving from North (Jammu and Kashmir) to south

and cover entire India during December month except Kerala, Tamil Nadu, Rayalseema, Andhra Pradesh, middle Karnataka and Telangana. The severe stress condition over the Eastern coastal states was locating from the April to September month while western coastal states except Gujarat were showing semi moderate stress condition. The oceanic features of Bay of Bengal and topography of eastern coast play important role for the generation of severe stress condition during April to September months. The mild stress condition over the Jammu and Kashmir was locating only from June to August while rest of months it show no stress condition. The mild, semi moderate or severe stress was always locating over the Tamil Nadu state.

In case of seasonal THI maps, monsoon season was the combination of semi moderate and severe stress condition located over the India. The winter season was combination of no stress and mild stress condition where the north India was showing no stress condition and the southern India showing mild stress condition. The post monsoon was combination of no stress condition, mild stress and semi moderate stress while the pre monsoon season was combination of semi moderate stress and severe stress condition. The Semi moderate stress located during the post monsoon season over the Tamil Nadu and Andhra Pradesh which get converted in to severe stress condition during the pre- monsoon season.

The thermal stress in different forms is continuously observed all over the country. Therefore, the mitigation practices should be followed for recovering the animals from the thermal stress during mild, semi moderate and severe stress condition. It is vital to keep cows as comfortable as possible, which maximizes dry matter intake and optimizes milk yield. Heat stress negatively affects cow comfort, dry matter intake and ultimately the productivity. The suitable management practices must be applied to counter environmental conditions that can lead to reduce the productivity. It includes fresh, cool, clean drinking water during stress condition with the balance ration. The use of cooling mechanisms including shade, fans, and sprinklers reduces the thermal stress mechanically. The cows' surroundings must be kept as clean and dry as possible to reduce microbial growth. Grazing is avoided during severe stress condition. The recommended pre-milking and milking time hygiene must be followed precisely to avoid infections. Finally, heat stress control practices should also be chosen according to the environmental, topographical and intensity of stress condition and applied carefully as one method proves successful in one place, this does not guarantee that it will be successful elsewhere in India.

References:

Bajagai, Y.S. (2011), Global climate change and its impacts on dairy cattle. Nepalese Veterinary Journal, vol. 30, pp. 2-16.

Bernabucci, U., Lacetera, N., Baumgard, L.H., Rhoads, R.P., Ronchi, B. and Nardone, A. (2010), Metabolic and hormonal acclimation to heat stress in domesticated ruminants, animal, 4(7), pp. 1167–1183.

Birthal, PS (2008), 'Linking smallholder livestock procedures to markets: issues and approaches', Indian Journal of Agriculture Economics, vol. 63, no. 1, pp. 19–37

Madhu Suman, Kale V.R., A.K. Tyagi and Nazam Khan (2012), impacts of Natural calamities on livestock sector and their mitigation strategies.

Xiaoxu Wu, Yongmei Lu, Sen Zhou, Lifan Chen, Bing Xu (2015), Impact of climate change on human infectious diseases: Empirical evidence and human adaptation, Environment International, Volume 86, January 2016, pp. 14–23.