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Trends in temperature, temperature humidity index and climate change at seven agro-climatic Regions of Tamil Nadu

KEYWORDS: Climate change, T maximum, T minimum, Temperature Humidity Index,

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ABSTRACT *In order to understand the climatic change happening in the different agro climatic regions of Tamilnadu,climatological data during the period 1955- 2005 were obtained from Indian Meteorological Department, Pune. From the basic temperature data mean maximum, mean minimum and Temperature Humidity Index (THI) was computed for each month for the seven agro climatic regions of Tamilnadu. Mean maximum temperature was observed at the month of May and Cauvery Delta zone showed maximum temperatureof 38.22 ± 1.33 ºCwith significant difference of P<0.01 between the regions. Mean minimum temperature was observed at the month of January and Hilly zone showed minimum temperature of 5.59±1.31 ºC with a significant difference of P<0.01 between the regions. The T max showed an increase in all the agro-climatic zones except in North Western Zone and Southern Zone. T min also showed a positive growth pattern in all agro-climatic zones except in North Western Zone and Southern Zone. Five agro-climatic zones viz. North Eastern zone, Western zone and Hilly zones, Cauvery Delta Zone and High Rainfall zone were showing a positive annual compounded growth rate for both morning and evening THI. In North Western zone the growth in THI was limited to morning and the evening THI showed a negative growth. Southern zone showed a negative annual compounded growth rate for both morning and evening THI.*

INTRODUCTION

Climate change disrupts temperatures, as well as rainfall patterns in many regions that would have great significance for livelihood and wellbeing of the people. Climate change will have social and environmental impacts that will likely increase uncertainty in water supplies and agricultural production for people across India (Geethalakshmi*et al.*, 2011). The cascading effects of rising temperatures are already affecting biodiversity, water availability and global feedbacks (Amin *et al*., 2004).

Many temperature trend studies particularly in India, main emphasis was directed on the analysis of annual and seasonal temperature data for a single station or a group of stations, as in the case of the present study, such studies date back to at least 50 years. First of this kind of studies were carried out by Pramanik and Jagannathan (1954). They did not find any general tendency for an increase or decrease in temperatures in relation with trends in the annual mean, maximum and minimum temperatures over the whole country. The study conducted by Srivastava *et al*. (1992) delivered the diurnal asymmetry of temperature trends over India which is quite different from that over many other parts of the globe. Significant warming trend of 0.57°C per 100 years was reported by Pant and Kumar (1997) who analyzed seasonal and annual air temperature series for 1881-1997. The magnitude of warming was higher in the post-monsoon and winter seasons.

Changes in mean temperature is an indication of climate variability, but changes in maximum temperature (Tmax) and minimum temperature (Tmin) provide more useful information (Braganza et al., 2004). It was found that countrywide annual surface air temperature has increased by 0.4^0C per 100 year in this century but the rate slowed down in the recent three decades (Hingane *et al.*,1985)

A likely increase of 1^0C over the central plains of India during monsoon season and a greater increase in minimum temperature compared to maximum have been indicated by Lal *et al.,* 1996. Rai and Chaudhary (1998) found an increasing trend of maximum temperature in all the seasons at Raipur, Madhya Pradesh.A similar trend was found in Punjab where minimum temperature has increased by about 0.4^0C in Patiala and 1.6^0C at Ludhiana (Hundal and Kaur, 2002). Rao *et al.* (2010) carried out the trend and time series analysis of the temperature data of 47 stations (Northern region 5, Eastern region – 7, Western region – 14, Southern region – 12 and Central region – 9) collected from Indian Meteorological Department. They found that three by fourth of the stations in southern region showed an increasing trend in maximum, minimum and average temperatures, which was not seen in stations of other regions. Singh and Rai (2011) assessed the changes in maximum and minimum temperature at Pusa using data of the period from 1953-2004 and found that annual average maximum temperature had decreased at the rate of 0.008^0C in the last 50 years. However, the annual minimum temperature had increased at the rate of 0.02^0C.

The vulnerability of animal production to climate change has hardly been documented in the context of India, which possesses the largest livestock population in the world. In general, the productivity level is lower in regions where

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mean annual temperature is higher and an increase in temperature is therefore, most likely to reduce the total optimum area where high-yielding dairy cattle can be economically reared (Gautam *et al.*, 2010).

Heat stress adversely affects production and reproduction of animals (Kazdere et al., 2002). A combination of adaptive and preventive measures are urgently required in conjunction with climatological data to assess climatic impact and provide a rational basis for decisions on long range management and housing strategies for livestock producers. It is important to conduct in depth vulnerability assessment to identify those areas of India which will be most affected by climate change. Similarly, a combination of long-term climate changes and expected production changes provide a rational basis for prediction of the impact of potential global climate changes on livestock production (Tadross *et al.,* 2005). Numerous studies have been performed to establish thresholds for heat stress in dairy cows. Milk production in dairy cows begins to decline when THI reaches the value of 72 (Johnson, 1980) or 69 (Bouraoui et al. 2002). The critical values for minimum, mean and maximum THI were 64, 72, and 76, respectively (Igono *et al.,* 1992). Vitali *et al*. (2009) found that the risk of death in dairy cows starts to increase when maximum daily THI is above 80. The aim of this study is to provide figures as well as composite (average) curves for the main meteorological parameters. Similarly, a combination of long-termclimate changes and expected production changes provide a rational basis for prediction of the impact of potential global climate changes on livestock production.

MATERIALS AND METHODS

Past data on temperature (maximum and minimum) and relative humidity for past 50 years (1955-2005) were collected from the National Data Centre, Indian Meteorological Department, Shivajinagar, Pune - 411 005, Maharashtra for understanding the climate change occurring in the Seven different Agro climate Zones of Tamil Nadu.Temperature Humidity Index (THI) was calculated for morning and evening from mean dry bulb and wet bulb temperature by using the formulaTHI = 0.72 (dry bulb temp+ wet bulb temp) + 40.6. From the basic temperature data mean maximum (T_{max}) and mean minimum (T_{min}) alongwith their standard deviation (SD) and significance was calculated by using SPSS 20. The long term mean and annual compounded growth rates of T. maximum, T. minimum and THI (morning and evening) were also worked by using the formula (LOGEST(DATA)-1)*100).Cluster analysis was performed with the primer software version 6. It is also essential to mention that there were some missing data in some months. Data were considered to be missing when the data were not recorded. To maintain the continuity, the gaps were filled up by the time mean values of the existing years. After completion collecting data were compiled, tabulated and analyzed according to the objectives of the study.

RESULTS AND DISCUSSION

Studying climate change has been one of the most challenging problems around the world because of both its practical value in meteorology and for scientific research. Every sign points to the facts that there is a recognized need for accurate estimates of the temperature on a variety of temporal and spatial scales ((Tadross et al., 2005). The THI morning in the seven agro-climatic regions of Tamil Nadu is presented in Table 1. All the seven agro climatic regions showed significant difference (P<0.01) in THI morning. Similarly, THI evening also showed significant difference (P<0.01) between different agro climatic regions that are presented in Table 2. The T_{max} in the seven agro-climatic regions of Tamil Nadu are presented in Table 3. Mean maximum temperature was observed at the month of May and Cauvery Delta zone showed maximum temperature of 38.22 ±1.33°Cand showed significant difference (P>0.01) between the regions. The T_{min} in the seven agro-climatic regions of Tamil Nadu are presented in Table 4. Mean minimum temperature was observed at the month of January and Hilly zone showed minimum temperature of 5.59±1.31 °Cand showed significant difference (P>0.01).

Table 1: Mean ± SD THI morning in the seven agro-climatic regions of Tamil Nadu

MONTHS	North Eastern Zone	North Western Zone	Western Zone	Hilly Zone	Cauvery Delta Zone	Southern Zone	High Rainfall Zone	Overall
Jan	69.72±3.30	69.67±1.87	71.14±2.76	53.59±1.29	72.29±1.09	73.74±1.31	74.59±0.94	69.60±6.20
Feb	71.36±3.69	71.18±3.71	72.46±2.28	55.08±1.17	73.89±1.34	74.84±1.26	75.84±1.06	71.03±6.31
Mar	74.50±3.84	74.41±4.00	75.07±1.87	57.53±2.62	76.88±1.09	77.36±1.03	78.29±0.71	73.87±6.44
Apr	78.16±4.32	77.63±4.28	77.53±1.22	60.61±3.02	79.95±0.72	79.88±0.83	80.09±0.69	76.82±6.42
May	78.94±4.88	77.87±4.30	77.70±1.39	60.77±5.17	80.21±0.74	80.69±0.88	79.97±0.84	77.21±6.72
Jun	77.83±4.19	76.36±4.13	76.34±1.76	60.29±0.74	79.13±0.59	79.95±1.02	77.99±0.91	76.06±6.24
Jul	76.94±3.98	75.44±4.00	75.35±1.95	58.64±3.74	78.23±0.68	79.01±0.87	77.10±0.72	75.07±6.51
Aug	76.53±3.85	75.12±3.96	75.25±1.80	59.35±0.57	77.82±0.63	78.98±1.01	77.05±0.74	74.92±6.12
Sep	76.34±3.84	75.25±3.99	75.53±1.71	59.53±0.74	77.51±0.61	78.80±1.02	77.59±0.72	74.92±6.04
Oct	75.52±3.70	74.81±3.94	75.26±1.43	59.47±0.81	77.07±0.61	77.44±4.41	77.70±0.64	74.37±6.07
Nov	73.25±3.50	72.78±3.80	73.95±1.84	57.91±1.22	75.34±0.82	76.23±0.97	76.78±0.64	72.70±5.85
Dec	70.74±3.38	70.29±3.61	71.93±2.52	55.53±1.75	73.29±1.02	74.53±1.35	75.28±0.90	70.53±6.03

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Table 2: Mean ± SD THI evening in the seven agro-climatic regions of Tamil Nadu

MONTHS	North Eastern Zone	North Western Zone	Western Zone	Hilly Zone	Cauvery Delta Zone	Southern Zone	High Rainfall Zone	Overall
Jan	75.75±1.30	75.78±1.71	76.22±1.57	60.51±.87	77.09±0.97	77.60±1.45	77.34±.77	74.81±5.20
Feb	78.28±1.87	78.35±1.73	78.53±1.38	62.04±1.10	79.43±1.25	79.43±1.25	78.32±0.90	76.94±5.41
Mar	80.95±2.49	80.83±1.57	80.86±1.36	63.64±1.02	82.27±1.16	81.68±1.02	80.20±0.74	79.30±5.70
Apr	82.86±2.70	82.26±1.31	82.12±1.29	64.41±.96	84.34±1.07	82.99±1.29	81.39±0.78	80.79±5.98
May	82.95±3.34	82.42±1.39	81.10±1.66	64.58±1.13	85.05±1.30	83.40±1.47	80.85±0.88	80.87±6.12
Jun	81.78±2.29	80.55±1.37	78.59±1.87	61.60±1.00	83.40±1.16	82.04±1.29	78.76±0.82	79.03±6.44
Jul	80.91±2.07	79.73±1.27	77.74±1.85	60.63±.83	82.64±1.16	81.89±1.32	77.98±0.75	78.18±6.46
Aug	80.71±1.95	79.51±1.15	77.86±1.68	60.96±.66	82.47±1.07	81.12±1.16	77.82±0.76	78.10±6.30
Sep	80.19±1.74	79.45±1.23	78.35±1.51	61.73±.84	82.05±1.18	81.07±1.27	78.33±0.72	78.14±5.98
Oct	78.41±1.28	77.91±1.13	77.72±1.07	61.51±.75	80.18±1.00	79.24±4.39	78.52±0.73	76.82±5.77
Nov	76.33±1.07	76.10±1.26	76.71±1.22	60.63±.93	77.85±0.94	78.08±0.99	78.11±0.54	75.31±5.28
Dec	75.11±1.07	74.87±1.48	75.60±1.53	60.20±.97	76.63±0.86	77.16±1.40	77.63±0.86	74.29±5.16

Table 3: Mean ± SD T_{max} in the seven agro-climatic regions of Tamil Nadu

MONTHS	North Eastern Zone	North Western Zone	Western Zone	Hilly Zone	Cauvery Delta Zone	Southern Zone	High Rainfall Zone	Overall
Jan	29.89±1.13	30.89±1.44	30.40±.87	21.10±1.19	30.42±0.71	30.84±.86	30.86±.58	29.52±3.09
Feb	32.73±1.32	33.57±1.34	33.06±1.09	21.66±1.19	32.89±.99	33.19±1.12	31.63±.56	31.73±3.68
Mar	35.69±1.39	36.2±1.15	35.62±1.08	22.68±1.19	35.57±0.93	35.82±1.18	32.18±.53	34.06±4.23
Apr	37.44±1.42	37.35±1.05	36.39±1.09	23.00±1.18	37.53±1.12	36.92±1.46	32.72±.56	35.25±4.59
May	38.13±1.65	36.84±1.29	34.79±1.31	22.27±1.15	38.22±1.33	37.66±1.56	32.43±.76	35.25±5.00
Jun	35.79±1.33	34.66±1.02	32.18±1.03	18.57±1.06	37.14±0.90	36.26±1.24	30.59±.82	33.15±5.50
Jul	34.33±1.26	33.62±.89	31.08±.95	17.20±.94	36.25±0.94	35.30±1.09	30.28±.74	32.07±5.55
Aug	33.76±1.21	33.06±.90	31.51±.77	17.59±.76	35.83±.81	35.39±1.03	30.39±.61	31.93±5.29
Sep	33.54±1.22	32.89±1.19	32.35±0.95	18.90±.82	34.89±1.06	35.62±1.22	30.53±.64	32.00±4.85
Oct	31.87±.97	31.53±0.97	31.48±0.90	19.09±.76	32.63±0.91	33.62±0.90	30.45±.48	30.68±4.19
Nov	29.72±.97	30.15±1.25	29.81±0.85	19.27±.82	30.36±0.82	30.99±1.14	30.19±.52	29.05±3.52
Dec	28.81±1.05	29.59±1.55	29.18±.95	20.33±1.26	29.42±0.81	29.42±0.81	30.27±.70	28.53±3.08

Table 4: Mean ± SD T_{min} in the seven agro-climatic regions of Tamil Nadu

MONTHS	North Eastern Zone	North Western Zone	Western Zone	Hilly Zone	Cauvery Delta Zone	Southern Zone	High Rainfall Zone	Overall
Jan	17.42±1.48	18.55±1.29	18.34±.92	5.59±1.31	20.46±.74	21.19±1.44	23.44±.53	18.12±4.82
Feb	18.82±1.54	19.66±1.35	19.44±1.06	6.59±.90	21.36±.98	21.88±1.46	23.86±.66	19.12±4.71
Mar	21.17±1.33	21.79±1.41	21.49±.80	8.83±.85	25.35±.92	23.63±0.92	25.14±.59	21.12±4.54
Apr	24.08±1.21	24.55±1.02	23.43±.59	10.73±.96	26.04±.60	25.66±.94	26.17±.48	23.44±4.54
May	25.15±1.36	24.75±.88	23.43±.58	11.58±1.00	26.80±.65	26.46±1.06	26.16±.62	24.01±4.50
Jun	24.73±1.32	24.03±.68	22.41±.54	11.03±.67	26.63±.55	26.18±1.11	24.58±.65	23.41±4.52
Jul	24.17±1.25	23.44±.65	21.81±.41	10.89±.58	26.11±.51	25.80±.97	24.04±.78	22.93±4.42
Aug	23.75±1.08	23.07±.62	21.83±.41	10.86±.72	25.64±.44	25.68±.98	24.00±.58	22.69±4.31
Sep	23.24±.94	22.80±.72	21.93±.37	10.39±.73	24.86±.44	25.18±.98	24.32±.41	22.34±4.29
Oct	22.26±.99	22.22±.74	21.81±.50	10.08±.93	24.15±.45	24.29±.96	24.31±.42	21.73±4.19
Nov	20.38±1.30	20.78±.91	20.73±.72	8.62±1.30	21.30±.67	23.07±1.45	23.77±.49	20.40±4.35
Dec	18.25±1.46	19.15±1.17	18.96±.92	6.85±1.51	24.02±0.38	21.78±1.45	24.02±.38	18.83±4.62

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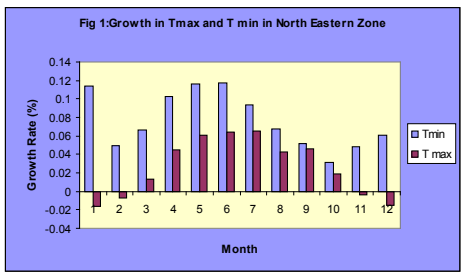
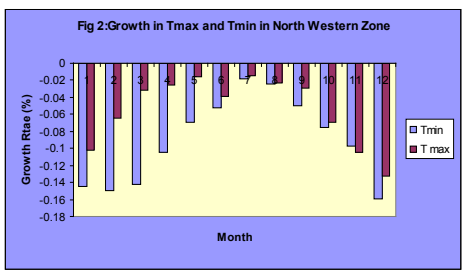
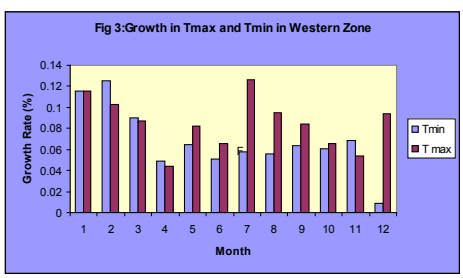
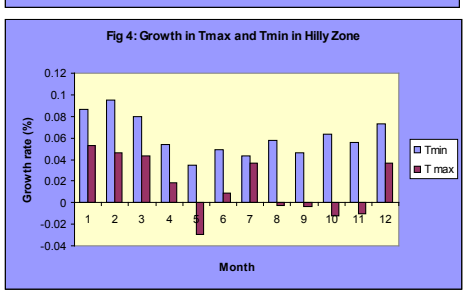
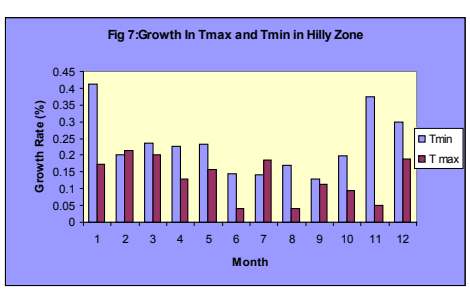
The annual growth rate of maximum and minimum temperatures showed different patterns for different agro-climatic zones in the study area. The annual compounded of T_{max} and T_{min} is shown in Fig 1, 2, 3, 4, 5, 6 and 7.

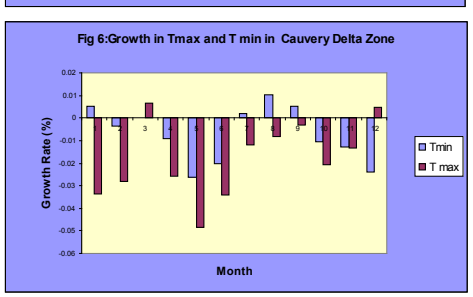




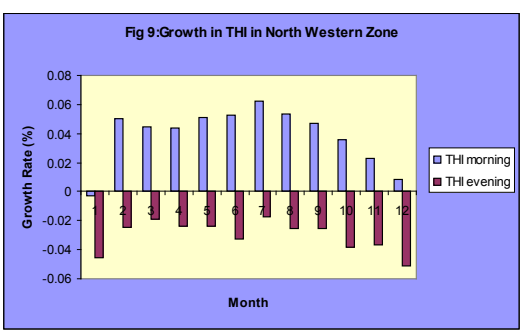


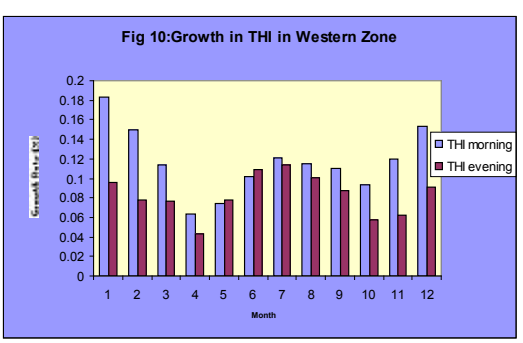


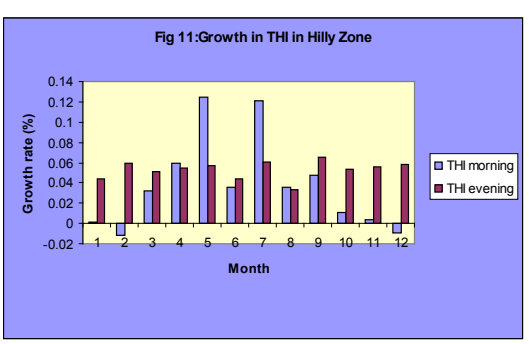




The T_{max} showed an increase in all the agro-climatic zones except in North Western Zone, Southern zone and Cauvery Delta Zone.T_{min} also showed a positive growth pattern in all agro-climatic zones except in North Western Zone and Cauvery Delta Zone. The annual growth rate of THI showed different patterns for different agro climatic zones that are presented in Fig 8, 9, 10, 11, 12, 13 and 14. Five agro-climatic zones viz. North Eastern zone, Western zone and Hilly zones, SouthernZone and High Rainfall zone were showing a positive annual compounded growth rate for both morning and evening THI. In North Western zone the growth in THI was limited to morning and the evening THI showed a negative growth and Cauvery Delta Zone showed a negative growth in THI Morning.







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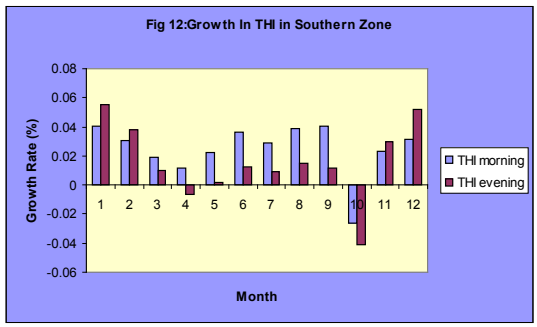

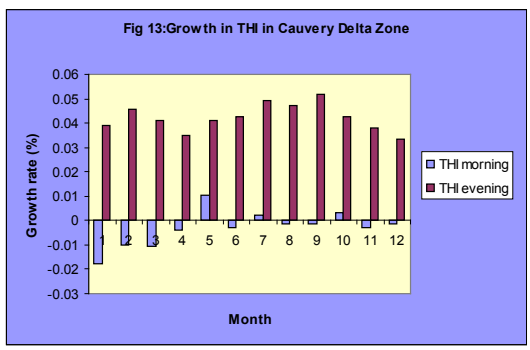

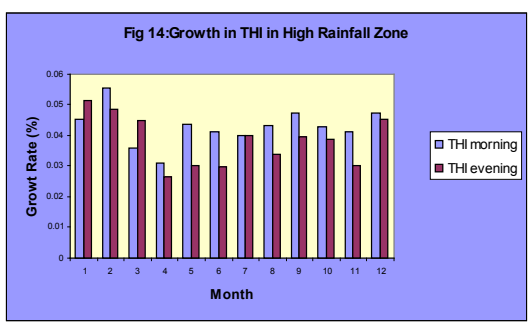

It can be seen that an environmental condition conducive to commercial dairy farming exists only in Hilly zone, where the temperature range is nearer to the thermal-comfort zone suggested by Hahn (1999). In other areas the THI was more than the mean critical value suggested by Igono et al. (1992). The above trend along with the decreasing trend of maximum and minimum temperature, points to the possibility that in future the North Western zone may become a very potential area for animal husbandry activities, especially for dairying. The increase in THI under the study areas indicate the future requirement for providing additional management measures for reducing the stress level of animals for improving the production. Sirohi and Michaelowa (2007) pointed out that climate change is likely to aggravate the heat stress in dairy animals, adversely affecting their productive and reproductive performance and hence reducing the total area where high yielding dairy cattle can be economically reared. In India a large number of farmers are depending on dairying for livelihood. A decrease in economic viability of dairying may force the farmers to go in search of other alternative employment opportunities.

CONCLUSION

The findings imply that there is definite climatic change in the different agro climatic regions of Tamilnadu and also significant (P>0.01) difference in change between the regions. Droughts, hot extremes, and heat waves are known to impact agricultural production and the livelihood of the local livestock farmers seriously. As climate change projections form the basis for assessing the impact on crop production and developing adaptation strategies, reliable future changes with reduced level of uncertainty are increasingly important. Careful intervention need to be adopted for sustainable livestock production and to improve productivity based on the specific needs of the region.

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