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Adaptation Practices of Dairy Farmers to Climate Change in Coastal Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

An investigation was conducted to evaluate the adaptation strategies of dairy farmers in light of climate change in Tamil Nadu. For this research, four out of the 13 coastal districts—Villupuram, Cuddalore, Ramanathapuram, and Thoothukudi—were chosen at random. Two blocks were randomly picked from each district for analysis. From each selected block, two villages were randomly identified from the existing villages. Consequently, 16 villages were included in this study. Fifteen dairy farmers were randomly selected from each village, yielding a total of 240 respondents for the research. Data were gathered using a predesigned interview schedule. The information collected was analyzed with suitable statistical tools to interpret the results of this research. It can be concluded that the area studied was primarily populated by crossbred cattle due to their high productivity, and "no distinct alterations of forage in the diet" were observed by fewer than half (48.33%) of the dairy farmers during periods of heat or cold stress. A notable 62.92 percent of dairy

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farmers did not employ feed additives during these distressing times, opting instead for a feeding strategy that involved “crop residues + unconventional materials” in drought conditions. It emerged that they were compelled to source water from open areas as adequate drinking water was not consistently available during drought periods. The majority of dairy farmers (70.42%) opted for a combination of “consult veterinarian + ethno veterinary practices” for addressing reproductive issues amid extreme weather events.

Keywords: Adaptation practices; climate change; weather extremes; drought; dairy farmers; heat/cold stress.

1. INTRODUCTION

Climate change refers to any considerable long-term alteration in the anticipated patterns of average climatic conditions of a certain area (or the entire planet) over an extended duration. According to the 5th assessment report of the Intergovernmental Panel on Climate Change (IPCC), by the century’s end, the average surface temperature of the Earth could rise by anywhere from 0.3 to 4.8 ◦C. The ramifications of climate change resonate across global agrifood systems. Severe weather occurrences and modified temperature and rainfall patterns impact the yields of crops and the availability of fodder [1]. The most severe consequences of global climate change are expected to be felt in developing nations due to their heavy reliance on low-input rain-fed farming and limited capacity to adapt [2]. Countries such as India are particularly susceptible to the impacts of climate change because they possess fewer resources to adapt socially, technologically, and financially [3]. Climate change presents a significant challenge to dairy farming because dairy animals are particularly sensitive to extreme temperatures and humidity as well as unpredictable climatic fluctuations. Warmer and drier conditions heighten the risk of heat stress in cattle, which negatively impacts reproductive performance in dairy animals [4]. Alterations in rainfall patterns affect the growth of pastures, thereby influencing the quality and quantity of both feed grains and fodder produced [5]. Climate change influences both the quantity and quality of feed and fodder resources, including pastures, forages, crop residues, and it also affects the severity and distribution of livestock diseases and parasites, thus impacting production performance. Given these circumstances, the necessity for a study examining the adaptation strategies of dairy farmers in response to climate change has been recognized.

2. MATERIALS AND METHODS

Tamil Nadu was purposively selected for the study as it has highest number of coastal districts. Comparatively, among the eastern coastal districts, the districts of Tamil Nadu were more vulnerable than the other districts, as they had higher exposure [6]. Tamil Nadu is one of the states with high and very high climate vulnerable districts [7]. For the present investigation, four of the 13 coastal districts, Villupuram, Cuddalore, Ramanathapuram, and Thoothukudi, were selected randomly. Two blocks were randomly selected from each district selected for the study. From each selected block, two villages were randomly selected from the available number of villages. Therefore, 16 villages were selected for this study. For the selection of respondents, the inclusion criterion was that the farmer should have at least two lactating dairy animals with a minimum of five years of experience in dairy farming. A list of farmers with these conditions at the time of investigation was prepared with the help of veterinary assistants at the village veterinary dispensary units. From the prepared list, 15 dairy farmers were selected randomly from each village, and 240 respondents were selected for the study. The data were collected using a pre-structured interview schedule. The collected data were then analyzed using appropriate statistical tools, such as frequency and percentage, to interpret the findings of the present study.

3. RESULTS AND DISCUSSION

3.1 Adaptation Practices According to Breeding Management

3.1.1 Available breeds in the study region

An overview of Table 1 illustrates that a significant portion (56.25%) of dairy farmers owned crossbred livestock, followed by crossbred + native cattle (16.25%), native (11.67%), crossbred + Undistinguished animals (11.67%), native cattle + Undistinguished animals (2.91%), and Undistinguished animals (1.25%) respectively. It can be inferred that the region exhibited a predominance of crossbred cattle due to their superior productivity. This

Table 1. Distribution of respondents according to their breeding management

S.no	Adaptation Practices	Frequency	Percentage
1.	**Available breeds in the study area**		
a	Crossbred (HF, Jersey)	135	56.25
b	Crossbred + desi cattle	39	16.25
c	Desi cattle	28	11.67
d	Crossbred + Non-descript animals	28	11.67
e	Non-descript animals	3	1.25
f	Desi cattle + Non-descript animals	7	2.91
2.	**Method of mating followed**		
a	Natural	39	16.25
b	AI	163	67.92
c	Both	38	15.83

observation contradicts findings from Parameshwarnaik et al., [8]. Furthermore, it was noted that just 11.67 percent of farmers maintained native cattle, attributed to their high expenses and reduced productivity.

3.1.2 Breeding method utilized

Examining Table 1 demonstrates that the vast majority (67.92%) of dairy farmers employed AI for reproduction needs. This preference may stem from the presence of efficient and accessible AI resources [9]. This was succeeded by natural service (16.25%). Conversely, 15.83 percent of dairy farmers implemented both (Natural + AI). This trend could be linked to the availability of services in the area during the reproductive cycle of the animals.

3.2 Adaptation Practices According to Feeding Management

3.2.1 The feeding pattern followed during heat stress

"The results presented in Table 2 revealed that less than half (48.33%) of the growers followed a feeding pattern of no specific forage change in the ration" [10]. "This may be due to seasonal fluctuations in the availability of feed for dairy cows, the lack of technical knowledge in the production, management, utilization and storage of feed; farmers lack resources, cannot buy quality feed and have no capital to invest in fodder production. "Increasing the proportion of forage in the ration and reducing the proportion of concentrate" (32.92%), "according to the nutritional needs" (15.00%) and "decreasing the proportion of forage in the ration and increasing the proportion of concentration" (2.91). %). This finding is against that of Parameshwarnaik et al, [8]. While only 0.84 percent of dairy farmers followed a feeding pattern of "increase the proportion of fodder only in ration" for their dairy animals. The low concentrate feeding of animals can be attributed to the low availability of concentrates, the high cost of concentrates and the lack of knowledge about the positive effect of concentrate feeding on the reproductive and production performance of the animals Based on the above results, it is suggested that immediate steps are taken to educate farmers on concentrated feed for a better adaptation of animals to extreme weather conditions" [11].

3.2.2 Frequency of feeding

"Majority (92.09%) of dairy farmers provide feed twice a day, followed by three times a day (7.50%) and once a day (0.41%). Since most of the respondents offer meals twice a day, which does not seem to be a good practice, they may be aware of the increased frequency of meals by dividing the meals in one day. In the latter case, the goal of the farmer was to save the life of the animal, not production and productivity. It can be concluded that most of the respondents in these regions have maintained their animals under-nourished due to less availability of food, feed and means to buy" [11].

3.2.3 Food additives used in hot/cold weather

This can be seen in Table 2. that the majority (62.92%) of milk producers did not use feed additives [10]. Only 37. 08 percent of dairy farmers used mineral mixtures as feed additives in hot/cold weather. This may be due to the lack of knowledge in farmers. In the study area, however, food additives to manage heat or cold stress were provided to respondents by the State Government Department/NGO, which promoted and provided only mineral mixes. They were not aware of other food additives, such as bypass fat and protein, which are more important to reduce heat stress.

Table 2. Distribution of respondents according to their feeding management [11]

S.no	Adaptation Practices	Frequency	Percentage
1.	**Feeding pattern followed during heat stress**		
a	Increasing the proportion of forage in the ration only	2	0.84
b	Increasing the proportion of forage in the ration and decreasing the proportion of concentrate	79	32.92
c	Decreasing the proportion of forage in the ration and increasing the proportion of concentrate	7	2.91
d	No specific changes of forage in the ration	116	48.33
e	As per nutritional requirement		
2.	**Frequency of feeding**		
a	Once a day	1	0.41
b	Twice a day	221	92.09
c	Thrice a day	18	7.50
3.	**Feed additives used during hot/cold weather**		
a	Mineral mixture	89	37.08
b	No feed additive is used	151	62.92
4.	**Coping strategy for shortage of fodder**		
a	Hay making	32	13.4
b	Purchase fodder from market	6	2.50
c	Hay making + purchase fodder from market	164	68.33
d	Hay making + urea treated straws+ purchase fodder from market	8	3.33
e	Hay making + urea treated straws + complete feed blocks + purchase fodder from market	5	2.0
f	Followed no strategy	25	10.42
5.	**Feeding strategy followed during weather extremes**		
a	Crop residues (Bajra, Jowar and Moong)	8	3.33
b	Use of unconventional feeding stuffs likes tree leaves- (Ber, Neem) and Moong straw, grain husk	5	2.08
c	Crop residues+ unconventional feeding stuffs	156	65.00
d	Crop residues+ unconventional feeding stuffs + grazing animals along roads/open fields	44	18.34
e	Unconventional feeding stuffs + grazing animals along roads/open fields + migration	27	11.25
6.	**Source of drinking water**		
a	Public tube well	160	66.67
b	Rainwater harvesting tank	40	16.67
c	Private tube well	20	8.33
d	Public hand pump	20	8.33
7.	**Watering practices during hot weather**		
a	Providing water in trough kept in shed	169	70.40
b	Providing water from open sources	71	29.60
8.	**Frequency of watering**		
a	Twice a day	35	14.58
b	Thrice a day	106	44.17
c	As and when water available	99	41.25

3.2.4 Adaptation strategy to fodder shortage during drought

Table 2 revealed that the majority (68.33%) of dairy farmers followed “grass production + market purchase as a coping strategy for fodder shortage during drought” [10]. Then comes "to weed" (13.34%) and "the lack of strategy" in times of drought (10.42%). This may be because they had a subsistence income from other sources to fight the drought and therefore did not pay attention to the animals due to their limitations. Moreover, they are used to save/reserve enough fodder for their animals

during the lean season. A smaller number of respondents (3.33%) followed the strategy of "grass production + urea treated straw + purchase of fodder from the market" and 2.50% "purchase of fodder from the market" to alleviate the situation of fodder shortage. However, only 2.08% of dairy farmers followed the adaptation strategy “grass production + urea-treated straw + complete feed blocks + purchase of fodder in the market”.

3.2.5 Feeding strategy followed during extreme weather conditions

As shown in Table 2, the majority (65.00%) of dairy farmers used “crop residue + non-conventional feed” as a feeding strategy during drought situations. This is followed by “crop residues + non-conventional foods + animals grazing along roads/open fields” (18.00%). 34%), “unconventional foods + animals grazing along roads/open fields + migration” (11.25%) [12]. While 2. 08 percent of them had used "unconventional foods (tree leaves, moon straw and cereal husks)" as a feeding strategy during periods of drought. The leaves of the trees used to feed the dairy animals were Khejri (Prosopis cineraria), Babul (*Acacia nilotica*), Ber (*Zizyphus spp*.), Ardu (*Ailanthus sp*) and Neem (*Azadirachta indica*). Due to drought, lack of water is a common phenomenon that prevents the growth of fodder crops and almost all pastures become barren without significant vegetation for grazing animals. Under these circumstances, to maintain milk production and productivity, the respondents were fed with dry fodder and non-conventional feeds. They have no choice but to take the dry fodder, because of the low price [13].

3.2.6 Source of drinking water

According to Table 2, the primary source of drinking water was the community tube well (66.67%), with rainwater harvesting tanks contributing significantly at 16.67%. These observations align with the research conducted by Kant et al. (2014). Both public hand pumps and private tube wells provided drinking water for an equal percentage (8.33%). The elevated water table has rendered the cost of drilling tube wells prohibitively high, preventing individual farmers from establishing their own. Considering these circumstances, the government has installed tube wells in the region to provide potable water; however, some affluent farmers have been able to drill their own tube wells.

3.2.7 Watering practices during hot weather

Table 2 illustrates that a significant majority (70.40%) of dairy farmers supplied water in troughs located within the shed. (Kant et al, 2014). Conversely, 29.60 percent of the dairy farmers sourced water from unregulated areas. This suggests that a notable fraction of the respondents were obtaining water from less sanitary sources. Nevertheless, during conversations with the farmers, it became evident that they were compelled to use open sources due to the inadequate availability of drinking water on a daily basis.

Table 3. Distribution of respondents according to their shelter management [11]

S.no	Adaptation Practices	Frequency	Percentage
1.	**Type of housing system**		
a	Loose/open house system	41	17.10
b	Conventional house system	151	62.90
c	Partially close and open house system	48	20.00
2.	**The approximate height of the shed**		
a	10 feet	149	62.10
b	11-15 feet	91	0.40
3.	**Floor space available/animal**		
a	As per recommended (3.5 x 7.0 m ^{2})	9	3.75
b	Less than recommended	209	87.08
c	More than recommended	22	9.17
4.	**Shed orientation for proper light and ventilation**		
a	North-South	115	47.90
b	East-West	42	17.90
c	Any orientation	82	34.20

3.2.8 Frequency of watering

Approximately 44.17 percent of dairy farmers were supplying water to their animals three times daily, followed closely by those offering water as needed (41.25%). Meanwhile, 14.58 percent of farmers provided water two times a day to their livestock (Table 2). It can be inferred that given the high temperatures prevalent in the region, the watering frequency appears inadequate [14]. Farmers who are supplying water twice a day might be encouraged to increase the watering frequency to alleviate the heat stress on their animals.

3.3 Adaptation Practices According to Their Shelter Management

3.3.1 Type of housing system

A significant portion (62.90%) of dairy farmers utilized a “traditional housing system,” followed by 20.00% and 17.10% of the participants who employed “partially enclosed & open housing systems” and “loose/open housing systems,” respectively. This observation aligns with the research of Kant et al., 2017. A closed housing system is not conducive to tropical climates. It is recommended that farmers adopt a loose housing system to alleviate the adverse effects of heat stress on their animals, potentially enhancing their productivity. Additionally, farmers are encouraged to plant ample trees around the animal shelter to optimize the microclimate in that area. Trees function as windbreaks, protecting animals from the drying westerly winds during summer.

3.3.2 The approximate height of the shed

A review of Table 3 indicates that a predominant 62.10% of dairy farmers opted for a shed height of 10 feet. Conversely, 37.90% of the farmers selected a height ranging from 10 to 15 feet. This trend suggests that the height of the sheds may not be suitable, possibly due to the elevated costs of construction materials, exacerbated by limited transportation options in the area. Additionally, there may be a lack of knowledge among the farmers concerning heat management and the optimal height for sheds.

3.3.3 Floor space available/animal

A significant majority (87.08%) of the dairy farmers adhered to providing "less than recommended" floor area in their livestock housing [15]. This is likely attributed to the farmers' insufficient knowledge. On the contrary, 9.17% and 3.75% of dairy farmers provided "more than recommended" and the "recommended (3.5 X 7.0 m^2)" floor area per animal, respectively. In most instances, inadequate space is allocated to the animals, leading to overcrowding within the shed. This scenario fosters an environment conducive to disease transmission, challenges in farm management, and ultimately a decline in the animals' productivity. It can be inferred that farmers lack awareness regarding the spatial needs of their animals.

Table 4. Distribution of respondents according to their healthcare management [11]

S.no	Adaptation Practices	Frequency	Percentage
1.	**Health management during extremes of weather**		
a	Preventive measures (vaccination)	51	21.25
b	Regular endo and ecto parasite control	17	7.08
c	Regular checkup for lameness and mastitis	4	1.67
d	Preventive measures like vaccination + regular endo and ecto parasite control	29	12.09
e	Preventive measures like vaccination + regular endo and ecto parasite control + regular checkup for lameness and mastitis	63	26.25
f	Regular endo and ecto parasite control + regular checkup for lameness and mastitis	7	2.91
g	No practice followed	69	28.75
2.	**Management of reproductive problems during extremes of weather**		
a	Consult veterinarian	4	1.67
b	Ethno-veterinary practices	9	3.75
c	Balanced feed + consult veterinarian	4	1.67
d	Consult veterinarian + ethno-veterinary practices	169	70.42
e	Balanced feed+ consult veterinarian + ethno veterinary practice	43	17.91
f	No measures taken	11	4.58

3.3.4 Shed orientation for proper light and ventilation

The study showed that 47.90 percent of dairy farmers adhered to a north-south shed orientation, followed by 34.20 percent who opted for 'any alignment' and 17.90 percent who chose east-west shed orientation. From Table 3, it can be inferred that a significant portion of the participants did not comply with the ideal shed orientation, which is identified as the north-south orientation; this negatively influences the environment within the animal shelter.

3.4 Adaptation Practices on Health Care Management

3.4.1 Health management during extremes of weather

“A significant portion (28.75%) of dairy producers did not implement health management strategies during severe weather conditions. (Table 4) This could be attributed to a lack of awareness among farmers regarding the health management protocols to adhere to during such climatic extremes. It would be beneficial to provide training focused on health management, particularly concerning climate fluctuations. Regarding preventive health measures such as vaccinations, regular control of endo and ecto parasites, and routine check-ups for lameness and mastitis, 26.25 percent of dairy farmers engaged in these practices. In contrast, 21.25%, 12.09%, 7.08%, and 2.91% of respondents utilized preventive actions like vaccinations, vaccinations combined with regular endo and ecto parasite control, only regular endo and ecto parasite control, and regular endo and ecto parasite control plus routine check-ups for lameness and mastitis, respectively. Nonetheless, merely 1.67 percent of dairy farmers practiced health management through routine lameness check-ups” [11].

3.4.2 Management of reproductive problems during extremes of weather

A significant majority of dairy farmers (70.42%) utilized the approach of "consult veterinarian + ethno veterinary practices" to tackle reproductive issues during severe weather conditions [16]. This was followed by the combination of "balanced feed + consult veterinarian + ethno veterinary practices" (17.91%), "no measures taken" (4.58%), and "ethno veterinary practices" (3.75%). An identical percentage of respondents (1.67%) employed practices such as "consult veterinarian" and "balanced feed + consult veterinarian". (Table 4). It can be inferred that most farmers sought veterinary consultation, depending on local availability, along with traditional veterinary methods to manage reproductive issues during severe weather conditions [17,18].

4. CONCLUSION

In the current situation, a majority of the participants did not implement adaptive strategies such as shed orientation, floor space, conventional feed stuffs, feed storage and health management during extreme weather. Therefore, it is crucial to provide farmers with information regarding climate change and adaptation through various formats such as brochures, pamphlets,handouts, and journals. It has been noted that the participants formulated adaptive strategies based on their experiences and available resources to mitigate the effects of climate change [10]. Initiatives should be undertaken to establish integrated methods for adaptation and sustainable practices to achieve this through educational programs and capacity enhancement involving all relevant stakeholders. Thus, it is recommended that the dissemination of technology should be refined by centering its focus on alleviating the negative impacts of climate variability by proposing suitable strategies through demonstrations, field exhibitions organized by KVKs, NGOs, and veterinary institutions. (Kant et al., 2014). Researchers need to be aware of how farmers are likely to react to climate change, as the responses can exacerbate the impacts. Policymakers must understand the needs of the farming community to formulate appropriate policies that enable adaptation to daily changes in rainfall patterns, temperature variations, crop production, livestock, and disease management, as well as to address disasters when they arise. The effects of climate change on rural communities are anticipated to intensify in the future, exerting additional pressure on rural economic activities such as livestock farming [19]. Going forward, building partnerships, improving research, and integrating indigenous knowledge will be vital in crafting effective and inclusive adaptation strategies for the dairy industry in the face of a shifting climate.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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