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Impacts, Adaptation, and Policy Needs for Marginalized Communities

Shouvik Chakraborty, Debanjana Dey, and Anjana Thampi

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Climate Change and Livestock in India: Impacts, Adaptation, and Policy Needs for Marginalized Communities

Shouvik Chakraborty,
Debanjana Dey, and
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Abstract:

This study examines the complex relationship between climate change and livestock holding patterns in India, focusing on coastal regions and marginalized communities. The research investigates whether landless and marginalized households, who constitute the majority of livestock holders in rural India, are adequately equipped to adapt to climate uncertainties. Analyses of Livestock Census data reveal a significant shift in livestock holding patterns in coastal India, with a 2.7 percent decline in the bovine population and a 22.1 percent increase in the sheep and goat populations between 2012 and 2019. This trend indicates an emerging adaptation strategy as farmers shift toward smaller ruminants, indicating greater resilience to heat stress and extreme weather conditions. We find that while large and medium landowners possess the financial resources to implement advanced adaptation strategies, marginal and landless households remain highly vulnerable due to their limited resources and heavy dependence on bovine livestock. The research concludes that region-specific livestock policies supporting indigenous breed development, traditional adaptation practices, and direct economic assistance are urgently needed to protect the livelihoods of these communities and prevent a rise in food insecurity among already undernourished populations. Furthermore, effective adaptation requires integrating local knowledge systems with scientific approaches to develop climate-resilient livestock management practices suitable for India's diverse agro-ecological regions.

Keywords: climate change adaptation, livestock resilience, marginalized communities, coastal India, livestock policy, heat stress

JEL Classification: Q18, Q12, Q54

In the last decade (2010–20), the Indian agricultural and allied sector has been stagnant, and in the latter half, the annual growth rate has declined from 6.8 per cent in 2016–17 to 4.3 per cent in 2019–20. The long-term trend in the share of this sector in India's total Gross Domestic Product (GDP) has been hovering around 18 per cent over the last decade. Despite the stagnation in this sector, the percentage of livestock increased from 4.0 per cent in 2011–12 to 5.2 per cent in 2019–20, which reflects the growing importance of it in predominantly rural Indian households. The importance of livestock in Indian households has been paramount because they have been a source of income and an asset that serves as insurance and savings to deal with crises, especially for the marginal section of the rural population. However, the current concerns surrounding climate change and its impact on the agricultural sector raise some doubts. Are marginalised and landless households—the major livestock holders—equipped to deal with the uncertainties related to climate change? This chapter explores how climate change and adaptation policies have directly or indirectly influenced livestock holding patterns in India and discusses the policy landscape to protect the livelihoods of marginalised groups. The chapter focuses on the coastal states of India, as these regions are highly vulnerable to climate change.

Livestock has a dual relationship with the phenomenon of climate change. Livestock contributes to climate change by adding more greenhouse gas (GHG) emissions. Interestingly, the rising temperatures on account of this GHG-induced warming, in turn, potentially impact livestock, especially dairy cattle. While the former has been discussed extensively in the mitigation strategy of climate change, the latter related to adaptation has not received much attention from social scientists and policymakers, although it has been studied to a certain extent, primarily by agricultural scientists.

According to the Food and Agriculture Organization of the United Nations(FAO), the total emissions from global livestock production are around 7.1 gigatonnes CO2eq per annum for the 2005 reference period, with a share of about 15 per cent of the overall human-induced GHG emissions (Gerber et al. 2013, 15). From 2005–15, the total emissions from the dairy sector globally increased by 18 per cent because of an increase in their population by 11 per cent, which also resulted in an overall increase in their milk production by 30 per cent. The global emission intensities, however, declined by 11 per cent over the same period (FAO and Global Dairy Platform Inc. 2019, 7). The mitigation measures aimed to reduce the emission intensity and, thereby, the absolute emissions have been partially successful because of the decline in the former. However, it is imperative to reduce total emissions as the world moves towards carbon neutrality by 2050.

Asia remains the world's largest milk producer, contributing to over 40.0 per cent of the global milk production in 2020. It showed a year-over-year growth rate of 2.6 per cent, with India, China, Pakistan and Turkey contributing mainly to this growth. Due to a favourable monsoon and improved feed and fodder,

milk production reached 195 million tonnes in 2020, an increase of 2.0 per cent compared to 2019 (FAO 2021, 2). India is currently the world's largest milk-producing country, contributing more than half of Asia's production and almost one-fifth of the global output. However, this sector is particularly vulnerable to the threats of climate change, and its risks can severely impact production as temperatures rise and humidity levels increase. Hence, the urgency of adapting to the changing climate cannot be overstated. It is crucial to ensure that the dairy sector plays a prominent role in India's agricultural and food sectors. However, as noted in the recent IPCC *AR6 WGII Summary for Policymakers*, to ensure the proper implementation of these adaptability measures, it is essential to recognize the changing climate scenario, the need for adaptability and the importance of policies, both scientific as well as social:

> The recognition of climate risks can strengthen adaptation and mitigation actions and transitions that reduce risks. Taking action is enabled by governance, finance, knowledge and capacity building, technology, and catalysing conditions. Transformation entails system transitions strengthening the resilience of ecosystems and society. (IPCC 2022, 6)

The following section discusses the evidence that climate change negatively impacts livestock productivity, mainly relying on the scientific literature. We discuss direct and indirect effects on livestock productivity, especially that of bovines. The smaller ruminants are more resistant to changing climatic conditions (Maiti et al. 2014, 656). So, there is evidence of a changing pattern in livestock holding in India, especially in the coastal states. The third section presents statistical evidence based on India's Livestock Census data to document this observation. The fourth section reports the holding patterns of livestock from the recent 77th round of the National Sample Survey (NSS) survey based on the landholding size of the households. The section argues that the livelihoods of the landless and marginalised operational landholding households would be most impacted due to their lack of access to resources, both economic and financial. Hence, the last section discusses the importance of scientific, social and economic policies for implementing adaptability measures to protect these marginalised sections' livestock and livelihoods.

A Brief Survey of the Literature

The mitigation strategies for GHG emissions have rightly focused on livestock as a significant source of emissions since the findings of Working Group III of the IPCC Fourth Assessment Report of 2007 (IPCC 2007, 66). The emissions occur directly through the raising of animals in the form of methane from enteric fermenting, nitrous oxide from manure storage and carbon emissions from the consumption of feed and energy needed for the rearing of livestock. However, there are also indirect emissions from livestock rearing.

While some recent progress has been made to reduce the emissions intensity from livestock to increase the effectiveness of this strategy, it is crucial to recognise the complex interactions occurring among the various components of the livestock production system (Grossi et al. 2019, 74).

Even in the case of effective adaptability measures, it is essential to understand how climate change impacts livestock, both directly and indirectly. The direct impact is on animal physiology, production and behaviour (Henry, Eckard and Beauchemin 2018, s447; Henry et al. 2012). The heat stress in livestock caused by rising temperatures and warm and humid conditions is usually known as acclimation, which reduces feed intake, increases water intake and alters physiological behaviours (Nardone et al. 2010). The scientific explanation behind this phenomenon is that animals have a thermal comfort zone, and their physiological activities properly function within that optimum temperature and humidity range (Rojas-Downing et al. 2017, 148). It impacts their normal physiological activities outside that zone, leading to adverse health conditions, increased mortality and declining populations because of poor reproductive health. The changing climatic scenario also has indirect impacts on the livestock through poor quality forage because of impacted pastureland, shortage of feed and fodder, lack of water resources, loss of biodiversity needed for their sustainability and increasing incidences of parasitic and vector-borne diseases (IPCC 2022; Cheng, McCarl and Fei 2022).

The potential consequences of climate change on livestock productivity are alarming. Dairy cattle—with their relatively higher metabolic rate during lactation—are highly susceptible to heat stress. This is most pronounced in a high-temperature zone, especially in the exotic breed cattle (Das et al. 2016). When the temperature-humidity index (THI) exceeds 70, a negative relationship exists between dry-matter-intake (DMI) and milk yield; both decline at 0.23 and 0.26 kg per day with every unit increase in the THI beyond 70 (Johnson et al. 1962). A recent study found that exposing dairy cows to moderate heat stress over four days in a climate chamber-controlled study reduced milk yield by 53 per cent and reduced the DMI by 48 per cent (Gantner et al. 2017). With the increasing yield of milk production over the years, dairy cattle have become more sensitive to such temperature changes, which eventually affect production (Berman and Kofinas 2004; FAO and Global Dairy Platform Inc. 2019, 16).

This reduction in milk and meat production yield becomes concerning, particularly for low-income countries such as India, for three reasons. First, given the projections of global population growth, a significant section of the population in the tropical and subtropical regions depends on these animal protein sources as a significant source of nutrition (De Almeida 2018, 1178). Second, this heat stress from climate change would be felt more in tropical countries because of this region's already high temperatures, lack of economic resources and the agrarian production system (Banik, Pankaj and Naskar 2015, 178). Third, 58 per cent of

Indian households are currently engaged in animal farming, and 71 per cent own some form of livestock (except pets). Among rural households, 48.5 per cent owned cattle (16.4 per cent in milk, 19.6 per cent in young stock, 12.5 per cent in others), 27.8 per cent owned buffaloes (10.7 per cent in milk, 11.7 per cent in young stock, 5.4 per cent in others), 21.9 per cent owned ovine and other mammals and 10.9 per cent owned poultries (Ministry of Statistics and Programme Implementation 2021, 66). So, any impact on milk yield and meat production would severely impact their livelihood during a period when the agrarian economy in India is already reeling under a severe economic crisis. This would force Indian farmers to adapt to the changing climatic conditions, which might become particularly challenging due to insufficient resources.

Interestingly, micro-level studies have shown that adaptive practices such as shelter modifications, water cooling or sprinkler systems and strategic nutritional supplements have evolved in coastal India due to changing climatic conditions (Maiti et al. 2014, 653). These practices, which are already in place, offer a glimmer of hope in the face of climate change. Another pattern that is also observed globally is the changing composition of livestock holding in favour of small ruminants such as goats and sheep. Sheep and goats generally appear less susceptible to heat stress. Goats are much better adapted to desert, tropical and subtropical environments (Silanikove and Koluman 2015, 32). These ruminants' ability to tolerate extremes of temperature and humidity and to function well even in water deprivation, water restriction and energy restriction is well documented in the literature (Kaliber, Koluman, and Silanikove 2016; Berihulay et al. 2019, 2; Lu, 1989). Therefore, given the higher ability to tolerate extreme temperatures and humidity, there is a possibility that there would be a shift towards favouring the holding of small ruminants such as goats and sheep rather than beef and dairy cattle.

There is some evidence from livestock holding patterns that such changes might already occur in other parts of the globe. It is observed in South America that under a hot and dry scenario, the numbers of beef and dairy cattle are projected to decrease by 3.2 per cent and 2.3 per cent, respectively, while sheep numbers are estimated to increase by 7 per cent (Seo, McCarl, and Mendelsohn 2010, 2492). Another study, using data from 9,000 African livestock farmers in 10 African countries, found that producers favoured goats and sheep over beef cattle in warmer locations (Seo and Mendelsohn 2008, 156). Since goats have numerous advantages that enable them to maintain their production under extreme climatic conditions, goats may play an essential role in adapting to harsh conditions due to climate change (Darcan and Silanikove 2018, 35). It would be interesting to see whether a similar pattern over the years is also observed in the Indian livestock sector, especially in the coastal belts, if the farmers are shifting towards holding more small ruminants.

Livestock Holding in India

We report the livestock population for all of India, especially the coastal states, to capture whether any change in the pattern of livestock holding is exhibited. Table 1 shows the change in livestock population in India based on the Livestock Census data. Although there has been a decline in the cattle population since 2007, there has been an increase in the buffalo population over the last decade. Hence, there was a marginal decline in the overall bovine population between 2007 and 2019. The goat and sheep populations increased by 6.0 per cent and 3.8 per cent, respectively, over the same period. Although there is no firm evidence of a changing pattern in livestock holding at an all-India level, the pattern is quite evident when we take a closer look at the coastal states in India.

Table 1: Livestock population in India

Year	2007	2012	2019	Change in percentage (2007–19)
Livestock	(Numbers in Millions)			
Cattle	199.1	190.9	193.5	−2.8
Buffalo	105.3	108.7	109.9	4.3
Bovine (Cattle and Buffalo)	304.4	299.6	303.3	−0.4
Sheep	71.6	65.0	74.3	3.8
Goats	140.0	135.2	148.9	6.0

Source: Calculated using 19th and 20th Livestock Census, Department of Animal Husbandry, Dairying and Fisheries, Government of India.

The specific reason to focus on coastal India is that the Indian coastline is the world's most vulnerable region to climate change impacts, including extreme temperatures, changes in precipitation patterns, increased incidence of extreme weather events and sea-level rise. Hence, given the extreme conditions, it is more likely that the changing pattern is evident in the coastal belt than in the inner heartland of India. To study the coastal belts, we focus on 10 states along the coastline—Andhra Pradesh, Telangana, Gujarat, Goa, Kerala, Karnataka, Maharashtra, Tamil Nadu, Orissa and West Bengal. Table 2 shows the livestock population share in India's 10 coastline states from 2007 to 2019. Although the share of the total livestock population in coastal India has declined marginally by around 1.8 per cent from 2007 to 2019, there is a drastic decline in the bovine population by almost 10 per cent. Among the small ruminants, the share of the sheep population has increased by 7.6 per cent, while the population of goats has marginally declined by 1.2 per cent.

Table 2: Share of Coastal India in India's livestock population

Year	2007	2012	2019	Change in percentage (2007–19)
Livestock	(in per cent)			
Cattle	45.4	43.4	41.8	−3.6
Buffalo	34.7	29.7	28.5	−6.2
Bovine (Cattle and Buffalo)	80.1	73.2	70.3	−9.8
Sheep	71.8	73.3	79.4	7.6
Goats	45.6	40.5	44.4	−1.2
Total livestock (including pigs)	46.3	43.0	44.5	−1.8

Source: Calculated using 19th and 20th Livestock Census, Department of Animal Husbandry, Dairying and Fisheries, Government of India.

As shown in Table 3, the shift in the pattern of livestock holding towards smaller ruminants becomes more evident in coastal India if one closely focuses on the absolute numbers and their change over 2012–19. We find that over this period when the impacts of climate change became more prominent, the bovine population of coastal India declined by almost 2.7 per cent while the sheep and goat population increased by almost 22.1 per cent—a dramatic shift in the pattern of livestock holding in coastal belts. So, a trend is developing in India, where one can see a change in the holding pattern of livestock. However, the issue assumes greater significance in the context of who will be more well-equipped to adapt to these changing patterns of livestock holding. More importantly, which category of farmers would be able to adapt to the changing climatic conditions and sustain if they persist in holding onto their existing bovine population? This also assumes greater significance considering the maladaptation policies highlighted in the WGII AR6 IPCC report.

Table 3: Livestock population in Coastal India

Year	2012	2019	Change in percentage (2012–19)
Livestock	(Numbers in Millions)		
Cattle	82.9	80.8	−2.5
Buffalo	32.3	31.3	−3.1
Bovine (Cattle and Buffalo)	115.2	112.1	−2.7
Sheep	47.7	58.9	23.5
Goats	54.6	66.0	20.7
Sheep and Goats	102.3	124.9	22.1

Source: Calculated using 19th and 20th Livestock Census, Department of Animal Husbandry, Dairying and Fisheries, Government of India.

Adaptability Policies: Who is Well Equipped to Adapt?

There have been a few recommendations for the adaptability of livestock to the changing climatic conditions, which are mainly applicable in the Western world. However, many of these recommendations are capital-intensive, beyond the capacity of the small farmers in India, who are already resource-constrained (Mahajan et al. 2015, 294; Pankaj, et. al. 2013, 30). Hence, given the practical applicability of these policies, adaptation policies must be localised, and the socio-economic conditions of the domestic economy must be considered. It is, therefore, crucial to determine the pattern of livestock holding depending on their financial and economic capacity—a proxy of which can be the size of their operational holding—to understand better which farmer's groups, based on their economic conditions, are well equipped to adapt to these changing conditions.

We consider the livestock holding by type of landholding category (Table 4). Here, landless households are those that have a holding of 0.002 hectares or less; households with 'marginal' holding include those who have more than 0.002 hectares but less than or equal to 1 hectare of land; and households with more than 1 hectare but less than or equal to 2 hectares are 'smallholders'. 'Semi-medium' landholding households have more than 2 hectares but less than or equal to 4 hectares; 'medium' holding refers to more than 4 hectares but less than or equal to 10 hectares, and households with more than 10 hectares of land are 'large' landowners.

Table 4: Average number of livestock owned per 1000 households by landholding category, 2019

Landholding	Cattle	Buffalo	Ovine	Poultry
Landless	878	333	819	1,762
Marginal	1,164	520	992	1,267
Small	1,376	878	770	1,453
Semi-medium	1,700	1,162	1,054	1,405
Medium	2,348	1,563	1,770	619
Large	2,768	2,307	1,584	1,354

Source: Authors' calculations using the National Sample Survey (NSS) Land and Livestock Survey 2019.
Note: The NSS 77th round does not separately report ownership of smaller livestock such as goats and sheep; they are reported collectively as 'Ovine and other mammals'.

On the one hand, on average, households with larger landholdings own more bovine livestock. On the other hand, landless households own more poultry on average than any other landholding category. For such households, owning poultry may provide sustenance and additional earnings. This may be particularly true during times of economic distress, such as during and after the slowdown of the Indian economy after 2018, as well as the pandemic and the lockdown.

It is important to note that large landholders, despite their higher number of bovine livestock, also diversify their livestock portfolio. In 2019, they owned a higher number of poultry, comparable to the average numbers owned by small and semi-medium landholding households. This suggests that large landowners, too, see the economic benefits of diversifying their livestock ownership. On average, medium landowners, followed by the large and semi-medium, owned the highest numbers of ovine animals that are also more climate-resistant (Table 4).

Further, in line with our hypothesis that the changing pattern is more evident in the coastal belt, we consider only coastal states (the 10 states considered in the third section) and compare the figures of corresponding landholder categories in Tables 4 and 5. On average, large landowners in coastal states own much higher numbers of ovine animals and poultry (Table 5) than large landowners across all states (Table 4). The average number of poultry and ovine animals owned by large landowners in coastal states is around double that owned by the same landholder category across all states, whereas the number of bovine animals owned by large landowners in coastal states is relatively less. On average, medium landowners in coastal states also own more poultry and less bovine animals than those across all states, although they also own fewer ovine animals.

Thus, there are indications of differential abilities to adapt across landholder categories and regions with differing exposure to the climate crisis.

Table 5: Average number of livestock owned per 1000 households by landholding category in Coastal States, 2019

Landholding	Cattle	Buffalo	Ovine	Poultry
Landless	783	154	764	2,315
Marginal	1,358	317	1,278	1,622
Small	1,310	513	874	1,776
Semi-medium	1,549	730	961	1,172
Medium	2,106	991	1,206	1,129
Large	2,688	2,044	2,756	2,965

Source: Authors' calculations using the NSS Land and Livestock Survey 2019.

Note: The NSS 77th round does not separately report ownership of smaller livestock such as goats and sheep; they are reported collectively as 'Ovine and other mammals'.

The distribution of land ownership among rural households reveals that medium and large landowners account for only 1.4 per cent and 0.1 per cent, respectively, while marginal landowners make up more than 76 per cent (Table 6). Notably, bovines constitute a significant portion of the total livestock holding among marginal and landless households, comprising almost 85 per cent of rural households. However, the evolving climatic conditions exacerbate the vulnerability of this group to decreased livestock productivity.

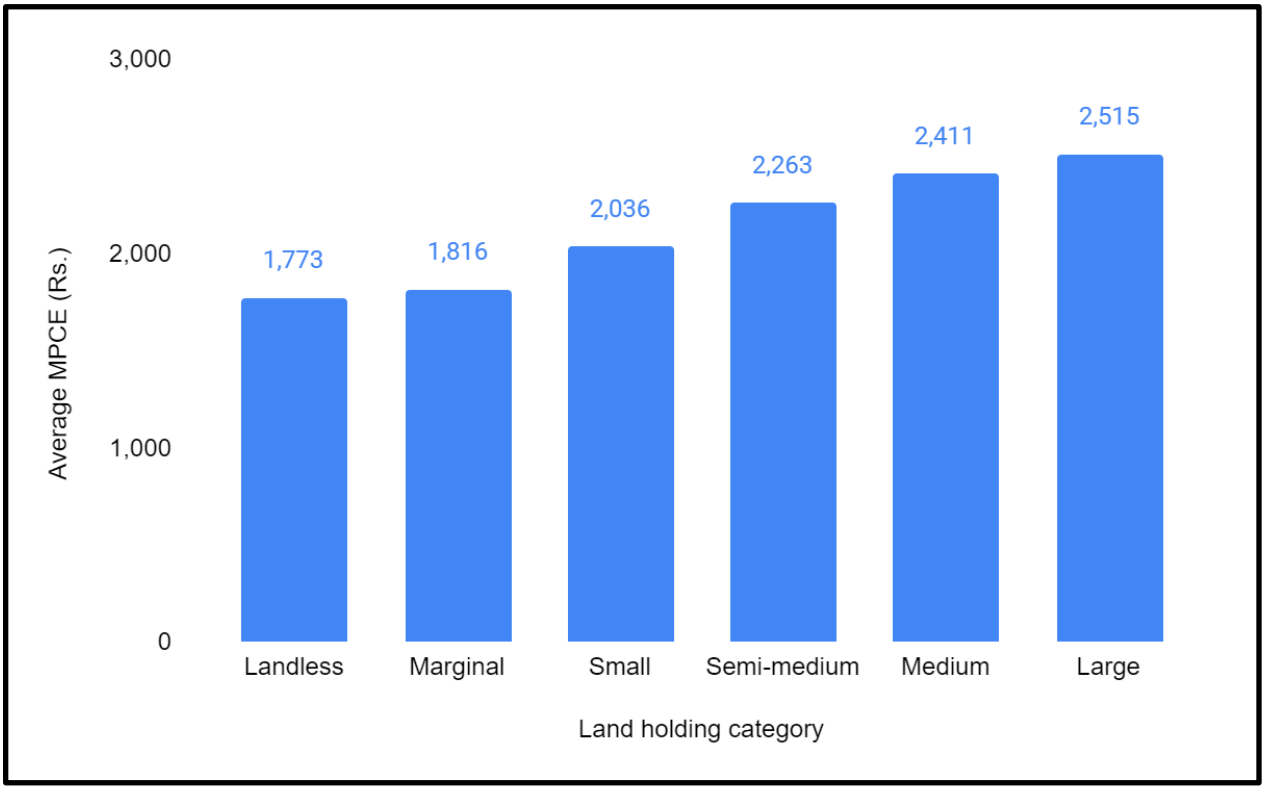
Table 6: Composition of rural households, 2019

Landholding	Per cent
Landless	8.2
Marginal	76.5
Small	9.3
Semi-medium	4.4
Medium	1.4
Large	0.1

Source: Authors' calculations using the NSS Land and Livestock Survey 2019.

An argument could be made that households without land ownership may be involved in alternative activities, such as salaried or wage employment, which do not necessitate land ownership. In this context, the average monthly per capita consumer expenditure (MPCE) across different categories (Figure 1) highlights a discernible trend of increasing MPCE by land ownership, signifying varying financial capacities to adapt to climate change. Large and medium landowners are better positioned to allocate more resources and adjust their livestock ownership or other activities to cope with climate change. On the contrary, individuals who do not own land or possess small plots and rely on agriculture and agriculture-based activities may face challenges in accessing adequate resources. For these farmer groups, whose livelihoods are closely tied to livestock and yet have limited resources, direct economic support from the state is imperative to facilitate adaptation. Furthermore, scientific policies tailored to address regional needs and domestic constraints are essential to aid them in adapting effectively.

Figure 1: Average monthly per Capita consumer expenditure (Rs.), 2019.



Source: Calculated using the NSS Land and Livestock Survey 2019.

The Need for Regional Policies for Climate-resilient Livestock Development

Animal husbandry has been a state subject wherein the state government designs policies and programmes suitable for livestock. Yet the union government has played a pioneering role in defining the direction of the sector. With the increasing demand for milk and milk products in the national and international markets, the impetus to increase milk production will continue. The dairy vision in India is set to achieve one-third of the global milk production by 2030. Historically, the policies in India related to livestock development have mainly focused on large livestock with an exclusive focus on dairy cattle to increase the yield per animal. These have been successfully delivered, and milk production has increased, but livestock development policies largely ignored the climatic specificities, regional specificities, nutrition availability or nomadic and pastoral communities in the different agro-ecological zones of the country (George 1985). Given the increasing frequency of climatic irregularities and the greater need for adaptation measures, the same policy instruments devised for increasing milk yield may not deliver.

To increase milk production, the livestock research that gained momentum was cross-breeding native cattle with exotic high-yielding ones to increase productivity. Research on adaptive traits, reducing methane emission, feed composition, and so on, received minimum attention. Of late, there has been some research focus on indigenous breeds and their adaptive capacities, reducing emissions from the dairy sector by tracking the carbon footprint of the dairy supply chain, measuring methane emission using the Sulphur Hexafluoride (SF6) Tracer Technique and nutrient optimisation for reducing enteric methane emission (NDDB 2022). As discussed earlier, there is scientific evidence of how climate change impacts the milk yield and the health of dairy cows, especially the exotic varieties and cross-breeds. However, hardly any livestock or cattle development policies or programmes have been implemented on a large scale to address these impacts. This is because climate change concerns are yet to be integrated into the sectoral plans and programmes.

Under the National Innovations in Climate Resilient Agriculture (NICRA) project of the Indian Council of Agricultural Research (launched in 2011), heat stress and fodder scarcity have been identified as the major climate-sensitive issues affecting dairy farming in India. For a livestock production system to be sustainable in the changing climate scenarios, there is a need to identify the best adaptive breeds in different agro-ecological zones, especially given the warning in the recent IPCC report on maladaptation practices. India has several unique adaptive livestock breeds across different livestock species due to years of selective breeding, seasonal movement and selective grazing (Voelcker 1893; George 1985). They can walk long distances, ingest and digest low-quality feed (high cellulose content), survive on minimum feed during drought conditions, perform thermoregulation, have resistance against diseases and have high fertility, as compared to the exotic temperate

breeds or cross-breeds (Köhler-Rollefson and Mathias 2010). For example, the Banni buffaloes from the Kachchh district of Gujarat can graze at night to escape the heat during the daytime. Scientific research to harness these traits and promote these breeds among livestock farmers may prove beneficial as an adaptation strategy for the future. There is a need to re-imagine livestock development policies in a regional context beyond just milk yield to consider these desirable traits for adaptation. Moreover, since 70 per cent of the cost incurred in livestock production is on livestock feed, promoting locally available animal feed and fodder, kitchen wastes and roughages or adopting a region-specific strategic feeding with respect to the livestock breeds of the region can reduce the dependence on expensive concentrate feeds.

Several adaptation strategies are employed, especially by farmers in advanced countries, to ease the impact of climatic stress on livestock and arrest the decline in milk yield owing to heat stress. As highlighted earlier, these strategies include shelter modifications to control the Temperature Humidity Indices (THIs), installing proper cooling facilities, spraying evaporation cooling to regulate temperatures and nutritional management. In Florida, for example, the construction of cooling shades alone increased milk production by 10–19 per cent (Toledo et al. 2024). However, such techniques are water-intensive, consume a significant amount of energy and are not always viable options for small and marginal livestock farmers in India.

On the contrary, traditionally, livestock farmers in India have used different local strategies to adapt to the changing warm and humid conditions, such as using natural trees and ponds as a source of shade and temperature control. They have also used different coping mechanisms like diversifying stock and migration to survive drought spells. There are several unique adaptation strategies of livestock farmers that need to be promoted. There is a need for localised livestock policies to promote such region-specific breeds (livestock breeds that have evolved over the years in a particular region) to make it easier for marginal and small farmers to adapt to changing climatic conditions. While promoting the adaptation strategies, the policymakers in India need to understand and consider the relationships between bio-physical systems, the diversity of the region and the sociocultural components of the local communities. Therefore, the climate-resilient livestock policies need to have a greater scientific and technological capacities that includes farming communities and their knowledge in the decision-making process.

Conclusion

The current discourse predominantly revolves around mitigation strategies, with minimal emphasis on adaptive approaches within the livestock sector, particularly in the context of India. Livestock holds significant importance in India's agricultural landscape, and the necessity to adapt to climate-related challenges cannot be overstated. Empirical evidence indicates that farmers are already adjusting their practices in response to the impact of rising temperatures and humidity on milk yield, particularly in coastal regions. However, the resource limitations faced by landless, marginal and small-scale farmers, who constitute a

substantial portion of people who rear livestock, present a formidable barrier to effectively adapting to these changing climatic conditions without adequate state support, both in terms of economic assistance and knowledge dissemination. The absence of such support may lead to the adoption of maladaptive practices by these farmers if they are solely subject to market forces. Dairy and animal products play a pivotal role in the dietary habits and protein intake of low-income households, especially in a country where over 35 per cent of children under the age of five suffer from stunted growth, indicating the cumulative nutritional deficiencies of both the children and their mothers. Without prompt government intervention, in collaboration with local farmers and relevant agencies, to safeguard livestock, the evolving climatic conditions could exacerbate food insecurity among the already undernourished population. There is a critical need for localised livestock policies that advocate for region-specific breeds, thereby facilitating the adaptation of marginal and small-scale farmers to the changing climatic conditions. Furthermore, the field of livestock sciences must be receptive to diverse knowledge systems and play a pivotal role in providing substantiated insights for policymakers.

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