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Climate Resilient Livestock Production in the Coastal Ecosystem of India

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Climate change is one of the important factors in the livestock sector affecting their production and reproduction. India has large areas of highly productive coastal ecosystems which include approximately 5,000 km^2 of mangroves, 1,700 km^2 of salt marshes, 177,000 km^2 of seagrass ecosystems and approximately 2,300 km^2 of coral reefs. Different human activities are causing damage to the coastal ecosystems thereby increasing the severity as well as frequency of cyclones and associated storms, acidification of seawater, occurrence of floods and increased air and water temperature. Studies suggest that if sea temperature rises by 2 to 4°C, the intensity of cyclones hitting the coastal areas can rise by 10-20%. Increased frequencies of extreme weather conditions, floods, and lack of rain will degrade grasslands, fodder production and quality of the fodder. Thus, the livestock as well as the keepers need to be resilient to the changing environment and continue to improve their production to meet the demand from the growing population. According to IPCC, resilience is defined as the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance by responding or reorganizing in a way to maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation. In time weather forecasting for early warning of hazardous weather events will allow the farmers to save the animals from bad weather conditions like severe heat, cold waves, heavy rains, thunderstorms, cyclones and floods. Adopting several strategies like use of locally adapted breeds/varieties, genetic improvement of animals, scientifically designed housings, improving diets, better herd and grassland management, establishment of climate resilient smart villages with shelters for man and animals during climatic havoc, *etc.*, will help in combating with the changing climate.

(***Key words:*** *Climate change,Coastal ecosystem, Livestock production, Resilience)*

Climate is a measure of prevailing weather conditions of a region such as temperature, atmospheric pressure, humidity, wind, precipitation, sunshine, cloudiness and other meteorological variables in a given region over a long period of time. In today's scenario climate change is a major concern across the globe affecting human, livestock and livestock production systems. A large proportion of the people in our country depend on thelivestock sector for their basic livelihood and therefore, climate change has a great impact on national economy. Due to climate change, climate resilient livestock production system is getting emphasis wherein resilience is the animal's capacity to be minimally affected by disturbances and rapidly return to the state pertained before exposure to a disturbance (Colditz and Hine, 2016).

The coastal regions of India are very rich in livestock production, crop production and fisheries. The livestock sector in the coastal ecosystem plays an important role and acts as a source of income and savings for the livelihood of the people. Therefore, India's coastal regions are a home to a variety of cattle breeds, including Gir, Kankrej, Tharparkar, Dangi, Ongole, Vechur, Malnad Gidda and Shweta Kapila. Additionally, one can find various buffalo breeds, including Banni, Jaffarabadi, Mehsana, Murrah, Surti, Chilika, and Gounti/local breeds.Breeds including Ganjam, Gohilwadi, Kutchi, Konkan Kanyal, Kanni Adu, Mehsana, Attappady Black, Teressa and Black Bengal are popular among goat breeds. These coastal

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regions are also a habitat for vast populations of sheep breeds of Ganjam, Kendrapara Patanwadi, Marwari Nellore, Chevaadu, Kilakarsal, Madras Red, Vembur, Garole, and Chottanagpuri. It has also been determined and popularised that crossed between Agonda Goan, Nicobari, and Yorkshire pigs are the best breeds for coastal, tropical and humid regions (Mandal *et al.,* 2022). However, the characteristics of coastal regions include tropical cyclones, storm surges, land subsidence, sea level rise, coastal erosion and coastal inundation (Dey *et al.,* 2016). Climate change has detrimental effects on coastal ecosystems via global warming, increasing severity as well as the frequency of cyclones, acidification of seawater, inland and coastal flooding, droughts, salinity intrusion and changes of the river bed level due to sedimentation and changes in morphological processes. Rising temperatures along with air and water pollution threaten the survival of many species, ecosystems, livestock production and loss of biodiversity. Temperature fluctuation and uneven rainfall lead to occurrences of vector-borne diseases, infestation of parasites and transmissions of new diseases (Thornton *et al.,* 2009). This impact results in the outbreak of new diseases and pests.

The poorest people of the country are affected first by climate change because they are more dependent on climate-sensitive livelihoods such as livestock farming. On the other hand, the global demand for livestock products is increasing day by day. Thus, a challenge exists to maintain a balance between production and climate change, food security and environmental preservation. The majority of dairy animals reared were non-descript (Desi) cows in the coastal regions followed by crossbred cows. The reason for rearing desi cows is that they are more disease-resistant and have better adaptability than pure-breed animals. The rearing of dairy buffalo is not common in coastal areas (Ray and Sengupta, 2016). Garole sheep breed is most widely reared in the coastal regions of India and Sundarbans is the native place. The characteristic of prolific sheep breeds in the hot and humid coastal region of West Bengal and Odisha states evolved through the process of adaptation. The prolificacy trait in coastal sheep breeds is associated with higher temperatures coupled with humidity (Shinde and Sejian, 2013). Most of the farmers own sheep which are mainly reared for meat purposes. They are highly resistant to diseases and have high adaptability as they are in their native place, so vaccination and deworming are not commonly practiced. The sheep and goat found in Odisha are known for their prolificacy and resistance to common endo-parasites, and exceptional quality to survive in water logging conditions which makes them adaptive to the climate. Similarly, cattle and buffalo breeds have good qualities for survivability under summer and saline harsh conditions and have a good growth and reproduction rate. Thus, this paper highlights the subject of climate resilience livestock production in coastal regions of India, emphasizing the contributing factors and the strategic opportunities to achieve it.

Impact of climate change on coastal livestock production

To develop climate resilience, it is imperative to initially comprehend the factors imposing challenges to coastal livestock production. Owing to its location, climate change is the primary cause of issues associated with livestock production along the coast. The phenomenon of climate change is interconnected with various factors. Consequently, the subsequent points delineate the factors influenced by climate change that further exacerbate the challenges faced by livestock production in coastal regions.

Quality and quantity of feeds

The primary factor in livestock production is the feed as animal production, growth, and health are directly impacted by the quality and quantity of the feeds, making it a crucial component of livestock management. Variations in feed quality, which are impacted by elements including soil erosion, climate change, and feed processing techniques, have a major impact on livestock productivity (Godde *et al.,* 2021). These differences in the quality of the feed have been connected to slower growth rates, less effective reproduction, and a higher vulnerability to diseases (Godde *et al.,* 2021). The primary productivity of pastures is reduced by rising temperature, rising carbon dioxide levels, nitrogen deposition, changes in land use and systems, species composition, *etc*. (Hidosa and Guyo, 2017). In the East Zone of India, which includes Bihar, Jharkhand, Odisha, and West Bengal, the primary

Fig. 1. *Coastal areas of India (Source: Centre for Coastal Zone Management and Coastal Shelter Belt)*

source of dry fodder is crop leftover from food grains, followed by forests and farm, horticultural, and kitchen waste. All states in the east zone, except Odisha, are experiencing a 43.9% deficit of dry fodder (Roy *et al.,* 2019).

Water

Water influences the livestock sector through the use of water for animal drinking, feeding crops and product processes (Thornton *et al.,* 2009). The livestock sector accounts for about 8% of global human water use and an increase in temperature may increase animal water consumption by a factor of two to three (Nardone *et al.,* 2010). Changes in the quantity of water and timing of precipitation affect the livestock. Increased rainfall and floods may lead to a high mortality rate in the animals leading to loss of life. Further, increased salt in water can have negative effects on animal metabolism, reproduction, and digestion. Hence, it can also lead to a reduction in livestock resources by limiting their access to water. In general, beef cattle are susceptible to severe effects from salinity, or the amount of salts in the water. Similar to other water quality issues, excessive salinity might hinder their ability to convert feed, which can reduce their weight gain (Tulu *et al.,* 2024). Heavy metals and chemical contaminants could also affect cardiovascular, excretory, skeletal, nervous and respiratory systems, and impair hygienic quality of production (Nardone *et al.,* 2010).

Livestock diseases

Climate change can affect animal health directly or indirectly. The direct impact of climate change on animal health has been described as reduced immunity (Bett *et al.,* 2017). The increase in temperature increases the morbidity and mortality of the animals. The livestock health can be affected by metabolic disorders, oxidative stress, immune suppression, decreased reproductive

performance, and death depending on the degree, duration and severity of heat exposure. The indirect impact of climate change are related to microbial communities like pathogens or parasites, increased frequency of vector-borne and food-borne diseases, host resistance and scarcity of feed and water (Nardone *et al.,* 2010; Thornton *et al.,* 2009). The impact of climate change on livestock diseases depends on the geographical region, land type, and animal susceptibility. It stimulates disease spreading, outbreaks of severe disease or even leads to the introduction of new diseases which may affect livestock that are usually not exposed to such diseases (Thornton *et al.,* 2009). The majority of the cattle diseases which have been identified in the Sundarbans region are of different types, such as bacterial, viral, protozoan and parasitic. Compared to cattle, buffaloes are more prone to Hemorrhagic Septicemia (HS) and experience a higher death rate (Talukder, 2020). Salinity is one of the common problems faced by the farmers affecting crops and the livestock depending on the crops are affected by many negative consequences such as diarrhoea, skin diseases, liver fluke, loss of body weight and decreased immune system (Alam *et al.,* 2017). Irregular flooding can affect livestock by altering food and shelter which causes infections like foot and mouth disease, bird flu, *etc*. resulting in huge losses.

Heat stress

The rising temperature and humidity imposed by climate change cause the inability to maintain thermal equilibrium of the body, leading to heat stress. The degree of thermal load and susceptibility of livestock to heat stress depends on temperature, relative humidity, species, genetic makeup of the animal, life phase and nutritional status. With the advancement of molecular biotechnologies, new avenues for identifying critical cellular responses to heat stress and characterising gene expression have been developed. According to Hao *et al.* (2016), heat stress causes a wide range of intricate cellular and molecular reactions in animals. The cellular response is one of the primary pathways which help the livestock to cope up and survive in the environment under heat stress conditions. Genes such as ATPase Na^+/K^+ transporting subunit alpha 1 and ATPase Na^+/K^+ transporting subunit beta 2, thyroid hormone receptor, fibroblast growth factor and heat shock proteins are involved with heat tolerance in farm animals (Aleena *et al.,* 2018). The well-known and highly conserved heat-shock protein (HSP) family of proteins controls how cells react to a variety of stressors. These molecular chaperones that have undergone evolutionary conservation are essential to an organism's ability to survive high temperatures in the environment. Major physiological functions regulated by HSP include defence against cellular damage, reducing the effects of stressors such as ischemia, cytokines, energy depletion, and promoting the development of thermotolerance (Hassan *et al.,* 2019). The commonly studied heat shock proteins in livestock are HSP70, HSP90 and HSP27 in which HSP70 was identified to be the ideal biological marker for heat stress in farm animals.

Animal production

Livestock production and productivity are affected when temperature rises in which shifts in the rainfall distribution and increased frequency of extreme weather events occur. This can occur directly through increased heat stress and reduced water availability, and indirectly through reduced feed and fodder quality and availability (Thornton *et al.,* 2009). Extreme hot temperature leads to heat stress of the animals which reduces milk production and less meat. High-producing dairy cows generate more metabolic heat than low-producing dairy cows and so high-producing dairy cows are more sensitive to heat stress. Along with heat stress, reduced feed availability and quality, illnesses (caused by outbreaks and compromised animal immune systems), and animal mortality from extreme weather events such as storms, floods, heat waves, and cold snaps are likely to have a detrimental influence on animal production, welfare, and life expectancy (Godde *et al.,* 2021).

Biodiversity

Biodiversity is defined as the variation found in all forms of life on earth, including genes, ecosystems, and the ecological and evolutionary processes that keep them alive. The behaviours of farmers and biodiversity are significantly impacted by climate change, so conservation is essential for inclusive and sustainable development. The pattern and dynamics of material and energy movement have altered as a result of the loss of biodiversity brought on by climate change, which has a significant influence on the ecosystem (Zhong and Wang, 2017). Biodiversity loss is largely because of the

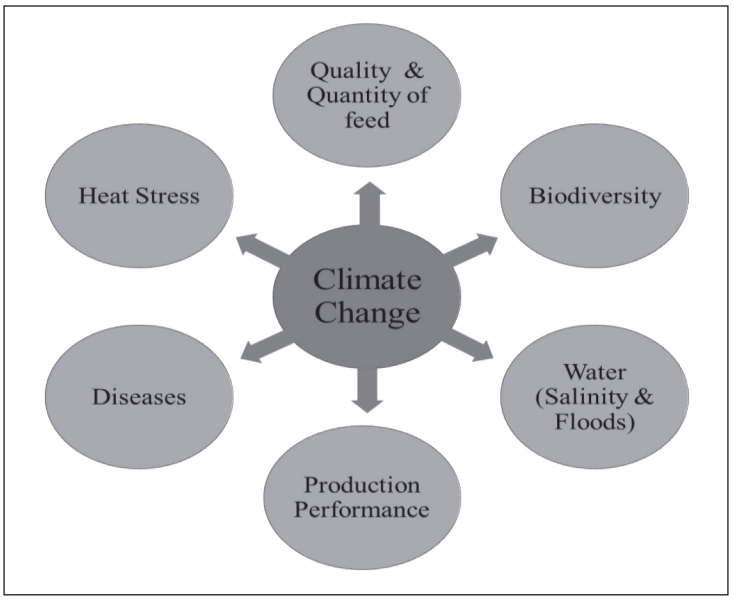

Fig. 2. *Factors affected by climate change in coastal livestock production*

livestock production system that emphasizes mostly on yield and economic returns and ignores the traditional production systems where other considerations like tolerance to extremes are also treated as important (Thornton *et al.,* 2009).

Strategies for climate resilience livestock production

Adaptation strategies

Adaptation strategies can enhance the resilience of livestock productivity to climate change. Implementing adaptation strategies aims to maintain development despite the unavoidable effects of climate change by gradually reversing its negative effects. The results of the adaptation measures ought to become noticeable right away or soon after which occurs at the local or regional level (Lalmuansangi *et al.,* 2023). According to Maiti *et al.* (2014), adaptation strategies followed by the livestock-keepers of eastern coastal regions include providing extra concentrate, minerals supplementation and feed additives to livestock, change in feeding schedule, change in grazing time and use of more amounts of crop residue and hay. A better way to adapt to climate change was also to provide the animals with clean, fresh water on a regular basis, bathe the cattle and buffaloes more than usual, reduce the size of the herd, and alter the microclimate in the cattle shed, grazing area, and stall. Shifting to small ruminants from large ruminants, keeping/promoting/interested in local breeds, providing more healthcare practices to the livestock and using mosquito nets to protect from mosquitoes were also included. Selling of few animals from the stock, livestock insurance, social migration and search of alternate sources of income were among the adaptation strategies followed by the livestock keepers.

The methods and technologies required for adaptation of livestock include understanding the impacts of climate change on livestock. Improving the health of the animal and development of new breeds through technology, enhancing the soil and water management, introduction of climate resilient fodder crops, poultry and livestock breeds, development of low-cost weather-controlled housing for livestock and strengthening animal disease surveillance facilities. In order to provide stability to farm productivity and household incomes and resilience through livelihood diversification in the face of extreme climatic events like droughts, cyclones, floods, hailstorms, heat waves, frost, and seawater inundation, workshops on climate change should be held. Climate awareness mass media campaigns should also be carried out (Pankaj *et al.,* 2023). Developing scientifically designed housings, improving diets, better herd management to improve output, better management of grassland, establishment

of climate resilient smart villages with shelters for man and animals during climatic havocs, *etc.*, will also help in combating with the changing climate. In-time weather forecasting for early warning of hazardous weather conditions will help the farmers to take necessary preventive measures to save the animals from bad weather conditions like severe heat and cold waves, heavy rains and thunderstorm, cyclone, tsunamis, flood and disease outbreaks.

Breeding strategies

Changes in the breeding strategies can help the animals improve their reproduction and growth development by increasing their tolerance to climate change and diseases. Adopting several strategies like use of locally adapted breeds/varieties that sustain well with the climate, genetic improvement of animals by improving the local breed through cross breeding with climate and disease tolerant breeds. Use of molecular genetic markers for heat tolerance in selection program and adopting livestock production as an adaptation strategy will help in the adaptation process. In the recent past, efforts were made to develop prolific sheep breeds for enhancing mutton production. At Nimbkar Agricultural Research Institute (NARI) at Phaltan, Maharashtra, Suwarna strain of Deccani sheep was developed to make the sheep production system more sustainable in the changing demographics, economic, and agricultural milieu. Similar to this, Avishaan a highly prolific triple cross sheep breed was developed at the ICAR-Central Sheep and Wool Research Institute (CSWRI), Avikanagar, Rajasthan from the crossing of Malpura, Garole, and Pattanwadi that have high prolificacy, more litter weight and better milk yields with the capability to adapt to the harsh climatic conditions of the country's desert and semiarid regions (Sharma *et al.,* 2022).

Conclusions

Climate change scenarios will continue in the future and livestock production is thought to be affected by the changes. In order to cope up with it, the adoption of locally adaptive animals to climate change, suitable breeding programmes and nutritional intervention research are the keys to adaptation. In-time warning system of climate change, research and development of new technologies to reduce the impacts of climate change livestock sector is needed. Educating the livestock farmers regarding climate change and ensuring them to adapt sustainable livestock production under the changing climate is necessary.

CONFLICTS OF INTEREST

The authors do not have any conflicts of interest to declare.

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