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Effects of Climate Change on Animal Production

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ABSTRACT

This paper examines the impact of global warming on animal production worldwide. The accumulation of greenhouse gases (GHGs) in the atmosphere is causing changes in extreme weather patterns and consequent climate variations, substantially affecting crop and animal production. Climate change is altering the meadows and pastures that serve as the primary feed sources for animal husbandry, leading to production losses and threatening the sustainability of this sector. A holistic approach is proposed to mitigate the adverse effects of heat stress on animal production. This involves identifying gene regions resistant to heat stress through breeding studies, improving the physical environment by modifying diets, and enhancing the genetic resilience of animals to climate change. Understanding the adaptation mechanisms of these genes will be crucial for future selection programs, enabling breeding animals better suited to the emerging environments resulting from climate change. Selection and breeding of climate-tolerant animals that can survive and reproduce under extreme conditions will ensure their contribution to future generations. Furthermore, responsible practices throughout the production and consumption chain are necessary to preserve a habitable environment for upcoming generations. The solution lies in a multi-pronged strategy that combines genetic research, environmental improvements, responsible practices, and sustainable animal husbandry to combat the challenges posed by global warming and ensure the long-term viability of animal production.

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Introduction

According to ESCAP (2012), climate change results from natural and human factors, including higher concentrations of greenhouse gases and aerosols, crustal movements, volcanic activity, and Earth's rotation. There is scientific proof that the effects of climate change on life on Earth are growing. It is anticipated that precipitation patterns will alter, average temperatures will rise, and extreme weather events, including heat waves, hurricanes, floods, and droughts, will occur more frequently and with greater intensity (McMichael, 2013).

Since animal production is weather-dependent in this setting, climate change primarily affects it (Oyhantçabal et al., 2010). With 40% of the GDP from the cattle industry, most developing nations rely heavily on it for economic and nutritional reasons (FAO, 2009). The demand for animal-based meals is driven by the growing global population and the growing understanding of balanced nutrition, which forces the livestock industry to grow. Extreme weather has a detrimental effect on the quantity and quality of animal products, which lowers feed production and has an adverse impact on animal welfare (Sejian et al., 2012).

That is a reasonable conclusion to draw. Numerous stresses, such as poor feed and temperature change, are experienced by animals raised in tropical climates and substantially impact their immune system, productivity, and reproduction. It isn't easy to manage, analyze, and investigate the effects of many environmental influences on livestock. It has been shown that stress variables have a negative cumulative impact on livestock development and reproductive qualities (Starling, Wilson et al., 2020).

Extreme weather, inadequate ventilation, crowding, handling, transportation, housing conditions, disease outbreaks, and social stress are a few of these variables. Because of different acclimatization mechanisms, livestock respond differently to individual stressors than to combination stressors, such as heat and nutrition (Sejian, 2013). Thus, many stressors must be considered in any investigation of how climate change affects cattle. Global temperatures are predicted to rise due to climate change, which will exacerbate heat stress in cattle and call for changes in agricultural and production practices. However, high-yield breeds dominate today's livestock output and frequently struggle to adjust to heat stress (Hall, 2012).

Environmental conditions are enhanced, and metabolic heat production is decreased to lessen the difficulties of adaptation and the expenses related to cooling systems and modifications to diet. However, growers must incur high costs due to these procedures (Sossidou, 2014). Because they may modify their physiology, behavior, and genetic makeup in response to environmental stimuli, species with great genetic variety and adaptability are more likely to withstand changing environmental conditions (Pauls, 2013). One of the many benefits of conventional livestock production techniques is their capacity to produce animals with high adaptability to arid environments without requiring costly inputs. However, their reliance on regional natural resources makes them vulnerable to problems like decreased feed availability and the advent of strange illnesses or parasites, which are made worse by climate change (Vanvanhossou, 2021).

Climate Change Impact on Growth

Animal productivity and growth may be significantly impacted by climate change. Through variations in temperature, precipitation patterns, and extreme weather events, climate change can affect the quantity and quality of feed available, water sources, and the general health of animals. Heat stress, decreased feed quality, and an increase in disease incidence are the three main issues that cattle may encounter due to climate change, according to the FAO (2013). An ongoing change in the global climate affects cattle in a big way. Livestock growth rates, milk and egg production, reproductive efficiency, morbidity and mortality, and feed availability are all significantly impacted by climate. Livestock also contributes to climate change; according to Rojas-Downing, Nejadhashemi et al. (2017), they account for 14.5% of all anthropogenic greenhouse gas (GHG) emissions.

It is important to note that the primary objective of livestock production is to achieve the most significant possible growth and productivity, such as milk or wool, within the constraints of efficient feed utilization and the judicious use of other essential resources and inputs. The term "animal growth" can be defined as an increase in size. Nevertheless, the implications of increased size are manifold. If we are referring to the growth of the whole animal, the growth of cells, tissues, and organs, or the growth before and after birth or before and after puberty, we can examine the growth from a different perspective.

An animal's body composition and proportions alter noticeably from the early stages of growth to adulthood. This is because different body organs and tissues grow at different rates, which don't necessarily coincide with the animal's overall development. All species of farm animals develop their various tissues in a similar order. It seems determined by how crucial a body part or tissue is to the animal's life (Beitz, 1985).

It is reasonable to conclude that global climate change affects animal productivity. It is commonly known that there is a global warming trend involving animal production. The most frequently mentioned effects of climate change or global warming on animals are limited production, disease resistance, limited feed resources, reduced reproductive success, and decreased survival. Additionally, 14.5% of all greenhouse gas emissions (GGE) are produced by animals raised for food, contributing to climate change (Cheng et al., 2022).

Both the environment and genetics regulate growth. It is characterized as the growth in live body mass or cell multiplication. The availability of nutrients, hormones, enzymes, and environmental conditions such as rising ambient temperature all impact the average daily gain (ADG) (Hafez & Hafez, 2013).

Effect of Climate Change on Feed Intake

Animals under heat stress use more water and less feed. They may even experience changes in their endocrine system, all contributing to a loss in the animal's overall performance (Gaughan and Cawsell-Smith, 2015). Numerous factors, such as land use practices, genetic variability in plant species, and climate change, can impact the quality of forage and the occurrence of illnesses. For instance, certain diseases may become more common in particular areas when temperatures rise, and changes in precipitation patterns may also impact the quality of fodder (Stein et al. 2017).

This method is a fresh scientific approach to stress level measurement in fish, even if fish farmers most commonly use it to analyze the usual daily performance of fish based on the degree of food anticipatory behavior, which measures the fish's feeding incentive. More research has been done on food intake, and it is well known that fish under stress will restrict their intake of feed (Folkedal, Torgersen). To minimize heat stress, cows lower their feed intake during the summer months as both the ambient and body temperatures rise (Ammer et al., 2018).

As a result, milk supply declines, and milk content gradually changes. Research has shown that dairy cows begin to consume less feed when the outside temperature hits 25 °C and that the amount of feed they consume drops dramatically when the outside temperature hits 40 °C. As a result, feed consumption is reduced by about 20–40%. This is how much is typically consumed (Liu et al., 2019).

A decrease in feed intake is one possible reaction to rising room temperatures. While ruminants exhibit decreased hunger, intestinal motility, and rumination in response to rising heat stress, nursing cows decrease feed consumption if the outside temperature increases over 25–26°C and falls more quickly than 30°C. Compared to other ruminants, goats can withstand heat stress better. However, they consume less feed when the outside temperature rises by ten °C above the thermal comfort zone (Cheng et al., 2022).

Effect of Heat Stress on Milk Production

One of the main pillars of global food security is animal production. Any global food security policy must consider the production of milk, eggs, and meat products. In addition, there is a substantial market for these goods worldwide, and this demand is expected to rise sharply along with population expansion and rising per capita income (Oyhantçabal et al., 2010). There has been a decrease in milk quality and a reduction in milk production. Lower-chain fatty acids, solid-non-fat content, lactose, and fat content have all decreased.

There is a noticeable rise in the amount of stearic and palmitic acids. Animals that produce more are typically the most impacted. One theory links output losses to the ability to respond to long-term shocks. Maintaining present output levels in an increasingly hostile climate is not sustainable. Rather than trying to smuggle "stress tolerance" genes into non-adapted breeds, it could be wiser to take into account using adapted animals, which might show lower production levels (along with lower input costs) (Gaughan, 2015).

It is evident that An animal's non-specific physiological reaction to a thermal environment producing more heat than it can dissipate is known as heat stress (Yang, 2014). The most common breed of dairy cattle worldwide is the Holstein. The breed's comparatively low surface area-to-body weight ratio, underdeveloped sweat glands, and short, thick body surface hair all impact milk production and limit its ability to dissipate heat through skin evaporation in the summer (Yang et al., 2010).

Effect of Heat Stress on Reproduction

High ambient temperatures have a detrimental effect on livestock reproduction in both sexes. Consequently, selection and productivity will suffer due to this circumstance. Tropical regions are home to around half of the world's cow population. Additionally, it's estimated that 60% of dairy herds worldwide suffer financial losses due to heat stress. Heat stress harms animal egg development and alters the release of progesterone, LH, and FSH during the estrous cycle. Animal fertility is decreased when chickens, rabbits, and horses are exposed to extreme temperatures.

Male birds are more likely than female birds to experience infertility due to heat stress, and males with high-quality semen have been observed to respond better to high temperatures (Nardone et al., 2010).

Reduced fertility, a longer initial insemination period because of the inability to detect estrus, and a lower pregnancy rate are the main findings of the research on reproduction. In addition, a decrease in the amount of blood entering the uterus as a result of elevated body and ambient temperatures, an increase in intrauterine temperature, a reduction in the rate of fertilization, a slowdown in the development of the embryo, and an increase in early embryonic mortality are all occurring simultaneously (Lacetera et al., 2003).

Impact of Heat Stress on Oocyte Maturation

Changes in ovarian function, egg fertilization capacity, embryonic development, pregnancy formation and maintenance, and finally, embryonic development show the deleterious consequences of heat stress on fertility (Hansen, 2018). Reduced birth rates in cattle are directly related to heat stress during pre-insemination (Al-Katanani et al., 1999). And sheep (Dutt, 1963), which would indicate harm to the oocyte's development during infertility. Heat stress has been linked to the finding that oocyte competence, as measured by growth rate following in vitro fertilization (IVF), is lower in the summer than in the winter (Rocha et al., 1998).

(Rutledge and others, 1999). Heat stress can impact oocytes through several different methods. Heat stress reduces the production of steroid hormones, which modifies follicular growth (Wolfenson et al., 1997; Wilson et al., 1998). Heat stress inhibits the growth of dominant follicles, and variations in follicular steroid concentrations hinder oocyte development (Badinga et al., 1993). Suppressing the development of secondary follicles with the dominant follicle increases their growth (Wolfenson et al., 1995), which leads to the ovulation of low-quality follicles (Mihm et al., 1999).

Impact of Heat Stress on Embryonic Development

Heat stress worsens embryonic loss and has an impact on embryonic growth. The embryo is impacted by heat stress at the pre-attachment stage, but the effect becomes less severe as the embryo grows. In pregnant cows, heat stress dramatically lowers embryo survival from day 0 to day 3 or days 0 to day 7. But as pregnancy goes on, the impact of heat stress on fetal life diminishes. On day 8 of gestation, embryo viability and developmental features were hindered in superovulating cows exposed to high temperatures on the first day of gestation. On the other hand, no harm came to individuals exposed to high temperatures on days 3, 5, or 7 of gestation.

This finding indicates that as embryonic age increases, the harmful effects of heat exposure on embryonic mortality diminish. During the early stages of pregnancy, there is an increased fetal resilience to cellular damage caused by high temperatures (Kasimanickam & Kasimanickam, 2021). Heat stress lowers the number of transferable embryos, interferes with hormone function, decreases fertilization rates, and lowers the quality of the embryos. It also diminishes superovulation. It has also been noted that high ambient temperatures reduce the success rate of in vitro fertilization. Furthermore, it prevents embryonic development.

Several techniques are available to enhance embryo development during heat stress, even though the effects of heat stress are difficult to prevent (Hansen et al., 2001).

Strategies for Mitigation

Mitigation measures can considerably reduce the impact of livestock on climate change. If adaptation and mitigation are included in national and regional plans, they can have a major influence (Rojas-Downing, Nejadhashemi, et al. 2017). In the dairy and beef cattle industries, heat stress is one of the main reasons for output losses and is linked to large financial losses. High-yielding dairy cows produce more metabolic heat than low-yielding dairy cows, resulting in an annual range of $1.69 billion to $2.36 billion in economic losses in the U.S. livestock industry owing to heat stress. Therefore, dairy cows with large yields are more vulnerable to heat stress.

Consequently, milk production falls when metabolic heat output rises due to heat stress. Buffalo, goats, and ewes all have reduced milk output due to heat stress. Nejadhashemi, Rojas-Downing, and others, 2017). Ewes are generally more sensitive to the temperature-humidity index—a combination of temperature and relative humidity—than they are to either alone. However, different breeds have different index values that cause heat stress in ewes (West, 2003). Goat milk's composition and quantity are also impacted by heat stress. For instance, during hot weather, a mechanism to lessen water loss is triggered in nursing goats. When there are insufficient water resources, this mechanism lowers urine water loss in favor of milk production.

Because high temperatures impact animal physiological processes, including pulse, respiration rate, and rectal temperature, they also decrease milk production in buffaloes (Seerapu et al., 2015). These animals have gotten less attention because they can survive in warm climates, and there is less market for their milk (Nardone et al., 2010). As components of climate change mitigation policy, these acts can be encouraged in various ways (Pilling & Hoffmann, 2011).In this regard, a workable strategy utilizing policy combinations is suggested to create pertinent policy programs and suitable portfolios for the approach. GHG mitigation instruments are categorized into economic, regulatory, voluntary agreements, research and development, publication, information, and public awareness categories based on realistic conditions (ESCAP, 2012).

The GHG mitigation approach should consider the agricultural sector's considerable variability concerning overall sustainability, which can vary depending on species, climates, and livestock production techniques. Generally speaking, the optimal result can only be obtained by carefully combining all available options; no single measure can fully capture the potential for emission reduction (Llonch et al., 2017). When evaluating a mitigation strategy's efficacy, it's crucial to consider the impact of "pollution exchange" (Gerber et al., 2013). Increased greenhouse gas emissions in fertilizers may counter methane emissions during intestinal fermentation. Nitrate leaching and ammonia volatilization during field application may increase if direct NO2 emissions are reduced during storage (Grossi et al., 2019).

Livestock emission intensities vary greatly across production systems and regions, and there may be a reduction in the difference between management practices that yield the lowest and highest emission intensities due to specific mitigation measures that lower greenhouse gas emissions from livestock (Gerber et al., 2013).

Climate Change Impact on Growth

The main objective of raising livestock, such as milk or wool, is to maximize growth and productivity while effectively using feed and other necessary inputs and resources. The simplest definition of animal growth is an increase in size. But growing larger has a lot of ramifications. Growth can be viewed in various ways depending on the growth of the entire animal, the growth of individual cells, tissues, and organs, the growth before and after birth, or the growth before and after puberty. Because the growth rates of various body organs and tissues vary from the entire animal's growth, an animal's body composition and proportions alter as it matures from conception.

All cattle species exhibit a similar pattern of tissue development. It seems predicated on how crucial a body part or tissue's functions are to the animal's survival (Beitz, 1985). It is widely acknowledged that global climate change is impacting the production of animals. The effects of climate change and global warming on animals that are most frequently mentioned are reduced productivity, disease resistance, lower survival, and reduced feed availability. Additionally, their animals produce 14.5% of all greenhouse gas emissions (GGE), which adds to climate change (Cheng et al., 2022).

Both the environment and genetics regulate growth. It is the growth in living body mass or cell multiplication. The availability of nutrients, hormones, enzymes, and environmental variables such as rising ambient temperature all impact average daily growth (ADG) (Hafez & Hafez, 2013).

Feed Intake

Reduced animal performance results from decreased feed intake, increased water consumption, and possible changes in the endocrine state in animals exposed to heat stress (Gaughan & Cawsell-Smith, 2015). Animals subjected to stressors outside their comfort zone lose body weight, average daily gain, and overall health. Reduced milk output, reduced fat content, lower chain fatty acids, non-fat content, lactose, and increased palmitic and stearic acid content were among the factors that contributed to a decline in milk quality scores, according to one study. High-production animals are more vulnerable to the adverse effects of their surroundings. Production losses and changes in an animal's genetic makeup might result from adaptation to persistent stresses.

Because of this, it is difficult to raise or sustain current production levels in environments that put the animal's physiology through stress. It could be preferable to use local breeds with high adaptability, even at lower production levels (and cheaper input costs), rather than attempting to transfer "stress tolerance" genes into breeds with weak adaption (Gaughan, 2015). Cows' body temperatures rise due to the high metabolic heat produced during the digestion of fodder. During the summer, cows limit their feed intake to minimize heat stress as the ambient and body temperatures rise (Ammer et al., 2018).

This causes the amount of milk produced to decline and the milk content to shift gradually. It has been observed that dairy cows begin to consume less feed when the outside temperature hits 25°C and that the amount of feed consumed by the cows drops significantly when the outside temperature rises above 40°C. The feed intake is then reduced by roughly 20–40%. Regular consumption is what this is (Liu et al., 2019). Feed consumption decreases in response to elevated outside temperatures. When the ambient temperature increases beyond 25–26°C and falls quicker than 30°C, lactating cows' feed intake is seen, even though ruminants experience a decrease in appetite, gastrointestinal motility, and rumination with rising heat stress.

Compared to other ruminants, goats can withstand heat stress better. However, they consume less feed when the outside temperature rises by 10°C beyond their thermal comfort zone (Cheng et al., 2022).

Effect of Heat Stress on Milk Production Animal production

We produce goods essential to any global food security program, like milk, eggs, and beef. Furthermore, the demand for these goods is high worldwide and is expected to rise sharply as the population and average per capita income rise (Oyhantçabal et al., 2010). Environmental stressors lower an animal's body weight, average daily growth, and physical condition. A decline in fat content, lower chain fatty acids, solids-non-fat content, and lactose content is seen, along with a decrease in milk supply.

There is an increase in the concentration of stearic and palmitic acids. Animals that produce more are typically the most impacted. Production losses may be linked to an organism's ability to adapt to chronic stresses. Increasing or maintaining existing output levels in an increasingly hostile climate is unsustainable. Instead of trying to smuggle "stress tolerance" genes into non-adapted breeds, it could be preferable to use adapted animals but at lower production levels (and lower input costs) (Gaughan, 2015). When an animal produces more heat than it can expel, it responds nonspecifically to a thermal environment by going into heat stress (Yang, 2014).

The most widely used dairy breed worldwide is the Holstein. The breed's comparatively low surface area to body weight ratio, underdeveloped sweat glands, and short, thick body surface hair all impact milk production and hinder its ability to dissipate heat through skin evaporation in the summer (Yang et al., 2010).

Effect of Heat Stress on Reproduction

High ambient temperatures have a detrimental effect on livestock reproduction in both sexes. Consequently, selection and productivity will suffer as a result of this circumstance. Tropical regions are home to almost 50% of the world's cow population. Additionally, it's estimated that 60 percent of dairy herds worldwide experience economic losses due to heat stress. Heat stress harms animal oocyte development and alters the release of progesterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH) during the estrous cycle.

Animal fertility is decreased in poultry, rabbits, and horses exposed to high temperatures. Male birds are more likely than female birds to experience infertility due to heat stress, and males with high-quality semen have been observed to respond better to high temperatures (Nardone et al., 2010). Reduced fertility, a longer first insemination period because of the inability to detect estrus, and a lower pregnancy rate were the major themes of the reproduction studies.

Simultaneously, elevated body temperature and high air temperature cause a reduction in the volume of blood reaching the uterus; this leads to an increase in intrauterine temperature, a decrease in fertilization rate, a slowdown in embryonic development, and a rise in early embryonic mortality (Lacetera et al., 2003).

Impact of Heat Stress on Oocyte Maturation

Changes in ovarian function, egg fertilization capacity, embryo development, pregnancy formation and maintenance, and finally, diminished embryo development are signs of the deleterious effects of heat stress on fertility (Hansen, 2018). Reduced birth rates in sheep and cattle (Al-Katanani et al., 1999; Dutt, 1963) are directly related to pre-insemination heat stress and may indicate harm to the developing egg in infertility.

Heat stress has been linked to the finding that oocyte competence, as measured by growth rate following in vitro fertilization (IVF), is lower in the summer than in the winter (Rocha et al., 1998; Rutledge et al., 1999). Heat stress can impact oocytes through several different methods. Heat stress reduces the production of steroid hormones, which modifies follicular growth (Wolfenson et al., 1997; Wilson et al., 1998). Oocyte formation is impacted by variations in follicular steroid concentrations, and heat stress inhibits the growth of dominant follicles (Badinga et al., 1993). Suppressing the development of secondary follicles with the dominant follicle increases their growth (Wolfenson et al., 1995), which leads to the ovulation of low-quality follicles (Mihm et al., 1999).

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Heat stress worsens embryo loss and has an impact on embryo growth. The embryo is impacted by heat stress at the pre-attachment stage, but the effect becomes less severe as the embryo grows. In pregnant cows, heat stress dramatically lowers embryo survival from day 0 to day 3 or day 0 to day 7. But as pregnancy goes on, the impact of heat stress on fetal life diminishes. On day 8 of gestation, embryo viability and developmental features were hindered in superovulating cows exposed to high temperatures on the first day of gestation. On the other hand, no harm came to individuals exposed to high temperatures on days 3, 5, or 7 of gestation.

This finding indicates that as embryonic age increases, the harmful effects of heat exposure on embryonic mortality diminish. Early in pregnancy, there is an increased fetal resilience to cellular damage caused by high temperatures (Kasimanickam et al., 2021). Heat stress lowers the number of transferable embryos, interferes with hormone function, decreases fertilization rates, and lowers the quality of the embryos. It also diminishes superovulation. It has also been noted that high ambient temperatures reduce the success rate of in vitro fertilization. Heat stress affects embryo development, decreases follicular development and the oocyte(s)'s capacity to fertilize, and delays the apparent commencement of estrous activity. Several techniques are available to enhance embryo development during heat stress, even though the effects of heat stress are difficult to prevent (Hansen et al., 2001).

Strategies for Mitigation

Unwanted byproducts of the animal production cycle include greenhouse gas (GHG) emissions (FAO, 2009). The raising and handling of grazing animals contributes to greenhouse gas emissions through the manufacture and application of chemical pesticides and fertilizers and the depletion of soil organic matter. The primary source of emissions is the transportation of feed using fossil fuels. Deforestation releases Significant amounts of carbon into the atmosphere to make pasture or arable for animal feed. As they grow and produce, animals release most of their emissions; ruminants release methane due to microbial fermentation as they break down fibrous food. Methane and nitrous oxide emissions are produced when animal dung is stored and used.

Additional greenhouse gas emissions are caused by the transportation and processing of animal products, mainly caused by using fossil fuels and expanding infrastructure. Several technical alternatives are available to enhance carbon sequestration on land used for livestock production and lower greenhouse gas emissions from the livestock industry. As components of mitigation policies for climate change, these actions can be encouraged in various ways (Pilling & Hoffmann, 2011). The first option, which would precisely quantify the externalities of global warming and impose financial penalties on individual greenhouse gas emitters, is quite challenging to implement.

In this context, a workable strategy utilizing policy combination is suggested for the second option, which aims to construct pertinent policy programs and create suitable portfolios for the approach. Greenhouse gas mitigation instruments are categorized into economic, regulatory, voluntary agreements, research and development, publication, information, and public awareness categories, realistically given the circumstances (ESCAP, 2012). The GHG mitigation plan should consider the tremendous variability of the agricultural sector in terms of overall sustainability, which can vary depending on various livestock production systems, species, and climates.

Generally speaking, the optimal result can only be obtained by carefully combining all available options; no single measure can fully capture the potential for emission reduction (Llonch et al., 2017). When evaluating a mitigation strategy's efficacy, it's crucial to consider the impact of "pollution exchange" (Gerber et al., 2013). Increased greenhouse gas emissions in fertilizers may counter methane emissions during intestinal fermentation. Increased nitrate leaching and ammonia volatilization during field application may occur from reduced direct NO_2 emissions during storage (Grossi et al., 2019).

Livestock emission intensities vary greatly between production systems and geographical areas, and there may be a reduction in the difference between management practices that yield the lowest and highest emission intensities due to specific mitigation measures that lower greenhouse gas emissions from livestock (Gerber et al., 2013).

Conclusion

There are many facets to the intricate interaction between animal production and climate change, which calls for thoughtful analysis and proactive response. The overwhelming body of scientific data demonstrates that climate change is a natural, continuous phenomenon impacting global temperatures, precipitation patterns, and the frequency of extreme weather events. This implies that the livestock industry, which is a vital part of agriculture, particularly in poorer nations, would be impacted. 40% of agriculture's GDP comes from livestock, which depends on weather patterns.

Extreme weather conditions and fluctuations in feed supply are two examples of several stressors that can simultaneously negatively impact livestock well-being, reproduction, and total productivity. Research in this field must take a longer-term perspective on the cumulative effects of these stresses, acknowledging that concurrent exposure may result in more serious outcomes. The cattle business faces opportunities and challenges as the world struggles with the increasing consequences of climate change. High-input systems that depend on foreign inputs and cutting-edge technology can use cooling systems and dietary changes to lessen the consequences of rising temperatures.

However, the susceptibility of these systems to future cost hikes brought on by climate change emphasizes the importance of resilience and diversification. Traditional manufacturing systems have difficulties despite frequently being more suited to difficult environments. Their reliance on regional resources leaves them open to interruptions in the feed supply and the introduction of new illnesses. Pastoralists need assistance in adjusting to climate change but lack financial resources. In these systems, striking a balance between using adaptable animals and integrating sustainable management approaches would be crucial. It is necessary to address climate change's worldwide effects on fodder production regions, which comprise 80% of all agricultural land.

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