Reverse Impact of Temperature as Climate Factor on Milk Production in ChaharMahal and Bakhtiari

V. Jafari, M. Jafari

Abstract**—**When long-term changes in normal weather patterns happen in a certain area, it generally could be identified as climate change. Concentration of principal's greenhouse gases such as carbon dioxide, nitrous oxide, methane, ozone, and water vapor will cause climate change and perhaps climate variability. Main climate factors are temperature, precipitation, air pressure, and humidity. Extreme events may be the result of the changing of carbon dioxide concentration levels in the atmosphere which cause a change in temperature. Extreme events in some ways will affect the productivity of crop and dairy livestock. In this research, the correlation of milk production and temperature as the main climate factor in ChaharMahal and Bakhtiari province in Iran has been considered. The methodology employed for this study consists, collect reports and published national and provincial data, available recorded data on climate factors and analyzing collected data using statistical software. Milk production in ChaharMahal and Bakhtiari province is in the same pattern as national milk production in Iran. According to the current study results, there is a significant negative correlation between milk production in ChaharMahal and Bakhtiari provinces and temperature as the main climate change factor.

Keywords**—**ChaharMahal and Bakhtiari, climate change, impacts, Iran, milk production.

I. Introduction

GLOBAL climate change generally means long-term changes in typical weather patterns for an area, such as alterations in air pressure, temperature, average precipitation, water availability, carbon dioxide levels in the atmosphere and the frequency of extreme weather events [1] in ways that will affect the productivity of crop and dairy livestock [2], [3]. In addition, climate change plays an important role in synergy to intensify risk: the combination of increased globalization change is powerful major than either component alone [4]-[8]. The report of the United Nations Intergovernmental Panel on Climate Change reviews the potential development of climate change in detail [9]. The fifth assessment report [10] gives an emphasis to the probability that the Earth's climate will continue to change, and it is expected that there will be elevated temperatures and increased imbalance in climate for most parts of the world. Recommendations on food safety from climate change analyses are normally universal and geographically large scale in scope, however, scientists and policymakers are mostly obliged to act more locally to gather evidence with the consequences of environmental change within their remit [11].

Main greenhouse gases (GHGs) in the Earth's atmosphere are carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), ozone (O_3), and water vapor (H_2O) which absorb and emit radiant energy within the thermal infrared range. This process is the principal reason for the greenhouse effect [12]. In the absence of GHGs, the average temperature of the Earth's surface would be about −18°C (0°F) [13], rather than the present average of 15°C (59°F) [14]-[16]. The levels of GHGs in the atmosphere have been increasing seriously and are unprecedented compared with the past 800,000 years [10]-[15]. GHGs are important in adjusting the Earth’s energy balance. Their presence in the atmosphere reduces the Earth’s ability to radiate the Sun’s energy back into space, and so the surface temperature rises [10].

On one hand, agriculture may result in global GHG emissions [17]. On the other hand, the changing climate also is responsible for the alteration of producing agricultural sector [2], [7].

Climate change affects milk production because of the sensitivity of dairy cattle to intemperate humidity and temperature [18]. By reducing milk production due to climate change, dairy production is also affected, which is an important part of the agricultural economy. Therefore, it is important to examine the issues that could challenge agricultural cattle ambition [6].

Iran is the second-largest country (1,648,195 km^2) in the Middle East (it lies between latitudes 24° and 40° N, and longitudes 44° and 64° E), with a long dairy tradition. The total population of dairy cattle and calves has been 8151 thousand heads in 2015 and elevated by 6% from the previous year, approximately [19].

The total dairy production has been about 9654 thousand tons of milk per year in 2015, an increase of 5.6% from the previous year [19].

II. Material and Methods

A. Study Area

This study aims to determine the impact of climate change on the milk production of ChaharMahal and Bakhtiari, which is one of the 31 provinces of Iran and its capital is Shahr-e kord. It covers an area of 16,332 km^2 with 895,263 inhabitants and 1,799,100 livestock [19]. ChaharMahal and Bakhtiari located at the center of Zagros Mountains, and are limited to Isfahan from the north and the east, from the west to Khoozestan province, from the south to Kohkilooyeh and Boyer Ahmad and from the northwest to Lorestan province (Fig. 1).

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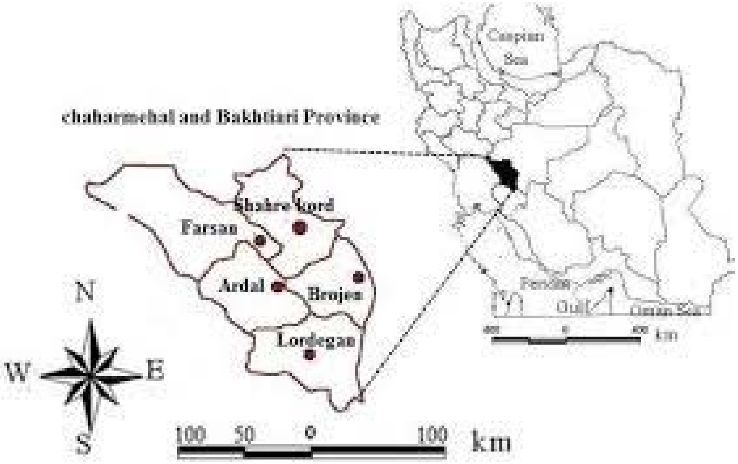

Fig. 1 Location of ChaharMahal and Bakhtiari Province in Iran [20]

The main water sources in the region are four rivers branched from Zagros heights (Zayandeh Rood, Karoon, Karkheh, and Dez Rivers). Because of the high Zagros Mountains, temperature varies in different parts of the province. The maximum and minimum temperature has been recorded at Lordegan synoptic station with 47.5° and Dezzak climatological station with -34.5°, respectively [21]. This province has a very appropriate rain. The rains are mostly affected by Mediterranean flows that have an effect for nearly eight months. The rains begin from October, increase to the peak value in January and decrease in May. The average level of precipitation is nearly 560 mm annually.

B. Research Methodology

The methodology employed for this study consists of the following steps:

1- Collect reports and published national and provincial data available on milk production as dairy productivity [22].
2- Collect all available recorded data on temperature and precipitation as climate factors [23].
3- Analyze all collected data using statistical software such as Minitab, Excel, and others.

Note 1. In this study, to isolate the effects of climate change on milk production, other variables are as considered constant.

Note 2. Milk production, temperature and precipitation data for ChaharMahal and Bakhtiari are collected for a minimum of 15 years.

III. Results and Discussion

According to the available data related to dairy cattle milk production, there is a significant correlation between annual milk production for the province of ChaharMahal and Bakhtiari and total milk production of the country (Fig. 2).

This study found evidence of a significant negative relationship between temperature as a climate change indicator and milk production of ChaharMahal and Bakhtiari. Climate change factors over 15 years showed decreasing asymmetric temperatures and irregular changes in precipitation, which increase dairy production in cattle (Figs. 3 and 4). Increasing temperature between the year 2007 and 2008, combined with a sharp decrease of precipitation, caused a stair-like decrease in milk production which can be attributed to heat stress [24].

Dairy cattle have a range of ambient environmental temperatures called the Thermoneutral zone (TZ) or Comfort zone (CZ) that is conducive to health and performance. Over this range is the point at which heat stress effects begin to affect the cattle’s milk production [24], [25].

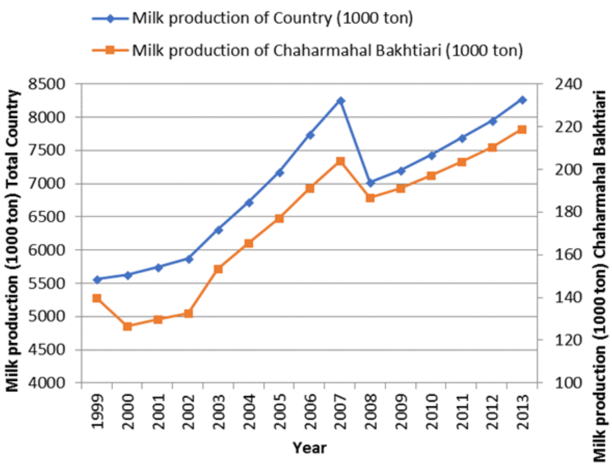

Fig. 2 Comparison of annual milk production for the province of ChaharMahal and Bakhtiari and total milk production of the country

A sharp decreasing temperature between the year 2001 and 2003 led to a significant increase in annual milk production of dairy cattle in ChaharMahal and Bakhtiari province which can be attributed to heat stress, and furthermore, temperature effect on forage production [1].

As shown in Fig. 3, there is a negative correlation between annual milk production and temperature.

There is a positive relationship between annual milk production and an irregular increase in precipitation (Figs. 4 and 5). Furthermore, annual milk production has increased significantly with a gradual decrease in temperature and an irregular increase in precipitation (Figs. 3-5).

As shown in Figs. 3 and 4, between the years 2006 and 2008, increasing temperature (about 10°C) led to a decrease in precipitation (about 400 mm) and annual milk production (about 4000 ton).

We found that our estimated milk production losses are strongly influenced by climatic and geographic variations in humidity and temperature. Temperature, as a climate factor, has an inversion correlation with annual milk yield. These results agree with the findings of [25], [26]. Based on this research, there is a significant correlation between precipitation and annual milk production which agrees with the findings of [26], [27].

IV. Conclusion

Because of significant correlation, ChaharMahal and Bakhtiari's milk production could be considered a representation of the country's total milk production. It seems that increased temperature is higher than cattle could be resisting, then there is a significant negative relationship between temperature as a climate change indicators and milk production. According to the 15 years climate data, temperatures showed a decreasing trend, which has a negative correction with increase dairy production in cattle. Combination of the sharp decrease of precipitation between the year 2007 and 2008 with increasing temperature, caused a stair-like decrease in milk production.

In 2001, temperature lowered the value of annual milk production. After rising temperature in 2007, we see a sharp decline in milk production. When the temperature is higher than the cattle's thermoneutral zone (an optimal range ambient environmental temperature), the animal will change physiological metabolism [28] to cool themselves to maintain body temperature. The first and most common behavioral changes are increasing respiration rate, increasing body temperature, increasing water intake (drink more) and decreasing dry matter intake [28]-[30]. Heat stress can negatively impact dairy production by lowering intake, milk production and reproduction.

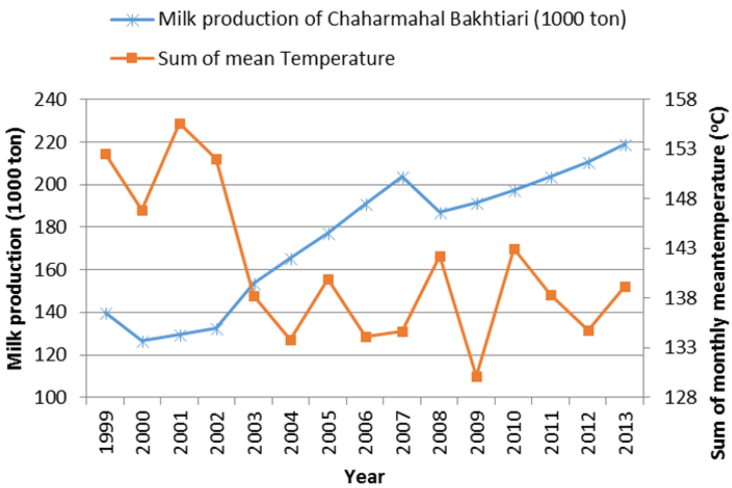

Fig. 3 Milk production and sum of monthly mean of temperature in ChaharMahal and Bakhtiari

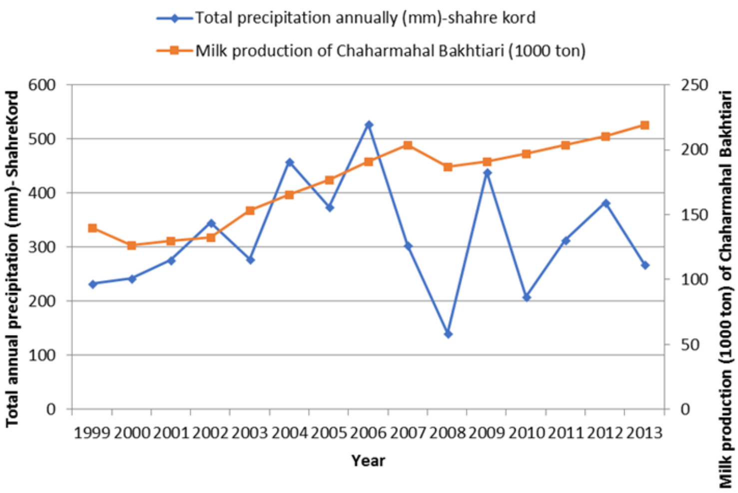

Fig. 4 Comparison of annual milk production of ChaharMahal and Bakhtiari and total annual precipitation

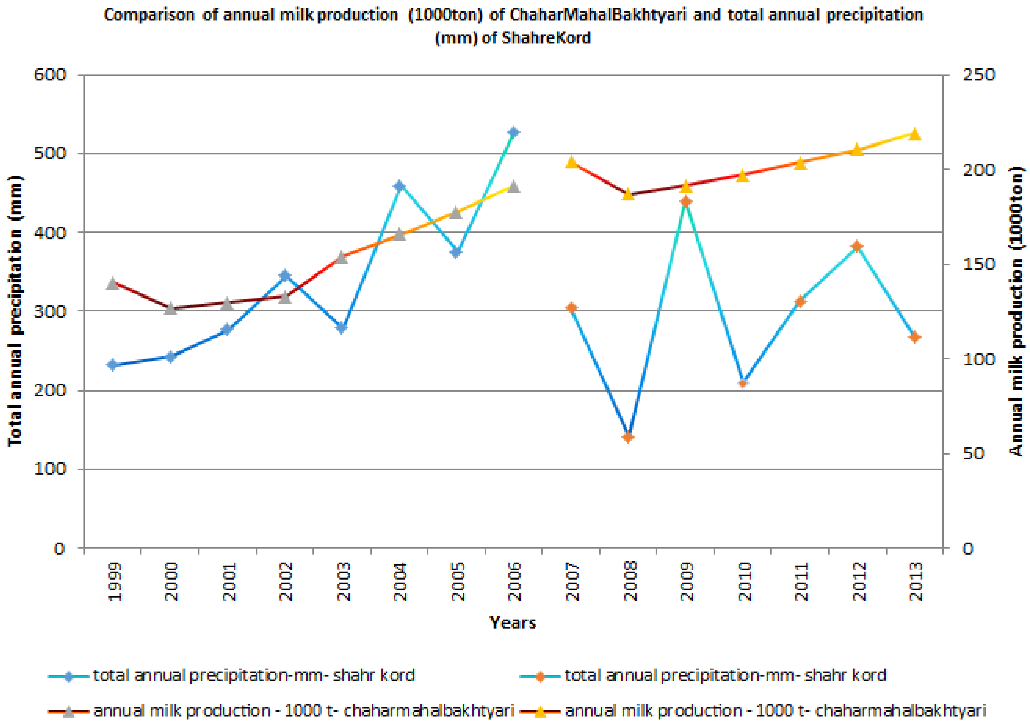

Fig. 5 Comparison of annual milk production and total annual precipitation of ChaharMahal and Bakhtiari and Shahr-e-kord

After the decline of precipitation in 2006, we see a slight decrease in milk production. The more frequent and intense precipitation can result in greater contamination of both silage and grazing pasture by heavy metals. These contaminants may influence the milk production of dairy cattle [3], [31]-[33]. In wetter conditions, animal diseases may become a complication factor. So, increased use of veterinary medicines increases the incidents of transmission of chemical residues in the food chain and direct drug resistance into the dairy industry.

Climate change may represent a fundamental challenge for the continuing development of the dairy sector. Heat stress and wet conditions are the two main causes of reducing milk production, in which the absence of these two factors has led to an increase in milk production.

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