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Analysing the impact of climate change on dairy farming as perceived by the women farmers: Application of analytical hierarchy process

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ABSTRACT

Impact of climate change on various sectors across the globe is quite evident and the dairy sector is no exemption to the threats of changing climate. Most of the activities in dairy farming are performed by women. Dairy farming is a source of sustainable income for the women in rural areas. Women are more vulnerable to the adverse effects of climate change due to their socio-economic position in the society. So, an attempt was made to capture the impacts of climate change on dairy farming from women farmers' perspective. A total of 360 women farmers were approached for the study. Analytical hierarchy process was used to identify which of the four components and 16 sub-components of dairy farming are most affected due to changing climate. Analysis of farmers' responses revealed that productive performance was perceived to be the most affected component and average daily milk yield was perceived to be greatly affected due changes in climate.

Keywords: AHP, Climate change, Dairy farming, Women farmers

Indian farmers rely economically on agriculture and livestock, both significantly affected by climate change. India has seen a 0.70°C temperature rise from 1901 to 2018, with projections suggesting a potential 4.40°C increase by 2100. Additionally, heavy rainfall intensity increased by 75% from 1950 to 2015 (Krishnan *et al*. 2020). Dairy farming faces climate change threats like higher temperatures and altered rainfall, impacting animal health, feed, water availability, and milk production. Heat stress is projected to cause significant losses: 339,000 tonnes of milk during 2020-29, rising to 629,000 tonnes by 2030-39. This equates to monetary losses of ₹15.25 billion from 2020-29, increasing to ₹28.30 billion in the next decade (Choudhury and Sirohi 2022).

Livestock production sustains employment, income, and food security for over 70% of India's population, with women playing a pivotal role, but often overlooked in its establishment (Kaur *et al*. 2019) and most of the responsibilities in dairy farming are shouldered by women. However, their participation in the financial activities of dairy farming is very low (Rajpurohit *et al.* 2019).

The threats posed by variations in climate change on milk production could cripple the livelihoods of women and their financial security. Hence, it is crucial to understand the negative impacts of climate change on dairy farming from the perspective of women farmers. This will help prioritize extension interventions and policy-making to sustain milk production and ensure the financial security of resource-poor rural women in India.

MATERIALS AND METHODS

Study area: The present study was conducted in the three randomly selected districts (Jind, Hisar and Rohtak) of Haryana's buffalo breeding tract. Two blocks from each district and again three villages from each block were randomly selected. Twenty women farmers who were having at least two dairy animals were selected randomly from each 18 villages of the three districts. Hence, a total of 360 women farmers were selected for the study.

Data source: A structured questionnaire consisting of all possible pairs of alternatives under each of the four identified components were prepared on consultation with the experts in the field. The farmers were presented with all the possible pairs of alternatives under each of the four components and were asked to identify which of the two in pair was most affected due to climate change and were further asked to indicate a degree of severity or importance as proposed by Saaty (2008) in his Analytical Hierarchy Process (AHP). The respondents were contacted at their doorsteps and data was collected. The collected primary data was statistically analysed with the Microsoft Excel and Analytical Hierarchy Process (AHP) developed by (Saaty 2008) was used to identify the sensitive components and alternatives. The procedure followed in the calculation of priority weights is presented in Fig.1.

Analytical hierarchy process: Effect of climate change on dairy farming is operationalised as negative consequences

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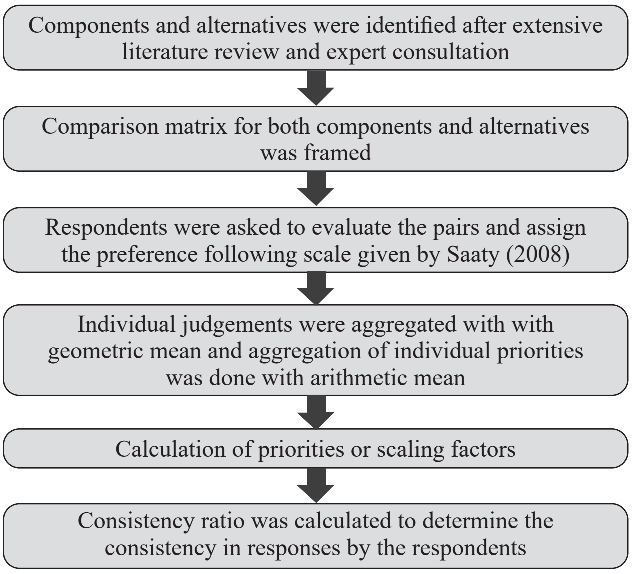

Fig. 1. Procedure followed in calculation of priorities using Analytical hierarchy process.

perceived by farmers on parameters like productive performance, reproductive performance, feed and fodder utilization and availability and disease susceptibility due to the changing climate. Analytical Hierarchy Process (AHP) was employed to quantify the effect of climate change on dairy farming as responded by the women farmers to the pair of statements (alternatives) under each component: four different components, i.e. productive performance, reproductive performance, feed and fodder availability and utilization and disease incidence and susceptibility. Again, under each component different alternatives were framed to further know which alternative is most effected due to vagaries of climate change (Fig. 2). An attempt was made to identify which of the four components was most effected due to changes in climate as well as to identify which sub-component or alternative under each component was most sensitive to climate change as perceived by women dairy farmers.

RESULTS AND DISCUSSION

Priority weights of the components and alternatives in relation to their sensitivity to climate change: The effect of climate change on dairy farming as perceived by women farmers was quantified in terms of priority weights (Higher the priority weight, higher the sensitivity) assigned by the respondents to four different identified components. The results presented in Table 1 clearly show that the consistency ratio is less than 0.1, indicating that responses given by the farmers were consistent. Farmers perceived that productive performance is the most affected component of all the components due to climate change followed by reproductive performance, feed and fodder availability and utilization, and disease incidence and susceptibility.

Table 1. Priority weights of the components considered for the study

Component	Priority weight	λmax	CI	CR
Productive performance	0.564			
Reproductive performance	0.161			
Feed and fodder availability	0.135	4.156	0.052	0.058
Disease incidence and susceptibility	0.139			

Perceived impact of climate change on productive performance: Five alternatives under productive performance component were identified and farmers were asked to respond to all the possible pairs formed and priority weights were calculated (Table 2). Higher the priority weight, higher the sensitivity to climate change. Average daily milk yield was followed by lactation milk yield. Farmers reported that around 1.5 to 2 L of milk reduction during May to September because of scorching heat coupled with high humidity levels. The negative impact of rise in temperature on total milk production in India has been estimated to be more than 15 million tonnes by 2050 (Balhara *et al.* 2017). Sudden variations in temperature, either a rise in maximum temperature (>4°C above normal) during summer or a fall in minimum (>3°C than normal) during winter can cause a sharp reduction in milk yield (Upadhyay *et al*. 2013).

Peak yield is another indicator that was most sensitive after average daily milk yield and lactation milk yield.

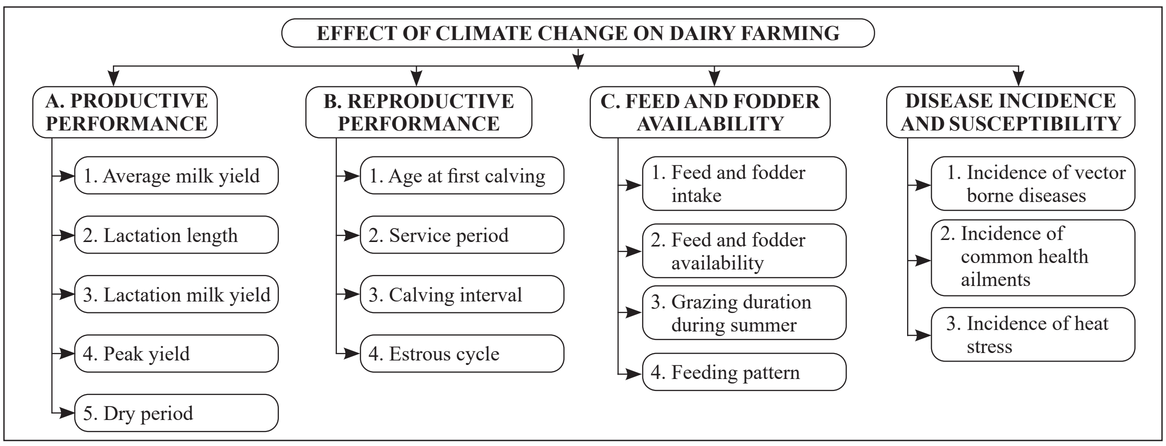

Fig. 2. Problem modelling of Analytical hierarchy process used in the study.

Farmers felt that if the peak yield period coincides with extreme hot humid period (June to September), there was a reduction of at least 2-2.5 L of milk in the peak yield. And extreme winters, i.e. December and January during which the temperature falls as low as 5°C, reduction of milk yield of about 1.5 L was reported by the farmers. The results reported in a study clearly indicated that a decrease in peak milk yield was associated with increase in maximum temperature and maximum humidity in the rainy season, i.e. June to September. For every unit increase in minimum temperature, maximum humidity, wind speed and THI has resulted a reduction in peak yield by -0.21, -0.03, -0.55 and -0.23 L, respectively (Kamble *et al.* 2014). Similar results were reported in another study that a decrease in peak milk yield average by 1 kg for every increase of 5 units over 71.33 THI units (Shinde *et al.* 1990). Fall in peak milk yield average was observed for every 3.06 units increase after 70.30 units of THI (Kundu and Bhatnagar 1985).

Lactation length or lactation period was the next most affected indicator under the productive performance component. Farmers reported that if the lactation period ends in summer months, milk yielding period was almost shortened by at least 15 days than the normal. Heat stress also leads to decrease in lactation period by 35 days and the fat, protein, lactose, SNF, total solids and ash by 7.92, 4.06, 3.97, 4.03, 5.21 and 5.63%, respectively when compared with that of winter season in HF cows (Gaafar *et al.* 2011). The studies conducted by Upadhyay *et al.* (2007) at National Dairy Research Institute, Karnal, India show that lactation period was reduced by 3-7 days during summers when Temperature Humidity Index was more than 80.

Dry period was the least sensitive indicator among the productive performance indicators. Animal is dried off for a period of 2-3 months before calving. Dry period is very important to the animal as it may rest and udder tissue is repaired. In high yielding buffaloes (more than 10 kg/day) should be dried off completely when the milk yield falls below 2.5 kg.

Perceived impact of climate change on reproductive performance: Farmers from the sampling area felt that the calving interval was the most sensitive indicator to climate change under the reproductive performance component (Table 2). Silent heat is very big problem in Murrah buffaloes. Climate, nutritional and other management factors push the service period further and thus affects the intervals between two calvings which is not economical for the farmer.

Estrus cycle was the next most affected indicator. Decreased day length and temperature are the two important factors that affect the activation of the buffaloes sexually (Zicarelli 2010). Breeding frequency is generally high in cooler months compared to hot and humid months of the year (Dash *et al*. 2016). Farmers generally felt that detection of heat in Murrah buffaloes is very difficult but not in cross and indigenous breeds of cattle. Majority of the farmers opined that estrus cycles are more disturbed and becomes difficult in summer months than in other months of the year to identify if the animal has come in heat. Farmers also observed that conception rates in summer months are very less, and repeated artificial inseminations were needed to be done. It was also found that threshold THI for successful conception was 75 and overall conception rates

Table 2. Priority weights and overall ranks of alternatives considered for the study

Component	Priority weight of the component	λmax	Consistency index	Consistency ratio (CR)	Alternative/Sub-component	Priority of the alternatives/ subcomponent	Overall priority of the alternative	Overall rank
Productive performance	0.564	5.236	0.059	0.053	Lactation length	0.109	0.061	5
					Average daily milk yield	0.477	0.269	1
					Lactation milk yield	0.202	0.114	2
					Dry period	0.083	0.047	7
					Peak yield	0.129	0.073	4
Reproductive performance	0.162	4.039	0.013	0.014	Estrus cycle	0.281	0.046	08
					Calving interval	0.305	0.049	06
					Age at first calving	0.168	0.027	14
					Service period	0.245	0.034	13
Feed and fodder availability and utilization	0.140	4.017	0.006	0.006	Feed and fodder intake	0.252	0.035	12
					Grazing duration during summer	0.143	0.020	15
					Feed and fodder availability	0.296	0.041	10
					Feeding pattern	0.309	0.043	09
Disease incidence and susceptibility	0.135	3.043	0.021	0.037	Incidence of common health ailments	0.269	0.036	11
					Incidence of vector borne diseases	0.148	0.020	15
					Incidence of heat stress	0.582	0.078	03

fell drastically when THI crossed 75 (Dash *et al*. 2013).

Service period is the third most sensitive indicator under reproductive performance component. Service period in buffaloes generally varies between 90-120 days during which reproductive organs rejuvenate to accommodate the fertilized egg in the foetus. Farmers felt that as heat detection becomes difficult in summer months. If they miss the estrus period due to silent heat and they must wait 21 days for the next heat due which service period is increased by 21 days and goes on increasing by 21 days whenever they miss to detect the silent heat. As the service period increases, it costs farmers with the loss of milk, efforts, increased labour charges for maintenance and increased calving period. The cooler months with lower values of THI has reduced the service period while in moths with higher THI vales prolonged service period was observed (Dash 2013).

Age at first calving was found to be the least affected indicator under the component of reproductive performance. Average age at first calving of Murrah buffaloes is around 40-44 months. Experienced dairy framers from the study area felt that age at first calving has gone up in the recent years compared to that of 2-3 decades back, but no sufficient logic was provided by them to support this. And some farmers felt it was due to huge variations in feeding management that evolved over the years.

Perceived impact of climate change on feed and fodder availability: Farmers felt that feeding pattern was the most affected alternative under this component. Farmers opined that, feeding pattern was affected more in hot humid summer months in terms of number of times of feeding and feeding material. Cattle and buffaloes feed more during cooler parts of the day. Feed and fodder supplied during daytime goes waste as animals do not eat much due to extreme heat. Dairy animals feed more on green fodder than the concentrates supplied due to which reduced milk yield and fat percentage was observed (Table 2).

Fodder availability was perceived by farmers as the second most sensitive alternative. Scarcity of feed and fodder is one of most serious problems that is being faced by the livestock sector in the country. In India, only 4% of land is devoted for cultivation of fodder purposes, while desired area should be around 14-17% of the agricultural land (Choudhary and Sharma 2023). With the growing population of cattle and climate vagaries it is feared that by 2025, there could be shortages in green and dry fodder by 39% and 23% respectively (Singh *et al.* 2022). In the state of Haryana, the lean period for fodder is May to mid-July and November-December. The green fodder availability during these periods is a huge problem. Paddy and wheat are cultivated during *kharif* and *rabi* seasons and providing irrigation for fodder crops during these periods becomes difficult due to shortage of water. Most of the respondent farmers from Hisar district, which basically is dry district felt that availability of sufficient quantities of green fodder has become difficult.

Feed and fodder intake by dairy animals was the next most affected alternative after fodder availability. Farmers reported that dairy animals feed less than normal during the months May to September. The number of times that animal feed was also reported to be less than the normal as well as feed, fodder wastage was also found to be high. Many researchers believe that feed intake by dairy animals during hot summer months will be 10-12 less resulting in loss of milk yield. At around 40°C, the dietary intake may decline as much as 40% in dairy animals. In cattle and buffaloes increased heat load decreases the nutrient uptake by 30% of the dry matter intake (Wheelock *et al*. 2010, Rhoads *et al*. 2013).

Grazing duration was the least sensitive alternative under this component. Only a small proportion land less farmers who cannot cultivate fodder, take out their animals for grazing. Generally landless dairy farmers go out and collect the fodder from distant areas and graze their animals on roadsides and in the barren lands especially after the *kharif* and *rabi* crops are harvested. Grazing is not a very common practice is the study area.

Perceived impact of climate change on disease incidence and susceptibility: Heat stress among dairy animals was perceived as the most troubling factor under this component. Hot summer months coupled with high humidity levels is impacting the physiological conditions of the dairy animals due to which the productive and reproductive performance of the animals is largely affected. Farmers felt that milk yield during this period falls by 2.5 to 3 kg per day. The mortality of calves and buffaloes were also reported from the study areas (Table 2).

Incidence of common health ailments due to variations in climate was considered by the respondent farmers as the second most sensitive alternative. Farmers reported incidences of clinical mastitis cases in hot humid weather. Research studies from India also confirm that occurrence of mastitis is largely associated with the climatic variables (Shinde *et al.* 1990).

Incidence of vector borne diseases was perceived to be the next serious factor. Farmers felt that incidence of ticks, mites and mosquitoes is huge problem during humid months of the year. Farmers reported of reduced milk yield due to mosquitoes during the monsoon period. Hot humid weather conditions were found to be favourable for infestation of cattle ticks and mites like *Boophilus microplus*, *Haemophysalis bispinosa* and *Hyalomma anatolicum* (Singh *et al*. 2000, Kumar *et al.* 2004). Though farmers reported of increased incidence of ticks and mites but not of incidences of diseases spread by these vectors.

Global priority weights for all the 16 alternatives under the four components were calculated by multiplying the priority weights of alternatives under each component with the priority weight of that component. Overall ranks based on sensitivity to climate change are presented in Table 2.

A multiple criteria decision-making technique called analytical hierarchy process (AHP) was employed to quantify the impact of climate change on different components of the dairy farming as perceived by the women dairy farmers. Four different components and 16 alternatives were identified and presented to the farmers for their response. Productive performance of the dairy animals was perceived as the most sensitive and affected component due to changes in climate and average milk yield was the most sensitive alternative. Majority of the alternatives prioritized by the farmers can be taken care of by following simple nutritional supplementation, management practices and by supplying weather information to the farmers. So, there is an urgent need to make the women farmers aware about the nutrient supplementations and their usage. Climate services for dairy farming may also be initiated in the lines of crop farming. Promotion of various climate resilient dairy practices may help in sustaining the milk production and improving the health profile of the dairy animals and thereby uplifting the economic status of the women.

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