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RESEARCH ARTICLE

Exploring the Determinants of Higher Level of Adoption of Climate-Resilient Dairy Farming Practices

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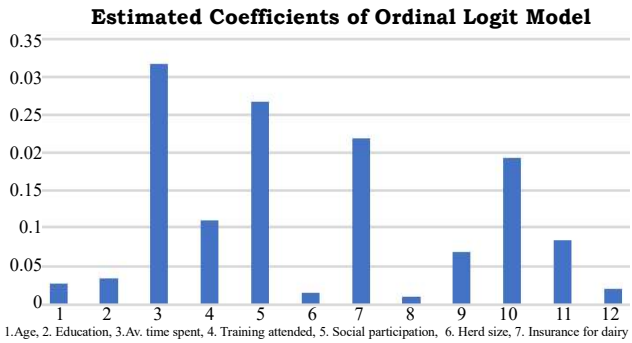
HIGHLIGHTS

- Ordinal logit model suggests that time spent, extension contact, social participation and knowledge about climate resilient practices were found to be determinants of higher levels of adoption
- Feeding and housing management are the most adopted practices
- Lack of awareness among women farmers is the most significant constraint

GRAPHICAL ABSTRACT



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ABSTRACT

Context: The dairy sector plays a significant role in supporting the livelihoods of women. To safeguard the livelihoods of women, it is crucial to promote the adoption of climate resilient dairy farming practices. Identifying the factors that determine the adoption and constraints faced by them in adoption of such practices is very crucial for designing effective policies.

Objective: The study aims to identify the factors that determine the adoption and constraints faced by women farmers in adoption of climate resilient dairy farming practices. Extent of adoption of climate resilient dairy farming practices was also captured

Methods: An ex-post facto research design was used in the present study. Data were collected from 360 women dairy farmers in the study area i.e., 18 randomly chosen villages from Jind, Hisar and Rohtak districts of Haryana. Ordinal logit model was used to determine the factors that influence adoption and garrets ranking method was used to prioritize the constraints.

Results and Discussion: Feeding management and housing management were found to be the most adopted practices based on their weighted mean score. Time spent, extension contact, social participation and knowledge about climate resilient practices were found to be the determinants of higher levels of adoption. Lack of awareness regarding these practices was identified as the most significant factor hindering their adoption.

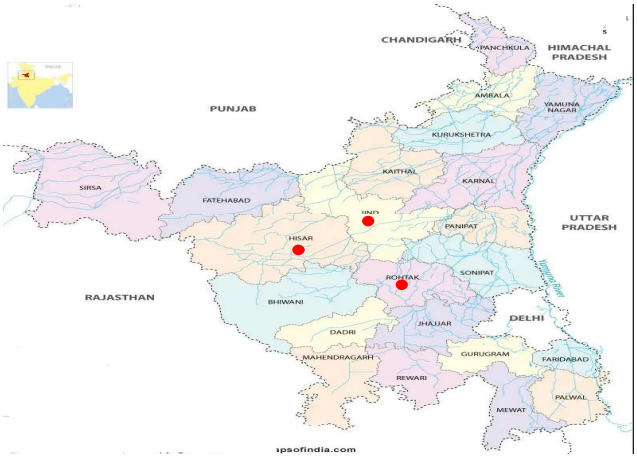
Significance: Findings reveal that adoption of climate resilient dairy farming practices among women farmers is considerably low which can be attributed to various constraints faced by them. Ordinal logit model reveals the factors that determine presence of women in higher level of adoption categories.

Dairy farming is an important component of agriculture and impacts the socio-economic life of the rural community (Anusha and Sharma, 2022) and provides a supplementary income to small and marginal farmers (Kumawat and Yadav, 2016). Livestock play a vital role in securing food supplies and act as a risk mitigation measure to support families during periods of crop failure (Channappa *et al.,* 2023 and Chauhan *et al*., 2022). While, men primarily focus on crop-related activities, women have a vital and substantial role in dairy farming, which is closely integrated with their family life (Meena *et al.,* 2022). In Indian dairy farming, women make up 71 per cent of the labor force, with a staggering 75 million women engaged in this occupation. In contrast, the number of men involved in dairy farming is only 15 million (Thakur & Chander, 2006). The income generated from dairy farming often serves as a means to support their families and communities and this demonstrates the financial significance and potential empowerment associated with dairy farming as it contributes to economic activities beyond the immediate farming context (Krishna *et al.,* 2022). While the dairy sector is playing such an important role on the livelihoods of women, it is being impacted adversely by changes in climate. Factors such as rising temperatures and altered rainfall patterns can have detrimental effects on animal well-being, availability of feed and water, and ultimately, the production of milk. Warmer and drier conditions due to climate change can prove to the productive and reproductive performance of dairy animals, as they are more susceptible to heat stress (Van den Bossche & Coetzer, 2008). In the densely populated region known for its high number of milch animals, which includes Punjab, Haryana, and western Uttar Pradesh, it is projected that heat stress will lead to production losses of 33,900 tonnes between 2020 and 2029, and 6,29,000 tonnes between 2030 and 2039. These losses are estimated to result in monetary losses amounting to Rs 15.25 billion and Rs 28.30 billion, respectively. (Choudhury & Sirohi, 2022). Climatic parameters are also found to be highly correlated with the occurrence of diseases like mastitis, Foot and Mouth Disease (FMD) and also with occurrence of fly population (Singh *et al.,* 2012).

In the wake of climate change, climate resilient practices or technologies are recommended and encouraged as a strategy to mitigate the negative impacts of climate change and are gaining traction as a means to safeguard farmers' livelihoods (Yadav & Ghosh, 2023; Meena *et al.,* 2023). Climate resilient technologies introduced under National Initiative on Climate Resilient Agriculture have proven to be effective and improved the income of farmers (Kalash *et al.,* 2023). Adoption of adaptation measures aim to address the challenges posed by climate change and enhance the resilience of food production systems. (World Bank Group, FAO, IFAD, 2015). In adoption of any practice irrespective of gender, both male and female farmers face constraints (Rohit *et al.,* 2023). However, social position of women farmers makes adoption of any technologies/practices even harder compared to male farmers. Considering the importance of adoption of Climate Resilient Dairy Farming (CRDF) practices and constraints faced by them, the present study was formulated to explore the issue further.

METHODOLOGY

The current research was carried out in three randomly selected districts of Haryana, namely Jind, Hisar, and Rohtak. To select the sample, two blocks were randomly chosen from each district, and subsequently, three villages were selected randomly from each block. A total sample size of 360 women dairy farmers (20 women dairy farmers from each village) was included in the study. An interview schedule was prepared to know the extent of adoption of CRDF practices and constraints faced by women in their adoption. A score of 2 was awarded, if the farmer had fully adopted the practice and 1 for adopted previously and discontinued and a score of zero if the farmer had not adopted at all. Based on the weighted mean scores highly adopted practice was determined.



Location of study area in Haryana state of India

The ordinal logit model was employed to identify the factors influencing the higher level of adoption of CRDF practices among respondents, aiming to address the challenges posed by climate change. The dependent variable, which indicates the level of adoption, was grouped into an ordinal scale based cumulative square root frequency method and assigned 1 for lower adoption, 2 for moderate adoption, and 3 for high adoption levels. The simplified version of the ordinal logit model given by following Greene (2009) is presented as follows.:

$$y^*=\beta' Z+ \varepsilon \ldots\ldots (1)$$

Here y^* = Given level of adoption,

Z = Set of explanatory variables,

β' = Vector of coefficient to be determined

and ε is a random error with zero mean and unit variance.

Y is unobserved, what we do observe is

$$Y=1, \text{ if } y^* \leq \mu_2$$

$$Y=2, \text{ if } \mu_2 < y^* \leq \mu_3$$

$$Y=3, \text{ if } \mu \leq y^*$$

The μ - values ($\mu 2$, $\mu 3$, are unknown parameters), referred as cut-points are to be estimated along with Vector coefficient β. A positive value in coefficient suggests an elevated likelihood of observing a respondent with a higher score on the independent variable in a more advanced level of adaptation. A coefficient signifies with negative value represents the probability of observing a respondent with a high score on the independent variables in a lower level of adoption. The independent (explanatory) variables incorporated into the model are presented in Table 2.

Garret's ranking technique was used to rank order the constraints faced by the respondents in adoption of Climate Resilient Dairy Farming (CRDF) practices.

RESULTS

The results on the adoption of climate-resilient dairy farming practices (Table 1) indicate that 96.95 per cent of respondent farmers have never adopted Vitamin E selenium supplementation, which is known to improve reproductive parameters in dairy animals. Deworming of dairy animals is practiced by all farmers at least once, but only 37.22 per cent use albendazole,

Table 1. Extent of adoption of climate resilient dairy farming practices among the respondent farmers (N = 360)

Practice	Adopted (%)	Adopted and discontinued (%)	Never adopted (%)	Weighted Mean Score	Rank
Supplementation of 2 gram of vitamin E and selenium	0.83	2.22	96.95	0.038	XV
Use of Albendazole for deworming	37.22	62.78	0.00	1.372	III
Management of endo-parasites through fenbendazole	38.22	61.78	0.00	1.392	IV
Management of ecto parasites	22.78	20.83	56.39	0.663	VI
De-worming and supplementation of mineral mixture, vitamins in non-pregnant anoestrous animals	8.89	13.06	78.06	0.308	XI
Feeding management of high yielding cattle and buffaloes during stress months	95.56	1.11	3.33	1.930	I
Ration and feeding management against climate stress	35.28	13.61	51.11	0.841	V
Feeding 60 gm mineral mixture/day and deworming twice in a year with two Cu-Co tablets/day for improving conception rate in buffalo	9.17	13.61	77.22	0.319	X
Balanced concentrate mixture with buffer	15.28	17.50	67.22	0.480	V111
Mineral mixture supplementation along with feed @ 30-50 g/ animal/day	9.38	13.61	77.22	0.327	IX
Feeding of bypass fat to high yielding dairy animals	3.89	7.50	88.33	0.152	XII
Advisory services based on Temperature-Humidity Index (THI)	7.22	0.28	92.50	0.147	XIII
Housing Management during summer	94.44	0.83	4.72	1.897	II
Primary product preparation (like preparation of butter, ghee, curd etc)	12.78	28.06	59.17	0.536	VII
Preparation of value-added milk products	1.67	6.67	91.67	0.100	XIV

Table 2. Estimated coefficients (ordinal logit) of explanatory variables determining various levels of adoption and its variability among the respondents (n=360)

Explanatory variables	Estimated Coefficient	Standard Error	P>|z|	Odds ratio	95% confidence limit of odds ratio		Predicted Marginal Effect (dy/dx)
					Lower limit	Upper limit	
Age	0.026	0.023	0.258	1.026	-0.019	0.072	0.003
Education	0.033	0.109	0.757	1.034	-0.180	0.248	0.004
Average time spent daily in dairy farming	0.318	0.142	0.025*	1.375	0.040	0.597	0.041
Trainings attended	0.110	0.247	0.656	1.116	-0.375	0.595	0.014
Social participation	0.267	0.107	0.013*	1.306	0.055	0.478	0.034
Herd size	0.014	0.037	0.705	1.014	-0.059	0.087	0.001
Insurance for dairy animals	0.219	0.517	0.672	1.244	-0.796	1.234	0.030
Total milk production (per day)	0.009	0.009	0.302	1.009	-0.008	0.270	0.001
Access to climate information	0.068	0.835	0.413	1.070	-0.095	0.232	0.008
Extension contacts	0.194	0.886	0.029*	1.214	0.020	0.367	0.025
Knowledge about climate change and climate resilient dairy farming practices	0.084	0.337	0.012*	1.088	0.018	0.150	0.010
Attitude towards climate resilient dairy farming practices	0.020		0.279	1.020	-0.016	0.058	0.002
Log likelihood	-351.989				0.019		
Pseudo R^2	0.050						
Prob > chi^2	0.000						
Observations	360						

*Indicates significance at 1 per cent level of significance, in a two tailed test.

Dependent variable: Y (Y = level of adoption, ordered variable: 1 = Lower level of adoption, 2 = Moderate level, 3 = Higher level of adoption

Table 3. Mean scores and ranking of various identified constraints (N = 360)

Constraint	Garret Mean score	Rank
Lack of awareness/knowledge about climate resilient dairy farming practices	66.000	I
Lack of financial independence	57.944	II
Lack of independence in decision making	53.430	III
Costs associated with the climate resilient dairy farming practices	44.416	IV
Cultural norms	28.208	V

and 38.22 per cent use fenbendazole for this purpose. Additionally, 56.39 per cent of the respondent farmers have not adopted practices to manage ecto parasites, which can lead to vector-borne diseases. Only 8.89 per cent of farmers adopted de-worming followed by supplementation of mineral mixtures and vitamins for non-pregnant anoestrous animals. In contrast, 95.56 per cent of farmers effectively implemented feeding management for high-yielding dairy animals.

Ration and feeding management of dairy animals during climate stress months is a crucial practice for sustaining milk production, yet 51.11 per cent of respondent farmers in the study area did not adopt this practice. Deworming and mineral mixture supplementation, essential for improving conception rates in dairy animals, were adopted by only 9.17 per cent of farmers. Additionally, supplementation of buffers, concentrate mixtures, mineral mixtures, and bypass fat were adopted by 15.28 per cent, 9.38 per cent, and 3.89 per cent of respondents, respectively. The management of animals based on the Temperature Humidity Index (THI) was not followed by 92.50 per cent of the farmers. On the positive side, almost all respondent farmers implemented proper housing management practices to mitigate heat stress during the summer months. Only 12.78 per cent of respondents

were involved in the preparation and selling of primary milk products like butter, ghee, and curd, and a mere 1.67 per cent engaged in producing value-added milk products.

Results from the ordered logit model (Table 2) suggest that explanatory variables like average time spent in dairy farming, social participation, extension contact and knowledge about climate change and climate resilient dairy farming practices were found to be contributing at a significant level (at $p < 0.05$) to the higher levels of adoption of climate resilient dairy farming practices.

The Table 3 highlights key constraints faced by farmers in adopting climate-resilient dairy farming practices, ranked by their significance based on Garret Mean scores. The most significant barrier is the lack of awareness or knowledge about these practices (66.000), followed by financial independence issues (57.944), and lack of independence in decision making (53.430). Costs associated with implementing these practices are also a considerable challenge (44.416), while cultural norms are the least significant constraint (28.208).

DISCUSSION

Nearly 97 per cent of respondents did not use Vitamin E selenium, which aids in maintaining reproductive and mammary gland health. Discussions with farmers during the study revealed that they were unaware of the supplement's existence. The majority of respondents deworm their animals based on veterinarian advice, typically when there is reduced conception and changes in dung consistency, which are generally perceived as indicators of gastrointestinal parasites. Mishra and Bardhan (2009) in their study also reported that adoption of deworming was around 57 per cent by the farmers and the reason was low knowledge and awareness among the farmers as majority of dairy farmers have medium level of knowledge about improved dairy farming (Meena *et al,* 2009).

Prevalence of ecto parasites is greatly influenced by the climatic factors and ecto parasites like ticks and mites leads to vector borne diseases and reduced milk production (Kumar *et al.,* 2016). Almost 57 per cent of the farmers had not adopted the practice of controlling ecto parasites. A study conducted by Jadav *et al*., (2021) in Gujarat state also indicated that more than 50 per cent of the respondents had not adopted the practice of controlling ecto parasites and the also stresses lack of knowledge was the main reason for non-adoption. Practice of supplementing mineral mixture after deworming which helps in improving the conception rates of the animals and around seventy per cent of the respondents had not adopted the practice.

Feed supplements like buffers play a significant role in digestion of the animals by reducing the acidity in the rumen of the animals and the practice was adopted by considerably less (15.28%) number of the respondents. Baking soda (meetha soda) is recommended for high-yielding animals at a dose of 120 grams to reduce rumen acidity. Mineral mixture supplementation is the important practice to provide animals with all necessary minerals and very few farmers had the idea of supplementing. Farmers often depend on concentrates to achieve higher milk fat percentages and increased milk yields. However, solely supplying animals with concentrates can lead to acidosis and deprive them of essential minerals. Therefore, it is advisable for farmers to supplement their animals with mineral mixtures, thereby reducing expenses on excessive amounts of concentrate mixtures. The Temperature-Humidity Index (THI) is a measure of discomfort that combines the assessment of ambient temperature and air moisture in a specific area during a particular time interval (Singh *et al.,* 2020). While the Indian Meteorological Department initiated agro advisory services, the majority of the information was directed towards the crop sector, with minimal focus on dairy farming (Manjusree et al., 2022). Providing advisory services based on crucial parameters such as temperature and humidity would assist farmers in taking necessary measures to ensure sustained milk production, especially during the summer months. Diversification of income sources is one of the most potential options to combat climate change and many researchers have suggested the same (Aggarwal *et al.,* 2004; Fu *et al.,* 2012; Abbas *et al.,* 2019 and Chauhan *et al.,* 2022).). Climate change can lead to reductions in milk yields and it is very important to diversify the income sources of farmers which reduces the dependency on milk yield fluctuations. Results indicate that very few farmers have adopted the practices of primary milk products preparation and value-added products preparation. Building farmers' capacity and providing financial support in this area can enable women farmers to diversify their income sources and secure their livelihoods.

When the practices were ranked on weighted mean scores of adoptions, feeding management of high yielding dairy animals during stress months was found to be the most adopted practice followed by housing management of dairy animals and deworming among the animals. Least adopted practice was supplementation of vitamin E and selenium. Supplementations like mineral mixture, buffer and bypass which are regarded as the most important in combating heat stress in animals were not among the top of the list, which warrants interventions from extension functionaries and Animal Husbandry department to raise awareness among the farmers.

Determinants of differential levels of adoption : Extension contact (p = 0.029) of the dairy farmers is found to be significantly influencing the adoption of climate resilient dairy farming practices. Marginal effects show the change in probability of being in higher levels of adoption when the predictor or independent variable increases by one unit (Torres-Reyna, 2014). Marginal effects of extension contact (dy/dx = 0.025) reveals that one unit change in the extension contact will contribute to 0.025 units increase in the probability falling in the higher adopter category. Many research studies report that having a good extension contact shall increase the adoption of climate resilient practices (Abegunde *et al.,* 2019; Meena *et al.,* 2016, Jena *et al.,* 2023; Manjunath, 2023; Nyasimi *et al.,* 2017). Extension services have always been directed towards men, as they are considered as head of households. Research evidence indicates that women are less likely to get access to extension services than their male counterparts (Ragasa *et al*., 2014). In this context, it is crucial to view women as our target audience and to integrate gender considerations into our outreach initiatives, aiming to promote the adoption of climate-resilient practices in dairy farming. It is also revealed that one unit increase in variables like average time spent in dairy farming and social participation shall lead to increase in the probability of the respondents being in higher level of adoption by 4.1 per cent and 3.4 per cent respectively. The low social participation of women due to barriers on their mobility outside the house, multiple responsibilities inside the house and lack of land rights which make them invisible workforce in agricultural sector are majorly responsible for their less accessibility to extension services (Singh *et al*., 2008). Inception of Self-Help Groups, women farmers associations, reservations for women in the political circles have contributed a lot to the social participation and still a lot can be done to improve the participation of women in the public life. Extension efforts may be directed on formation of Self-Help Groups which can contribute to increased social participation which in turn improves the extension contact. While a unit increase in extension contact and knowledge about climate change and Climate Resilient Dairy (CRD) farming practices the probability of respondents being in higher level of adoption category shall be improved by 2.5 per cent and 1 per cent respectively. Basunathe *et al*., (2010) also outlines that lack of knowledge is the major driver for non-adoption of the dairy production technologies. According to Mishra and Bardhan, (2009) awareness and knowledge play a key role in determining adoption of the practices. The women farmers in the region typically dedicate approximately 5.5 hours per day. With increased time investment in managing dairy animals, there is a higher likelihood of comprehending the intricacies of animal health dynamics and implementing essential measures to safeguard the animals from illness during months of climate stress. Women dairy farmers are members of milk cooperatives and they receive extension services from the cooperatives. The membership in cooperatives and other local organizations such as Self-Help Groups (SHGs) might contribute to the probability of being in higher level of adoption of CRD practices category. Jena *et al.,* (2023) and Manjunath (2023) in their studies opined that improvement in extension contact determines the level of adoption of climate resilient practices. Numerous climate-resilient practices in dairy farming exist to counteract the negative impacts of climate change. Yet, the adoption of these practices hinges greatly on the level of awareness and understanding regarding their presence and significance. (Dar *et al.,* 2020).

Constraints in adoption of Climate Resilient Dairy (CRD) farming practices: Farming community in general face lot of constraints ranging from technical to financial aspects in adoption of any practice, which would help in betterment of their livelihood. Further, women farmers face a different set of problems in adopting any improved agriculture practice due to their socially disadvantaged position in the society. After careful review of literature, group discussions and expert consultations, five constraints that seemed specific to women farmers were listed and presented to the women farmers for prioritization as perceived by them.

Awareness or knowledge about the existence of the practice is very vital for making a decision about the adoption of the same. Majority of the respondents in the study did not even know the existence of practices which would help them in sustaining/improving the milk production and wellbeing of their dairy animals. Few of the women farmers opined that had they known about the practices and their benefits, they would have tried to adopt them by convincing their male partners. Women farmers' awareness/knowledge about climate resilient dairy farming practices is affected by many latent factors like education of women farmers, accessibility to extension services etc. Women farmers of Kenya who were aware about negative effects of climate change and climate resilient practices had adoption levels of twice as that of women farmers who were not aware about climate change and resilient practices (Tambo, 2016). Thus, improving the farmers' knowledge about climate change and climate resilient practices would improve the adoption of the practices. The respondents in the study ranked this particular constraint as the most important in adoption of climate resilient dairy farming practices.

Lack of financial independence for women at household level is the second most important constraint as ranked by women farmers. Lack of financial independence also affects the decision making related to management of dairy animals. Decision making (third important constraint) is the primary process that is very vital in resource management of the family. Though women contribute so much in farm related activities, their involvement in decision making process remained very low in the average Indian households. According to Godara et al., (2014) in Haryana, only 40 per cent of the women reported that they were consulted in making decisions related to crop production and other allied activities. They also highlighted that only 22 per cent of the women were consulted by their male counterparts in making decision related to dairy farming activities.

Cost of the products is the next major constraint in the adoption of climate resilient practices. Farmers who knew about the existence of the practices felt that those products were expensive due to which they were backing out from adoption of those products or technologies. A kilogram of mineral mixture costs around Rs 250-300 in the market and this price seemed to be expensive for the farmer to afford keeping in mind the amount of time each kilogram would last. Farmers may need to be sensitized about suppling less amounts of concentrates so as to utilize the same amount for purchasing of mineral mixture or any other product which would help them in sustaining or improving milk production and health of animals. Market prices of the inputs have high influence on the direction and progress of technology adoption by affecting the relative profitability of the technologies (Kumar *et al.,* 2018).

Women are expected to follow particular patterns or norms in the society. India is generally a conservative society and in particular the state of Haryana strongly influences a patriarchal society in the community (Kapur, 2020). Extension system in India has always been male centric due to the existing cultural norms in the society which alienated women farmers' accessibility to extension serves, which in turn might affect the uptake of technologies.

CONCLUSION

Adoption of climate resilient dairy farming practices is very important to negate the negative impacts of climate change. The findings from the study revealed that out of the 15 practices, only two practices were adopted by more than 50 per cent of the respondents and the results clearly state that adoption of climate resilient dairy farming practices among women dairy farmers is low. Social participation, extension contact and knowledge about climate change and climate resilient dairy farming practices were found to be significantly influencing the higher adoption levels among the women farmers. Women from the study area also prioritized the constraints in adoption of climate resilient dairy farming practices. Lack of awareness about climate resilient dairy farming practices was the most prioritized constraint by women dairy framers. Efforts may be taken up to promote the climate resilient dairy farming practices to protect the livelihoods of women farmers by building their resilience capacity to stand against the impacts of climate change.

Women are quick learners, keen observers and regarded as the best team workers, so they should be encouraged to build their capacities (Saikia, 2022) and entrepreneurship in dairy farming can help diverse their income sources and help withstand against the adverse effects of climate change. Promotion of climate resilient practices through innovative ICT means among farmers is need of the hour.

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Authors' contribution: The first author collected and analysed the data. Second author conceptualized the study and guided the research while rest of the authors were instrumental in analysis and provided critical inputs for the study.

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