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Impact of climate change on Temperature Humidity Index Values in Egypt

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ABSTRACT

Climate change will have far-reaching consequences for animal production, especially in the vulnerable parts of the world. The aim of this study is to evaluate the changes of temperature humidity index (THI) values under climate change in Egypt. The evaluation has been done based on calculating the THI and classified according to the stress level under future climate for 12 governorates distributed on different climatic regions (Lower, Middle and Upper Egypt). The climate change data has been obtained from the database output of "regional climate change database for the agriculture sector" project in Egypt during the period from 2016 up to 2060. The results give evidence for significant changes in the THI values during the period from 2046 to 2060. The classifications of THI during the study period found that the moderate class shows significant gradual increase with time in all studied governorates and none stress class percentage tends to decrease in all governorates to the account of increasing the mild and moderate classes.

Keywords: Temperature Humidity index, Livestock, Climate change, and Egypt.

I. INTRODUCTION

Weather and climate is a constraint on efficient livestock production systems. One of the most important challenges in livestock production is to maintain appropriate microclimate, i.e. sufficient air temperature, humidity, air flow velocity, low pollution (with dust particles and microorganisms) and low content of gases. Weather indices are particularly useful for computing a single measure that accounts for the interaction between a set of weather variables and cattle production. Extreme weather conditions can cause substantial livestock production losses are able to dissipate heat, resulting in heat stress (Ghavi et al., 2013). Climate change is actually the most important environmental issue of any time. With severe and widespread destructive effects, warming of the planet threatens ecological systems, peoples' livelihoods, and species survival (Bekele Fereja, 2016). It is therefore necessary to develop and apply seasonal forecast, climate prediction and climate projection modelling tools and capacities in the all countries to enable scientists to provide the information needed to inform policy-making and decision-making on climate change adaptation and measures to enhance resilience across the all countries, special, in the Arab region (United Nations report, 2015). Climate change (CC) impacts agricultural production because climate provides essential inputs (water, solar radiation, and temperature) needed for plant and animal growth. The climate change especially global warming may highly influence production performance of farm animals throughout the world. Global CC alters ecological construction which causes both the geographical and phonological shifts (Van den and Coetzer 2008; Slenning 2010). These shifts affect the efficiency and transmission pattern of the pathogen and increase their spectrum in the hosts (Brooks and Hoberg 2007). A temperature-humidity index (THI) is a single value depicting the integrated effects of air temperature and humidity associated with the level of heat stress. This index has been developed as a weather safety index to control and decrease heat-stress-related losses (Bohmanova et al., 2007). The THI is a practical and useful tool and a standard for many applications in animal biometeorology. THI is extensively used in hot regions all over the world to evaluate the effect of heat stress on dairy cows and is currently used to estimate cooling necessities of dairy cattle in order to improve the efficiency of management strategies to alleviate the negative effects of heat stress (Ghavi et al., 2013). Rust and Rust 2013, have been reported the direct impacts of air temperature, humidity and wind speed capable of influencing growth rate, milk production, wool production and reproduction. The objective of this study is to evaluation the changes in temperature humidity index values under future climate.

II. METHODS AND MATERIAL

A. Study areas

The study areas were conducted on the 12 governorates distributed on different climatic regions (Lower, Central and Upper Egypt) according to the table 1.

Table 1: Coordinates of the studied locations.

No.	Region	Location	Latitude [°N]	Longitude [°E]	No.	Regions	Location	Latitude [°N]	Longitude [°E]
1	Lower Egypt governorates	Kafer Elsheikh	31.12	30.95	7	Middle Egypt governorates	Beni Suef	29.07	31.07
2		Beheira	31.03	30.46	8		Fayoum	29.30	30.85
3		Sharqia	30.58	31.50	9		Minya	27.74	30.83
4		Gharbia	30.82	31.93	10	Upper Egypt governorates	Asyut	27.20	31.17
5		Dakahlia	31.20	31.40	11		Sohag	26.60	31.78
6		Monufia	30.60	31.02	12		Qena	26.18	32.73

B. Future climate data

The future temperature and relative humidity data have been obtained from the database output of regional climate change database for the agriculture sector project in Egypt which simulate the climate change scenario of Representative Concentration Pathways RCP 4.5 for the global climate model (ECHAM6) by a horizontal resolution 50 km. The study focuses on the period from 2016 up to 2060 for the determined governorates to monitoring the changes of temperature humidity index values under climate change.

C. Temperature Humidity Index

Evaluating the changes in temperature humidity index values under climate change conditions will be done based on calculated the temperature humidity index (THI) equation which applying by Mader et al. (2006) as the following:

$$THI = (0.8 * T) + [(RH / 100) * (T - 14.4)] + 46.4$$

Where: T is air temperature (°C); RH is relative humidity (%).

D. The THI classes

The THI values have been classified in to five classes according to the stress level as shown in table 2 which recommended by (Chase, 2013). The studied time series from 2016-2060 were assessed at different levels of analysis of monthly, annual averages and classifications of THI.

Table 2: THI classes based on changes in THI values.

THI	Stress Level	Comments
< 72	None	
72 – 79	Mild	Dairy cows will adjust by seeking shade, increasing respiration rate and dilation of the blood vessels. The effect on milk production will be minimal.
80 – 89	Moderate	Both saliva production and respiration rate will increase. Feed intake may be depressed and water consumption will increase. There will be an increase in body temperature. Milk production and reproduction will be decreased.
90 – 98	Severe	Cows will become very uncomfortable due to high body temperature, rapid respiration (panting) and excessive saliva production. Milk production and reproduction will be markedly decreased.
> 98	Danger	Potential cow deaths can occur

III. RESULTS AND DISCUSSION

The current study investigates to evaluate the impact of climate change conditions on the THI values. The monthly and monthly averages as a normal trend for the study periods of THI have been calculated for the determined governorates in each region. Figures (1, 2 and 3) show the monthly average of THI values for the periods (2016 - 2030, 2031 - 2045, and 2046 - 2060) as a representation for climate change profile at the Lower, middle, and Upper Egypt governorates respectively, and it has been observed that the highest THI values were found during the last period (2046 -2060) and the lowest THI values were found in the period (2031-2045) in the three regions. Among the studied governorates, the highest THI values were found in Kafer Elsheikh governorate at Lower Egypt region while the lowest THI values was found in Asyut governorate at Upper Egypt region. July and August months record the highest THI values while January and December months record the lowest values of THI in the three regions.

Figures (4, 5 and 6) illustrate the annual average of THI values for the periods from 2016 up to 2060 at the Lower, middle, and Upper Egypt governorates respectively, and it has been observed that the highest years of THI values in the three regions were found during the last fifteen year from 2046 to 2060 and the lowest years of THI values were found in the first fifteen year from 2016 to 2030 in the three regions. The highest THI values were found in Kafer Elsheikh governorate at Lower Egypt region during the year 2059 while the lowest THI values was found in Asyut governorate at Upper Egypt region during the year 2016. The highest and lowest values of THI were found at Kafer Elsheikh and Monufia at Lower Egypt region, Minya and Beni Suef at Middle Egypt, Sohag and Asyut at Upper Egypt region.

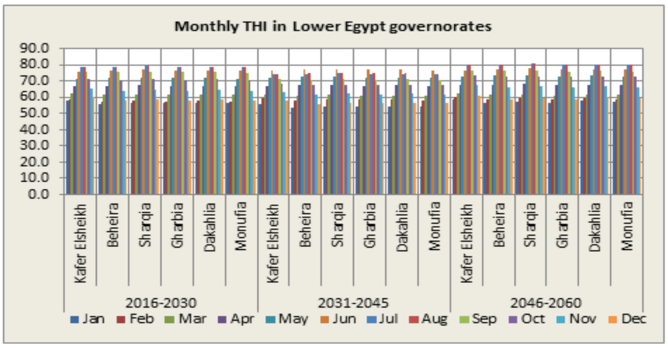

Figure 1. Monthly THI in Lower Egypt governorates.

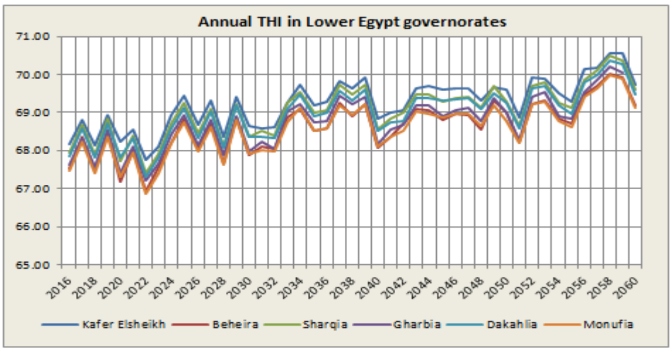

Figure 4. Annual THI in Lower Egypt governorates.

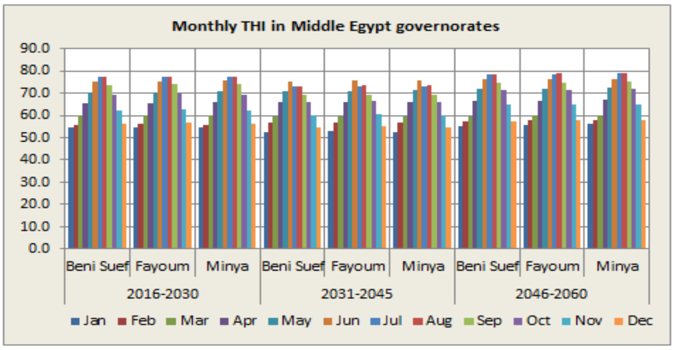

Figure 2. Monthly THI in Middle Egypt governorates.

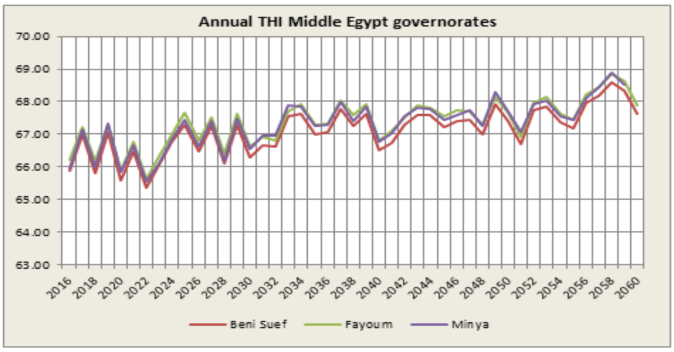

Figure 5. Annual THI in Middle Egypt governorates.

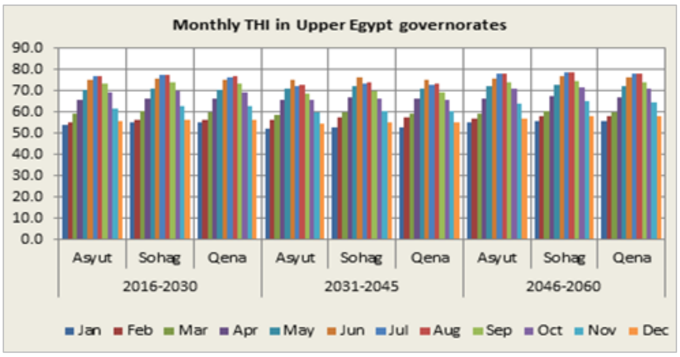

Figure 3. Monthly THI in Upper Egypt governorates.

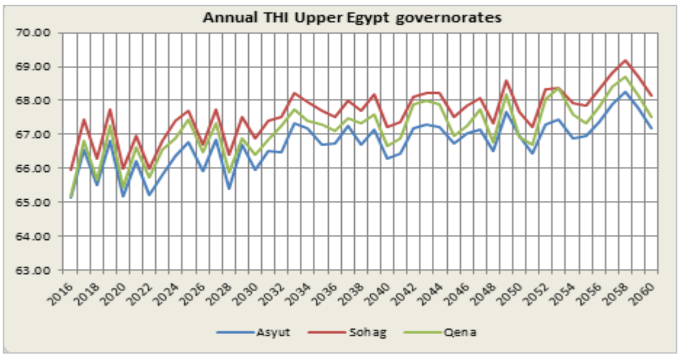

Figure 6. Annual THI in Upper Egypt governorates.

Figures (7, 8 and 9) illustrate the annual differences between the average annual THI for the years from 2016 up to 2060 as a normal in three regions (Lower, Middle and Upper Egypt) and the average of each year. Annual differences reflected that the highest positive and negative differences were found in the years of 2058 and 2022 in all governorates of Lower and Middle Egypt while in Upper Egypt the highest positive and negative differences were found in 2058 and 2016.

The first nine years from 2016 to 2024 were below the normal in Lower and Middle Egypt governorates while the last nine years from 2052 to 2060 were above the normal and the other years from 2025 to 2051 ranged between above and below the normal.

In Upper Egypt governorates the first period from 2016 to 2024 except 2019 were below the normal and the last nine years from 2052 to 2060 were above the normal. In addition, the other years from 2025 to 2051 ranged between above and below the normal.

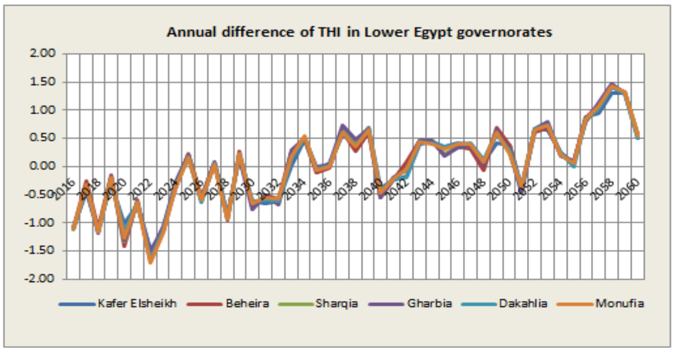

Figure 7. Annual differences of THI in Lower Egypt governorates.

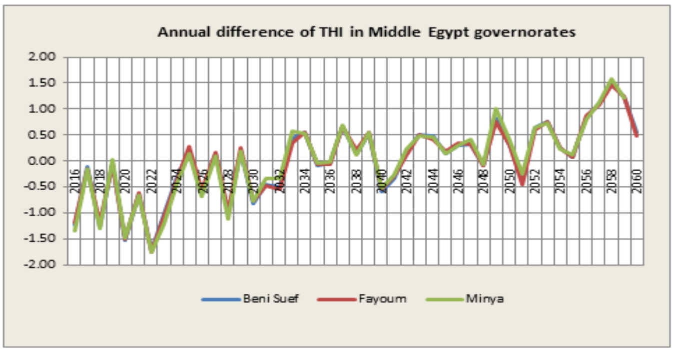

Figure 8. Annual differences of THI in Middle Egypt governorates.

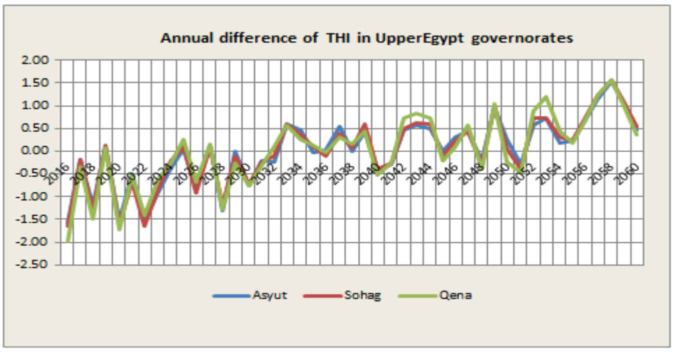

Figure 9. Annual differences of THI in Upper Egypt governorates.

The THI classifications have been checked in the monthly THI results of the studied governorates in each region and as indicated from figures (10, 11 and 12) which show the percentage of each class during the determined periods in the governorates of Lower, Middle and Upper Egypt respectively, the results limited to the three classes only from the stress classification of table 2 which are none, mild and moderate classes and the conditions of severe and danger were not observed during the study period. Among the governorates of all regions, the common stress classification is the mild class (as the none stress class is not account in the severity rating), however in the same time, the moderate class show significant gradual increase with time in all studied governorates where it's record highest percentage in the last studied period (2046 - 2060), and the governorates of Mnoufia, Minya, and Asyut were the highest sensitivity to this increase in the Lower, Middle, and Upper Egypt where their result projected to increase from 3%, 0%, and 4% in the (2016 - 2030) to 16%, 7%, and 11%, respectively by the period (2046 - 2060). Also it worth to mention that, the none stress class percentage tends to decrease in all governorates to the account of increasing the mild and moderate classes, and the decrement rate reached to its highest value in the Dakahlia governorate by a 9% from the begging period compared by the studied governorate.

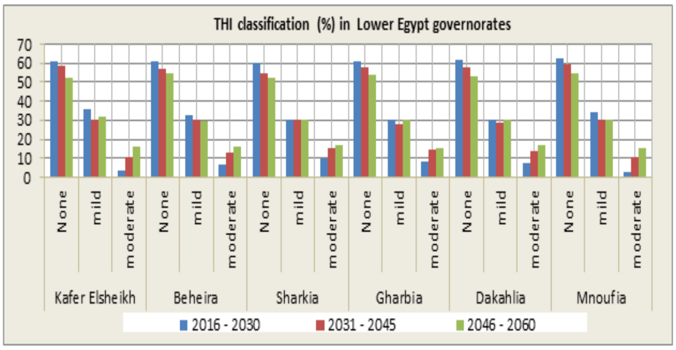

Figure 10. THI Classification in Lower Egypt governorates.

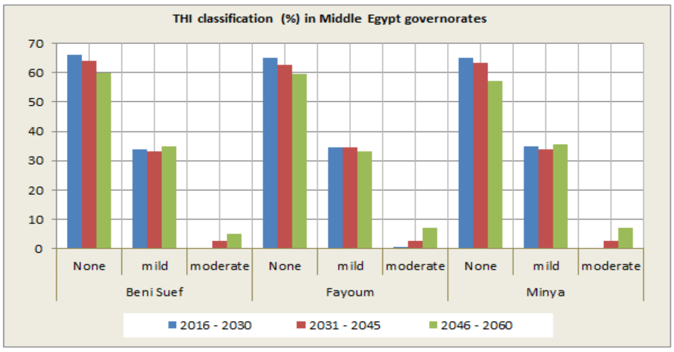

Figure 11. THI Classification in Middle Egypt governorates.

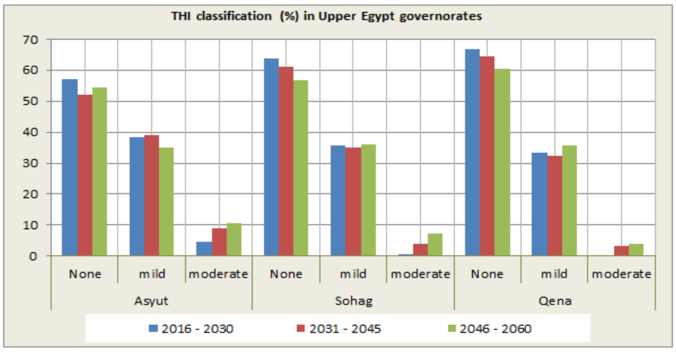

Figure 12. THI Classification in Upper Egypt governorates.

One regional study focused on the impacts of climate change on livestock production (Getachew, 2016) which is reported that the climate change could affect animal production and well-being, especially because of increases in air temperature. (Gantner, 2011) studied the determine microclimatic conditions in three climatic regions of Croatia as well as to evaluate the effect of temperature-humidity index values on the daily production of dairy cattle and found that Heat stress conditions indicated with mean daily values of THI>72 were determined during spring and summer season in all analyzed regions. The highest incidence of exceeded THI was observed in Mediterranean region (15 days in spring and 38 days in summer period). Absence of heat stress conditions during autumn and winter season characterized all three regions. In addition, the direct effects of air temperature, humidity and wind speed capable of influencing growth rate, milk production, wool production and reproduction have been reported by (Rust, 2013). (Amundson et al., 2005) studied the effects of temperature and temperature- humidity index on pregnancy rate in beef cows and found that average THI greater than 65 for the first 30 days of the breeding season tended to decrease pregnancy rate in the first 30 days, but there was no effect on pregnancy rate. If the 60-day average THI was greater than 70, pregnancy rate for 60 days tended to decrease. Breeding season THI had no effect on pregnancy rate. High temperatures and high temperature-humidity index decrease the pregnancy rate during the first 30 days of the breeding season. Also (Herbut and Angrecka, 2012) studied the effects of microclimate parameters of the barn have been assessed based on the THI (temperature-humidity index) in relation to milk production and reported the research revealed that the animals suffered from thermal stress which resulted in decreased milk production. The temperature-humidity index is nearly as good a predictor of rectal temperatures in a subtropical environment (Dikmen and Hansen, 2009).

IV. Conclusion

In general, this paper presents the impact of climate change on THI values in different three regions in Egypt during the period 2016 up to 2060. The results give evidence for significant changes in the THI values during the period from2046 to 2060. The classifications of THI during the study period found that the moderate class show significant gradual increase with time in all studied governorates where it's record highest percentage in the last studied period (2046 - 2060) and the none stress class percentage tends to decrease in all governorates to the account of increasing the mild and moderate classes

V. ACKNOWLEDGEMENT

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