Towards Exploring Development Intervention of Three Key Pillars of Climate-Smart Agriculture (CSA) as Options for Livestock Farmers

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Abstract

This paper explore negative impact of climate change in livestock, provides insights and novel approaches of development intervention through increases livestock productivity, modern ways of mitigation of greenhouse gases emissions and developing strategic approaches to livestock with tolerance and adaptation mechanisms to climate change as a three key pillars component of climate-smart agriculture. This review extensively highlighted the recommendations of animal scientist from various disciplines in ameliorating the climate change impact in livestock production such as animal nutritionist (feeding pattern, nutritional alternative to depress methanogenesis without affecting ruminal parameters and modification of rumen physico-chemical conditions with the aid of various strategies, use of ionophores, organic acids, plant extracts and use of probiotics), Animal breeders (through selection and breeding of animals with tolerance ability to harsh climate condition, use of molecular genetic alteration of animal to speedily cope with climatic condition), Animal environmental physiologists (Monitoring pen environmental temperature and humidity with designing modern housing that will provides animals with ventilation, automated control of animal manure/litter, artificial cooling and use of other novel approaches to ameliorate thermal stress), Pasture agronomists (through changing farmers attitude of grazing, reduce GHG emissions, introducing grass and legumes species into grazing land that enhance carbon storage in soil), and better waste management through the use of covered storage facilities, recovery of re-usable and recyclable materials from animal waste. It is therefore, concluded that there are urgent need for animal scientist to further intensified their effort with robust ideas of mitigating climate change, need for policy framework programme for breeding and developing animals that are better not only in adaption to climate change but provides maximum productivity.

Key words: Livestock, Climate-Smart, Key-Pillars and Development Intervention

Introduction

Globally, human population is expected to increase from around 6.5 billion today to 9.2 billion by 2050. More than 1 billion of this increase will occur in Africa. Rapid urbanization is expected to continue in developing countries, and the global demand for livestock products (Meat, milk, egg, fibers, wool) and other uses (transport, draft, game, exhibitions, research and their manure) will continue to increase significantly in the coming decades [1]. Therefore, global demand for foods of animal origin is largely growing and it is apparent that the livestock sector will need to expand [2]. However, livestock are adversely affected by the detrimental effects of extreme weather and climatic condition [1].

To understand the concept of climate change and make decisions about how to respond to it, it is important to distinguish between climate and weather. Weather refers to the condition of the atmosphere at a particular place and time such as temperature, relative humidity, rainfall (Precipitation), cloud cover, barometric pressure, and wind speed. Climate on the hand is the weather experienced by a given location, average over several decades. A region`s climate tells how hot or cold, wet or dry, windy or still, and cloudy or sunny it generally is. Climate is determined not only by average weather conditions, but also by seasonal changes in those conditions and weather extremes [3]. Climate change may manifest itself as rapid changes in climate in the short term (a couple of years) or more subtle changes over decades. Various climate model projections suggest that by the year 2100, mean global temperature may be 1.1 – 6.4ºC warmer than in 2010. The difficulty facing livestock is weather extremes e.g intense heat waves, floods and droughts. In addition to production losses extremes events also result in livestock death. Animals can adapt to hot climates, however the response mechanisms that are helpful for survival may be detrimental to performance. Therefore, this paper focuses on negative impact of climate change and strategic conclusion of animal scientist from various area of specialization suggestion to mitigate its effect on livestock production.

Implication of climate change in Livestock

Climate change affect livestock overall performance and productivity with a great threat to well-being in a number of ways such as:

i. ***Reproductive implications:*** Reproductive processes are affected by thermal stress. Conception rates of dairy cows may drop 20-27% in summer, and heat stressed cows often have poor expression of oestrus due to reduced oestradiol secretion from dominant follicle developed in a low luteinizing hormone environment. Reproductive inefficiency due to heat stress involves changes in ovarian function and embryonic development by reducing the competence of oocyte to be fertilized and the resulting embryo [4]. Heat stress compromises oocyte growth in cows by altering progesterone secretion, the secretion of luteinizing hormone, follicle stimulating hormone and ovarian dynamics during the oestrus cycle. Heat stress has also been associated with impairment of embryo development and increase in embryonic mortality in cattle. Heat stress during pregnancy slow growth of the foetus and can increase foetal loss. Secretion of the hormones and enzymes regulating reproductive tract function may also be altered by heat stress.
   Heat stress depressed egg production and reduced the external and internal egg qualities [5-6] The depression as reported by Mahmoud et al. was due to an imbalance in calcium-estrogen relationship and lowered Haugh unit of the albumen. This implies that high environmental temperature depresses yolk size, albumen consistency, and optimum calcium deposit in the egg shell.
   In males, limited temperature stimulates testicular growth in the early phase and promotes increased semen volume and concentration, a subsequent rise in temperature suppresses reproductive capacity as a result of a decrease in seminiferous epithelial cell differentiation, which is manifested in decreased semen quality and quantity with time in poultry [7]. Heat stress adversely affects spermatogenesis perhaps by inhibiting the proliferation of spermatocytes.

ii. ***Impact on production:*** Exposure to high temperature generates behavioural, physiological, metabolic and immunological responses, which cause detrimental effects to the various livestock species.
   In case of poultry chronic heat exposure reduces 16.4% feed intake, 32.6% body weight and a 25.6% higher feed consumption ratio in broilers at 42 days [8] and also adversely affect fat metabolism, growth of muscle and decreases the quality of meat and chemical profile due to imbalance of electrolytes and activation of lipid peroxidation [9-10].

iii. ***Impact on feed and fodder availability:*** climate change affects livestock production by altering the quantity and quality of feed available for animals. Climate change is expected to change the species composition (and hence biodiversity and genetic resources) of grassland as well as affect the digestibility and nutritional quality of forage [11]. Droughts and extreme rainfall variability can trigger periods of severe feed scarcity, especially in dry land areas, with devastating effects on livestock populations. Reduction in the quantity and quality of feed (leading to less feed intake and higher mortality) could make the impacts of climate change on livestock systems severe in certain in places.

iv. ***Impact on livestock health:*** Agbeja et al (2021) stated that the effects of climate change on the health of farm animals have not been studied in depth. However, it can be assumed that as in the case of humans, climate change, in particular global warming, is likely to greatly affect the health of farm animals. Global climate change alters ecological construction which causes both the geographical and phonological shifts [1]. These shifts affect the efficiency and transmission pattern of the pathogen and increase their spectrum in the hosts [12]. The livestock systems are susceptible to changes in severity and distribution of livestock diseases and parasites as potential consequences. Incidence of external parasite (43.3%) was first ranked as the problem in the warm temperate [13].

Drivers of Climate Change

Scientists were extensively discussed several drivers of climate change amongst are not limited to

i. Greenhouse gases effect whereas the sun rays hit the planet, some of the energy is absorbed while the rest of the energy is trapped and hold in a form of warm-air blanket that surround the planet. The greenhouse gases are responsible for the trapping of the atmospheric energy and heat and send it back to the earth which eventually contributes to the global warming [14]. The main greenhouse gasses are carbon dioxide (CO_2), Methane (CH_4) (from plant decay and other sources) Nitrogen oxide (N_2O), from volcanoes and ozone. Less prevalent but very powerful greenhouse gasses are hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and sulphur hexafluoride (SFe). Without these gases the earth would be far too cold to sustain our current ecosystem. Scientists estimate that the average temperature on Earth would be colder by approximately 30 degrees Celsius (54-degree Fahrenheit), far too cold to sustain our current ecosystem environmental prerequisite for life on Earth [15].

ii. Agricultural activities contribute significantly to air pollution and climatic changes through the emissions of carbon dioxide and other greenhouse gases. Different forms and types of agricultural activity such as deforestation (when trees are cut down, the benefit those trees provide by absorbing CO_2 from atmosphere which is a greenhouse gas is forfeited [16]. The use of fertilizers containing nitrogen which tends to increase nitrous oxide emissions from the soil to the atmosphere [17], increasing livestock farming activities such as ruminant animals particularly, cow and sheep produce large amounts of methane during process of food digestion. The results in the results in climate change challenges in Nigeria and other parts of the world [18].

iii. Human activities: According to the environmental protection agency, most of the greenhouse gas which is responsible for global warming results from different human activities such as burning of fossil fuel, use of electricity, transportation devices that emits gases, fumes from industrial machines, oil and gas flaring. These activities produce carbon dioxide and nitrous oxide that exacerbates climate changes issues [19].

Development Intervention of Three Key Pillars of Climate-Smart Agriculture for Addressing Climate Change

1. **Proper Implementation of Existing Government Policies:** In Nigeria, the recommendations for federal, state and local government and the private sector for improving livestock production are

outlined in Agriculture in Nigeria [20]. If implemented, these recommendations could make an important contribution to climate change adaptation in the agriculture sector.

The following adaptations actions are recommended for livestock sub-sector as discussed by Oyeniyi and Ewuola, (2021):

Intensive livestock keeping: keeping livestock in a confinement instead of free range (extensive) will help farmers adapt to climate change impacts like disease infestation. Government, private sector and NGOs can help livestock farmers adapt to climate change by providing soft loans needed to initiate intensive livestock production.

Planting trees near livestock houses and on pasture: This strategy will help farmers adapt to severe windstorms which are responsible for destruction of livestock houses and forage land.

Greater support for insurance: Government should increase support for the Nigerian Agricultural Insurance Scheme and farmers should be encouraged to register with the scheme. This will help farmers in the event the death of livestock due to flood, diseases, and lack of water.

Developing improved livestock breeds: Government should increase support for livestock breeders in developing disease resistant species.

Building up measures to institutionalize early warning system: This will increase livestock farmer's ability to respond to climate related drought, flooding and disease impacts.

Provision of potable water for livestock: Construction of dams, boreholes, and wells are recommended to cater to the water needs of livestock management during the dry spells.

Construction of embankment (dikes): This will help to reduce flooding caused by high rainfall events.

Encouraging rainwater harvesting practices: This will helps farmers adapt to shortage of water during dry spells and improve available forage on rangelands [20].

2. **Adopting Findings and Role of animal Scientists in Mitigating Negative Impact of Climate Change in Livestock:**

Role of Animal Nutritionist: Animal nutritionists were extensively come out with approaches of mitigating negative impact of climate change in livestock these include not limited to: An increase in the level of concentrates leads to a corresponding decrease in methane production as a proportion of energy intake; significant modification of rumen physic-chemical conditions and microbial populations has been found to result from the replacement of structural carbohydrates in concentrates (starch and sugars). This is an offshoot of increased feed intake, higher rate of ruminal fermentation and accelerated feed turn over. A shift in volatile fatty acid production from acetate towards propionate occurs with the development of starch fermenting microbes which results in lower methane production. This is so because the relative proportion of ruminal hydrogen sources declines while hydrogen sinks increase. Concentrates rich in starch such as maize, wheat and Barley have a more important effect on low CH_4 production than fibrous concentrates [20-21]. Animal nutritionists have demonstrated that level, nature and presentation of lipids have a profound effect in depressing methanogenesis without affecting other ruminal parameters [22]. The mean decreases of 52% of CH_4 production was observed in supplements of animals with linseed oil at 5.8% whereas a decrease by 37% has been observed with soyabean lipid at 6% [20]. Also, Beauchemin et al., (2009) reported that CH_4 production in dairy cows was more affected by linseed and rapeseed than by sunflower seed. The reason for decrease in methane production when lipids are feed to animals is lies precisely due to the fact that lipids sources is unlike other feed constituents such as forage and cereals they are not fermented in the rumen, and thus the decrease in fermented organic matter leads to a decrease in methane production [21].

Today ruminant animal nutritionists explore the use of ionophores and organic acids as feed additives to suppress methanogenesis and increase efficiency in ruminant production. Their mode of action often is directly on microbes wherein there is a shift in fermentation towards propionate production as against acetate. Ionophores also affect protozoa; the reduction and subsequent recovery in protozoal numbers perfectly matched CH_4 abateent-up to 30% and restoration to previous level in cattle trail [23] Organic acids (Malate, Fumarate and Acrylate) have been assayed as diet additives. Fumarate and acrylate has been shown to be the most effective in vitro [24].

There is growing interest in the use of plant extracts (Condensed tannin, saponin, and essential oils) as plant secondary compounds for CH_4 mitigation strategy. Preparation from plants are seen as a natural alternative to chemical additives and most trails with plant extracts have been done in vitro and response of these molecules on methanogenesis is highly variable [20]. Recently, Tiemann et. al, (2008) reported that the inclusion of the tannin-rich shrub legumes species *Callinadra calothyrsus* and *Fleminga macrophylla* in the diet reduced methane emissions in growing in growing lambs by up to 24%, but this was associated with reduced organic matter and fibre digestibility [25].

Scientist where extensively evaluate and found that the use of probiotics (Acetogens and yeast) for the stimulation of rumen microbial populations capable of decreasing CH_4 emissions remains a potentially interesting approach. Reductive acetogenesis is a natural mechanism of hydrogen utilisation that coexists with methanogenesis in the gastrointestinal tract of many animals. This pathway is the dominant one several hindgut-fermenting mammals (humans, rabbits, hamsters, rats) but also in foregut fermenters such as Kangaroos [20]. The use of acetogens as probiotics has also been tested by several authors with and without the addition of methanogen inhibitors to favour competitions [26]. Result, so far, have either unsatisfactory or not conclusive, since variations were extensively exist depending upon the dosage levels, type of animals involves in the trails and so on. Live yeast, the most commonly used probiotic in ruminant production, has not been extensively tested for their effect on CH_4 production [27]. The mechanism by which yeasts decrease methanogenesis has been proposed to be by increasing microbial synthesis [24] and by stimulating reductive acetogenesis [28].

Role of Animal Breeders: Breeding of genetically improved animals that can tolerate tropical weather condition in the phase of a changing climate is of outmost importance. This strategy involves selection of breeds of farm animals that will adapt to hot environment and tolerate heat stress. Breeding strategies address not only the tolerance of livestock to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases [29]. Animal breeders achieved these measures through firstly, identifying and strengthening local breeds that have adapted to local climatic stress and feed resources and secondly improving local breeds through crossbreeding with heat and disease tolerant breeds. In case of poultry, birds with reduced feather mass and those with ''Naked neck and frizzle genes'' have been found to produce more and have good growth rate at high temperatures.

Role of Animal Physiologist: Physiologically, ruminants adapt to high heat load through enhanced respiratory and sweating rates. Usually, higher respiration rate and sweating rates are observed when animals are exposed to extreme environmental heat. Therefore, animal environmental physiologist play an important role in proper site selection, orientation and designing of animal housing that will enable them to overcome heat stress. Daily examination of animal vital parameters (rectal temperature, pulse rate, respiratory rate) by animal physiologist will helps to determine the intensity of animal stress and suggesting the idea for thermal stress mitigation. When humidity is increased, evaporative loss due to increase in temperature is reduced, according to Lin et al., (2005) and Sinha et al., (2017), temperature and relative humidity of the surrounding environment influences the cooling mechanism of the birds [30] and [31]. Environmental physiologist extensively involves in modifying animal housing to protect animals (birds) from climate change negative impact through the following features: Insulation (it was demonstrated that wall or insulation of poultry houses reduces heat that enters the building since on a hot day, the surface of a roof can reach 60°C were the heat will ultimately radiated from the ceiling into the house thereby increasing heat load on the birds), building design (Recently, In Nigeria, modern designs are now considering compliance to environmental control, direction of the wind, radiations from the sun and improved bio-security requirements), Ventilation (It was very essential that movement of air and around a room or building reduces the risk of heat stress), insulated curtains (In most Nigerian open-sided poultry houses, a curtain were used to control air movement and reduces heat loss in cold area) and stocking density (stocking density is very important, because overstocking may rise temperature dangerously due to increases metabolic heat production in the house) [15].

Role of Pasture agronomist: One of the major GHG emission contributions from livestock production from livestock production is from forage or feed crop production and related land use. Proper pasture management through rotational grazing is the most cost-effective way to mitigate GHG emissions from feed crop production. Animals grazing on pastures also help reduce methane (CH_4) emissions attributable to animal manure because no storage is necessary. Introducing grass species and legumes into grazing lands can enhance carbon storage in soils. Scientists have estimated that the soil contains carbon more than twice the quantity in the atmosphere and demonstration by soils could make a potentially useful contribution to climate change mitigation [15]. Promotion of high-quality forages in ruminant feed and use of legumes in grazing rations is now being encouraged. To heat loss, supplemental shades and housing systems should be developed to reduce exposure to solar radiant heat load [32].

Forage species and stage of maturity play significant roles as]Benchaar et al. (2001) found out that the substitution of Timothy hay with lucerne decreases methane emission by 21% expressed as % digestible energy [33. An inclusion of tannin rich legumes such as Lotus, and certain shrubs in the diet also contributes to the suppression of methanogenesis due to the condensed tannins. Waghorn (2002) observed that methane production from grazing dairy cows increased with forage maturity from 5% to 6.5% of Gross energy intake [34]. Research have demonstrated that young fresh forage produces low CH_4 and this may be attributed to the higher content of soluble sugars and linolenic acid [35].

In rangelands increasing the number of watering points will reduce the distance animals have to walk to drink and will have the co-benefit of encouraging more even pasture utilization. In extensive systems, including shade over watering points will reduce evaporative loss, reduce water temperatures, increase the efficacy of water intake by animals and thus assist with reducing heat stress [36].

Others Management Role: Involves Climate smart agriculture in manure management since intensive livestock production creates challenges in managing the large volumes of manure produced. Manure contributes to greenhouse gases, but conscious efforts can be made to capture the manure in solid, liquid or slury form. It can then be stored, treated and utilized to enrich soils in an environmentally sustainable manner through biogas production. Ologhobo, (2021) state that ‘‘the level GHG emissions from manure such as CH_4 and N_2O from liquid manure depend on the temperature and duration of storage’’ [15]. Long term storage at high temperatures results in higher GHG emissions. In the case of ruminants, pasture grazing is an efficient way to reduce CH_4 emission from manure because no storage is necessary. It is possible not only to mitigate GHG emission. In order to handle growing volumes of wastes, integrated waste management was developed where nothing is considered waste. This is where everything is re-generated, leaves, stems, and roots are used to produce animal feed, soil mulch, compost manure and aquatic plants, such as water hyacinth, are used to generate gas and purify water. Animal wastes such as poultry droppings, horn, bones, intestines, feathers are equally used for biogas production and compost manures. Rainwater harvested for aquaculture, irrigation and human needs [15].

Conclusion

It is therefore, concluded that there are urgent need for animal scientist to further intensified their effort with robust ideas of mitigating climate change, need for policy framework programme for breeding and developing animals that are better not only in adaption to climate change but provides maximum productivity. It was however, recommended that they should be an increase provision of government, climate smart agencies, private sectors and enterprise-specific on climate smart agriculture to render support for research in all aspect of livestock production.

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