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FORECASTS ABOUT LIVESTOCK PRODUCTION IN PUNJAB-PAKISTAN: IMPLICATIONS FOR FOOD SECURITY AND CLIMATE CHANGE

H. Z. Mehmood[1], H. Afzal[2], A. Abbas[2*], S. Hassan[2] and A. Ali[3]

[1]Department of Agribusiness and Applied Economics, Muhammad Nawaz Sharif University of Agriculture, Multan
[2]Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad
[3]Institute of Agricultural Extension and Rural Development, University of Agriculture, Faisalabad
*Corresponding Author's Email: Azhar.Abbas@uaf.edu.pk

ABSTRACT

This study is aimed at estimating the role of livestock sector in food security by considering the past trends and future forecasts in livestock population, situation of feed & fodder availability and potential adaptation/mitigation strategies in the epoch of climate change. In this regard, secondary data was collected from World Bank, FAO, Ministry of Finance Pakistan and Pakistan Bureau of Statistics and was analyzed using semi-log model, automatic ARIMA, and Lorenz curve methodology. The results of this study forecasted the increase in the population of cattle, buffalo, goat and camel in near future while forecast about population of sheep shows decrease in its population in coming years. Lorenz curve and Gini coefficient revealed relatively equal distribution in the number of cattle and buffalo among herds than that of sheep and goat. The total area under fodder production' and 'fodder productivity' have a declining trend. The linkages among livestock production index, GNI per capita and consumption expenditure elaborate that the livestock is playing a major role in food security of Pakistan and other neighboring countries (China, India and Bangladesh). Analyzing various adaptation and mitigation strategies in the context of Pakistan revealed that in the era of climate change and food insecurity, this sector could help by wisely adopting cost-effective adaptation/mitigation strategies like educating farmers about managing and altering feed production and consumption techniques. Therefore, maintaining a consistent policy to focus livestock economy on the wake of increasing food security concerns and climate change, a holistic approach is required to make decisions for the uplift of the rural economy in the country.

Key words: Climate change; food security; livestock production; model forecasts; mitigation strategies

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INTRODUCTION

Since the advent of farming, humans have been reliant on the livestock for food but still there is serious gap between demand and supply which leads to food insecurity. According to the World Bank (2020a), over 1.3 billion people are dependent on the livestock sector and FAO, (2018) reported that ~0.82 billion people across the globe and about 13% of the population in developing nations is seriously undernourished. On the other hand, the livestock sector alone is emitting around 7.1 Gigatons (Gt) of CO_2-equivalent annually, representing greater share (14.51%) of human-induced greenhouse gas (GHG) emissions (World Bank, 2020a).

Livestock acts as a custodian of food security by furnishing 34 per cent of food protein globally (FAO, 2020), but at the same time, some countries in south Asia are most vulnerable to a shortage of food due to climate change problems and the lack of technical and economic support for mitigation strategies (Godber and Wall, 2014).

Contribution of livestock products to the food security of rural and urban people is significant in south Asian countries like Pakistan, India, Bangladesh and China. Moreover, Balehegn et al. (2020) mentioned that livestock sector in India is supplying nutritional security to the fast-growing population and Mahmood *et al.* (2014) stated the positive relationship between the milk and animal per person, work animal per hectare and food safety in Pakistan. Similarly, the possible influence of livestock possession on food security of individual households in Pakistan was calculated using the propensity score matching approach by Ali and Khan (2013) and results indicated that level of food security was higher for the households having livestock as compared to households having no livestock. Most of the small farmers in Pakistan are heavily reliant on animals as a source of money. Furthermore, livestock plays a vital part in meeting the fundamental necessities of many households' food requirements (Khan et al., 2019).

Currently, the livestock has a major share (60.6%) in the agriculture sector with the most stable average growth rate of ~3 per cent (Ministry of Finance, Pakistan, 2020). Milk, fats, eggs, bones, and mutton production all have a positive, significant association with Pakistan's agricultural GDP (Rehman et al., 2017).

Cattle, buffalo, sheep and goat are the most important livestock species in Pakistan, and among these

livestock species, cattle and goats showed higher growth rates in the past three-year 2018 to 2021 while, buffalo and sheep recorded lower growth rates (Ministry of Finance, Pakistan, 2020). Pakistan has the world's second-largest buffalo population (Hussain et al., 2017) and the Punjab province has >60% buffaloes of the country (Afzal, 2009). Cattle is the second main animal (36.7 per cent contribution in milk and its by-products) after buffalo (60.24 per cent share in milk and its by-products) in total production (Ministry of Finance, Pakistan, 2020). The livestock sector is supplying essential amino acids to people which leads to food security (Warsewicz et al., 2018).

Many studies on livestock and food security in Pakistan describing the chief role of livestock products in food security lack proper forecast regarding population of cattle, buffalo, sheep and goat in context the of Pakistan and its link with food security. The feasible climate change adaptation strategies for livestock raising were not considered in previous research. So, this study focused on forecasting of cattle, buffalo, sheep and goat populations, analyzing fodder and feed availability as well as proposing ways to address production issues in the arena of food insecurity and climate change.

MATERIALS AND METHODS

In this study data on livestock was taken from agriculture census (1972-2010), Livestock censuses (1976-2006), Economic Surveys of Pakistan (1971-2019), FAO, World Bank, and different websites of Agriculture in Punjab, Pakistan.

Empirical models: Semi-log regression model was used for analyzing past trends in livestock population and feed/fodder availability in the country. The general form of the model is given in equation (1).

(1)

Where;
= Livestock population in a given year; and
t = Time (Year)

Time series data are used from 1971-2019, which is obtained from various sources (Ministry of Finance, Pakistan Bureau of Statistics). This study focuses on cattle, buffaloes, goats, sheep, and camel. Other livestock species and sub-sectors (poultry and fisheries) were not considered in this study for limitation of time. Automatic ARIMA model selection was made using EViews 9 for modelling and forecasting of livestock population because it helps in finding the best fit with minimum chances of error. This approach was used for forecasting of inland fish production in India (Goswami and Zade, 2015) as well as fish landing in Ganga basin (Vass *et al.,* 2009). Similarly, Paul *et al.* (2013) applied Seasonal ARIMA (SARIMA) model for forecasting total meat export from India.

Distribution of livestock is vital element for growth of this sector, and it most probably have a link with future of livestock, so it looks appropriate to study level of inequality among livestock species and their herds along with forecasting their population. So, this study takes Lorenz ratio as well as Gini coefficient as a measure of inequality among livestock owners and this technique was used to measure land inequality in previous studies as well (Julka and Sharma, 1989; Naseer *et al.,* 2016).

(2)

(3)

Where;
X_i = Cumulative percentage frequency with respect to number of herds corresponding to the size of class (X_i = 1,2,3, …, n).
Y_i = cumulative percentage frequency with respect to number of animals corresponding to size of class (Y_i = 1,2,3, …, n).
X_{i+1} and Y_{i+1} = Preceding observation of X_i and Y_i
X_{i-1} and Y_{i-1} = Previous observation of X_i and Y_i

RESULTS

Forecasting different livestock species: ARIMA model for forecasting of a series can be divided into four steps: First, the selection of any transformation in the dependent variable, e.g., taking the log. Second, to select the level of difference for the dependent variable. Third, the selection of exogenous variables and fourth, picking the order of the ARMA terms. In EViews', automatic forecasting performs steps 1, 2, and 4 automatically. This procedure does not select exogenous variables automatically, but it allows the specification of any number of variables to include. Automatic ARIMA for model selection and forecasting was done using EViews 9. Forecast graphs with ± 2 S.E are shown in the following figures. The letter F at the end of the name cattle, buffalo, etc. shows that it is a graph of the forecast by using root mean square error (RMSE). It is non-negative, and a value of 0 indicates a seamless fit for the data. So, a lower value of RMSD is better than a higher one.

For both RMSE and MAE, lower values are better than higher values. The mean absolute percentage error (MAPE) (or mean absolute percentage deviation) (MAPD) is a measure to check the prediction accuracy of a forecasting technique, for example, in trend estimation. The smaller the MAPE, the better the forecast.

Cattle forecast (Figure 3) shows that each year (2019-2025) cattle population will keep on increasing.

Root mean square error (0.24), mean absolute error (0.24) and mean absolute per cent error (0.50) values confirm that forecast is reliable. The forecast (Figure 4) of buffalos indicates that every year (2019-2025) population of buffalo will be increasing for the coming years. Lowest values of Root mean square error (0.0035), mean absolute error (0.0035) and mean absolute per cent error (0.0088) values confirm that forecast is entirely reliable.

Figure 5 shows the forecast for sheep, indicating that each year (2019-2025) sheep population will continue to decrease slightly for the coming years. Root mean square error (0.57), mean absolute error (0.57) and mean absolute per cent error (1.84) values confirm that the model used for the forecast is reliable. Similarly, Figure 6 shows the projections of the goat population; each year, the goat population will exhibit an increasing trend for the coming years (2019-2025). Root mean square error (0.82), mean absolute error (0.82) and mean absolute per cent error (1.07) values endorse that model used for the forecast is reliable.

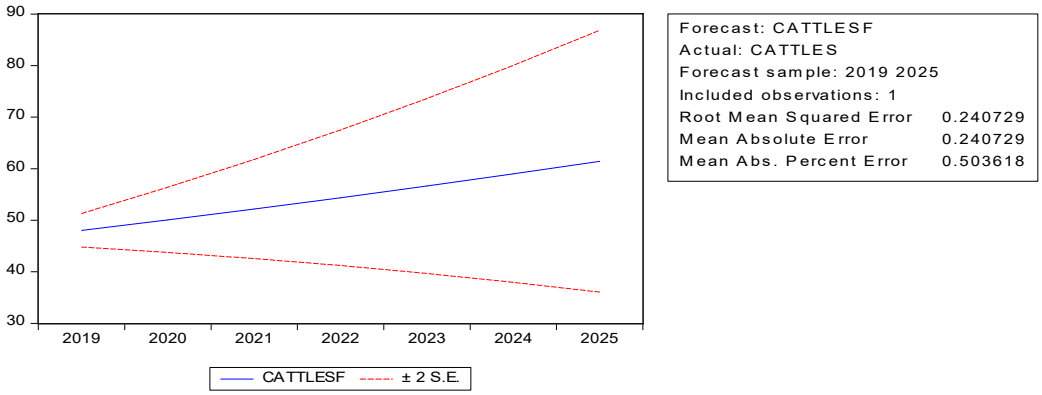

Figure 3. Cattle Forecast

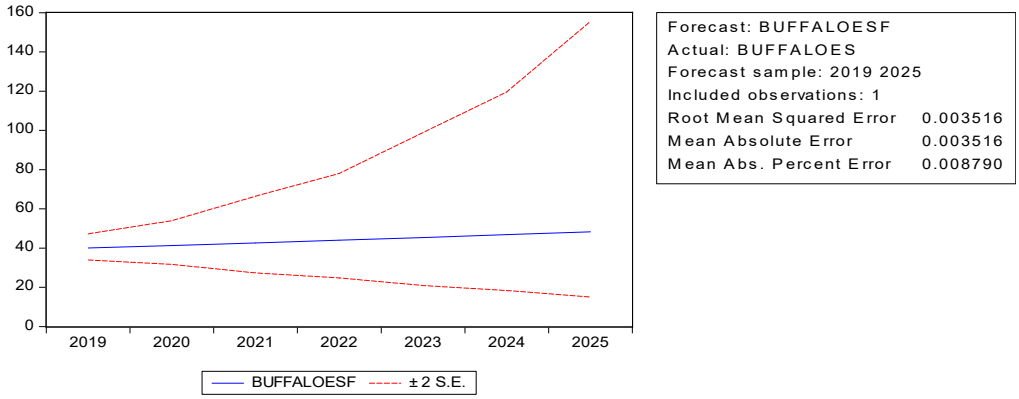

Figure 4. Buffalo Forecast

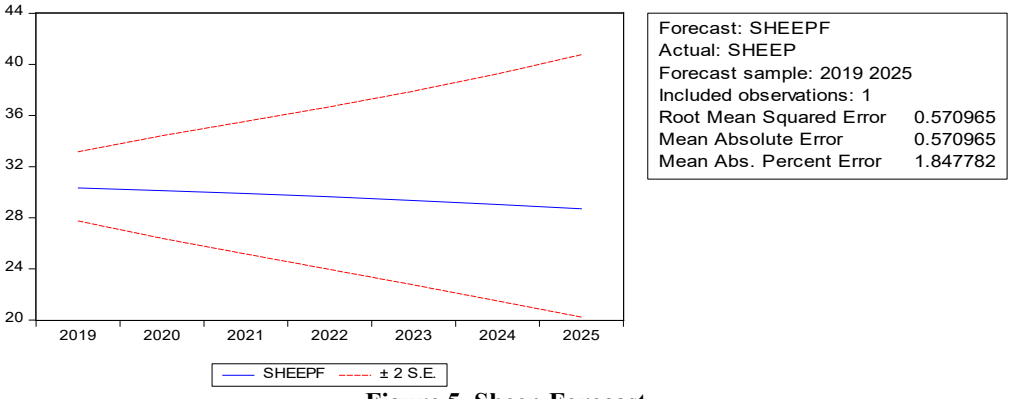

Figure 5. Sheep Forecast

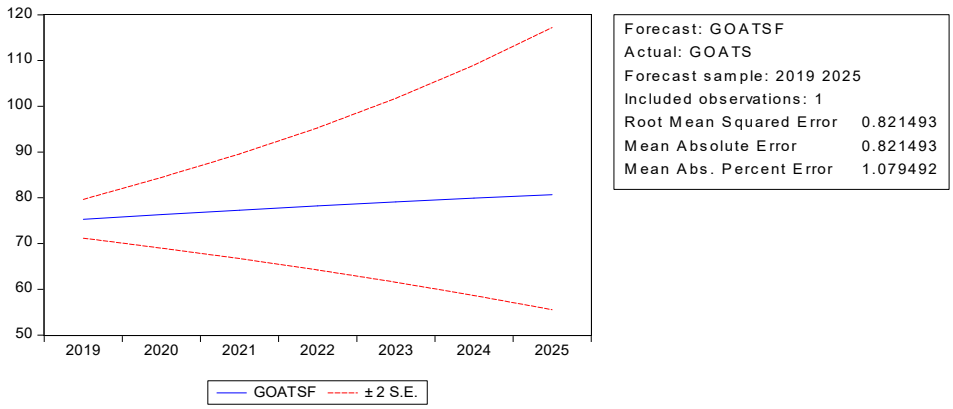

Figure 6. Goat Forecast

Figure 7 is showing a forecast of camel population which witness that each year camel population will exhibit a slightly increasing trend for the coming years (2019-2025). Root mean square error (0.82), mean absolute error (0.82) and mean absolute per cent error (1.07) values show that the model used for the forecast is reliable.

Distribution of Livestock population among herds: Lorenz Curves shows the actual quantitative relationship between the percentage number of animals and the percentage number of herds. The more the Lorenz Curve is apart, from the perfect equality diagonal line, the higher the degree of inequality. We calculated the Lorenz curve for cattle and buffalo herds (combined) as well as sheep and goats (combined) because data was available in combined form. Lorenz curve for cattle and buffalo shows that a lower 30 per cent cumulative percentage number of herds are closer to the line of equality than that of the upper 70 per cent. But the Lorenz curve calculated for sheep and goats reveals that there is significant inequality among all herds, and this inequality is more than that of cattle and buffalo.

Another method to find out the extent of variation prevailing in the distribution of animals among herds is the Lorenz ratio. Lorenz ratio closer to 1 means more equality in the given category and if closer to 0 then more inequality. Lorenz ratio for cattle and buffalo is 0.82 and 0.77 for sheep and goats, showing that there is more equality in the distribution of cattle and buffaloes than that of sheep and goats. Gini coefficient also measures the degree of equality, but here 0 means perfect equality and one mean perfect inequality. For cattle and buffalo, the value of Gini coefficient is 0.56 (closer to 0 than that of sheep & goat) which shows more equality in distribution of these animals among herds while for sheep and goats the value of Gini coefficient is 0.87 (closer to 1), significantly higher than that of cattle and buffalo.

Trend Prediction of Fodder Area: Fodder area in Pakistan has decreasing trend as Figure 10 shows a negatively sloped trend line. Regression equation shows that with a unit change in time (year), fodder area is decreasing by ~2 per cent, and a high R^2 value of 0.82 reveals that fodder area is closely related to time. Based on the fitted line, we can predict future changes in the fodder area. Figure 14 shows that fodder production also has a decreasing trend.

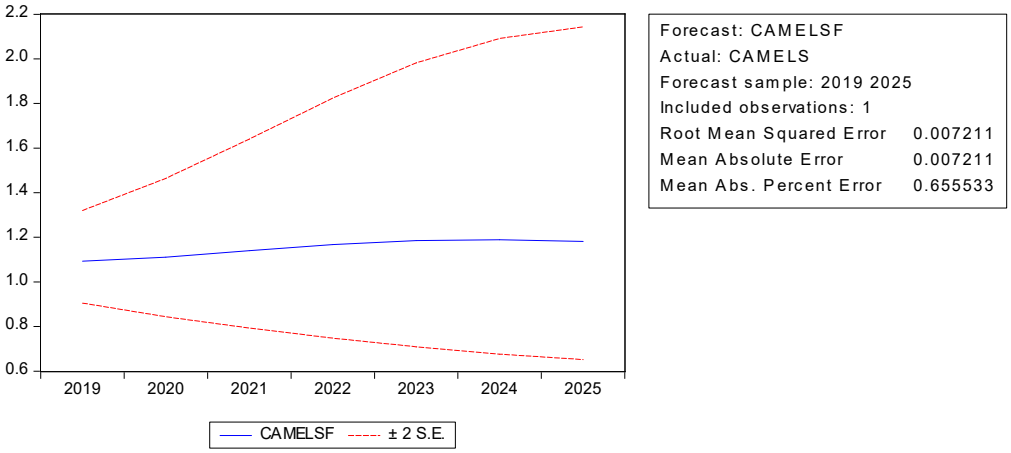

Figure 7. Camel Forecast

Figure 8. Lorenz Curve for cattle & buffalo

Figure 9. Lorenz Curve for Sheep & Goat (Pakistan Bureau of Statistics, 2011)

Figure 10. Trend Prediction of Fodder area (million ha) and Fodder Production (million tons) (Pakistan Bureau of Statistics, 2011)

Linkages between Food Security and Livestock Production in Pakistan and neighboring countries: The livestock production index measures overall livestock output and productivity, so it is a good indicator for linking livestock production with other food security indicators. Per capita GNI and consumption expenditure of households are taken as indicators of food security and their linkage with livestock production index can give us a clue about contribution of livestock sector in food security. The positive relation of livestock production index, per capita GNI and per capita consumption expenditure with time is an indication of livestock's contribution to food security of a country. This relation is observed using Livestock production index (2004-2006 = 100), GNI per capita based on purchasing power parity (PPP) and Households Final consumption expenditure, PPP (constant 2011 international $), which shows a strong positive relationship among these indicators in case of China, India and Bangladesh while in Pakistan's perspective relationship between Livestock Production Index and Consumption expenditure is not as strong as of other three countries (Figure 11) but positive enough to conclude that livestock production is an essential element for increasing and consumption expenditure of people which is a sign of the substantial contribution of this sector in food security of Pakistan.

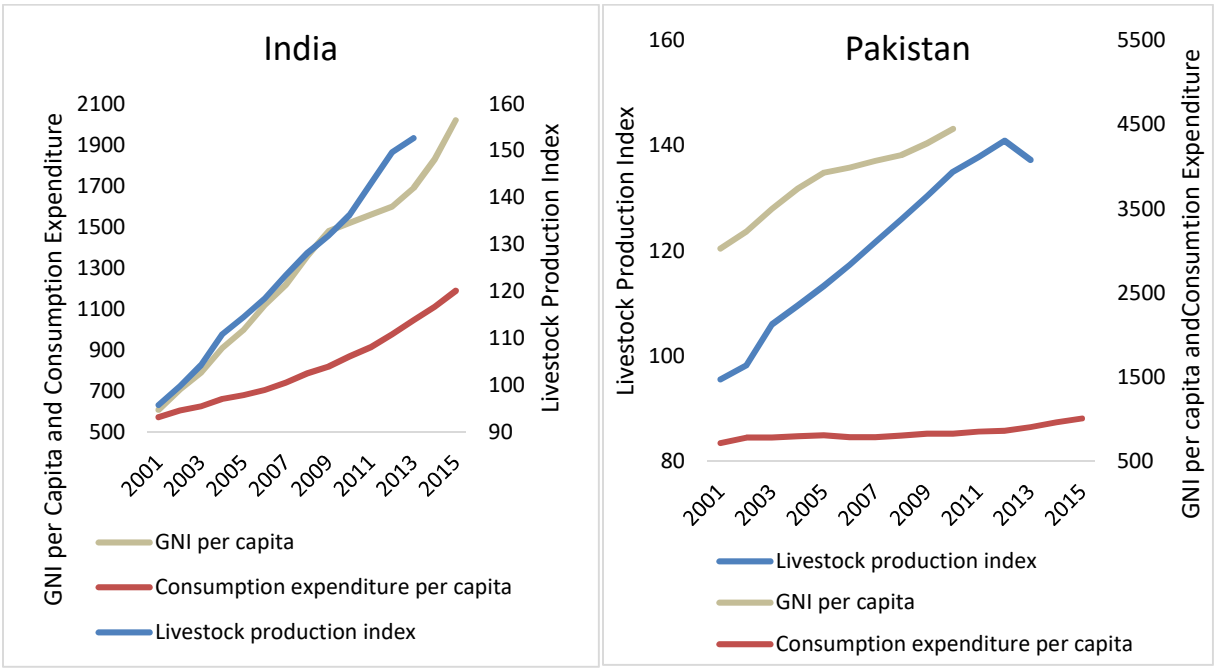

Figure 11. Linkage among Livestock Production Index, Per Capita GNI and Consumption Expenditure (PPP) Source: World Bank (2020b).

Future of Livestock Production in the Context of their Contribution to Greenhouse Gases and Climate Change in Pakistan: There is a need to enhance per unit productivity of animals instead of increasing in numbers and reduce greenhouse gases emitted by livestock to meet the ever-increasing demands of the expected huge human population soon. Worldwide, the livestock sector is contributing to a huge amount of GHGs (14.5%) (FAO, 2018; World Bank, 2020; Gebreegziabher *et al.,* 2020). Only production and processing of feed is contributing about 45% (3.2 Gigatons of carbon dioxide) of the entire livestock sector's emissions (Gerber *et al.,* 2013). In comparison, enteric fermentation is the second-largest source of emissions with 39% contribution, storage of manure is sharing 10% of total and remaining 6% is contributed by the transportation and processing of animal goods, which is equal to 2.8, 0.71 and 0.42 Gigatons of carbon dioxide (CO_2) respectively (Gerber *et*

al., 2013). Following are prominent mitigation strategies for livestock based GHGs emissions found by various researchers.

Mitigation Strategies: There are a lot of mitigation strategies proposed by various researchers. Knapp *et al.* (2014) highlighted that the rise in forage quality had revealed a great potential to reduce in enteric methane about 5% per unit of fat protein corrected milk. Physical processing of fodders mitigates enteric methane production in ruminants and enhances forage digestibility (Gerber *et al.,* 2013). Improved husbandry practices can reduce emissions by 20-30 per cent, across all production systems (FAO, 2017) and, in ruminants, adding the fatty acids or fats to their diets reduces the enteric methane emissions (Llonch *et al.,* 2017). Reducing the storage temperature of manure decreases emissions by 30–50% (Borhan *et al.,* 2012). Normal eradication of the manure to outside storage could be a good practice. Regular discharged of manure from the channels decreases nitrous oxide and methane emissions by 41% and 55% separately (Mohankumar Sajeev *et al.,* 2018). Another method of mitigation is a solid-liquid separation which has 30% more potential of greenhouse gases (GHGs) mitigation as compared to untreated manure (Montes *et al.,* 2013). Anaerobic digestion is a decaying process of biological matter in which there is more than 30 per cent reduction in GHG emissions compared to traditional manure handling systems (Battini *et al.,* 2014). More energy is required when animals are fighting against some infection/disease for maintenance. Cattle diseases may rise 24% GHG emissions per unit of milk produced and up to 113% per unit of the beef carcass (Williams *et al.,* 2015). By improving cattle health through cost-effective methods will decrease greenhouse gas emissions.

Adoption of Mitigation Strategies in context to the livestock sector of Pakistan: Optimizing animal productivity through adoption of management technologies, enhanced genetic potential, the efficacy of rumen fermentation in ruminants and exhaustive rotational grazing systems have great mitigating effect in both developing and developed nations. But in developing countries like Pakistan economical, easy, and those strategies for which the government is providing any form of subsidy are viable to be implemented due to the majority of small and medium livestock holders.

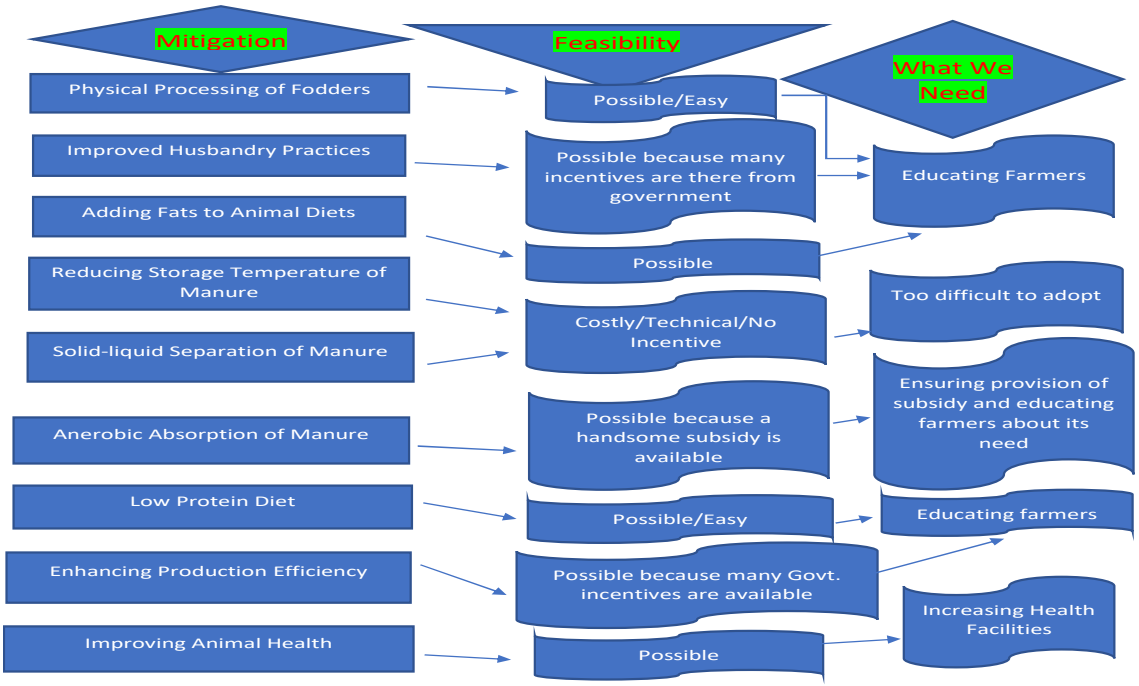

Figure 12. Feasible mitigation options in the context of Pakistan

Most of the mitigation strategies in Figure 12 are possible and cost-effective with some further requirements, like physical processing of fodders, adding fats to animal diets, and use of lower protein diet are most feasible options which only needs educating livestock holders, and the government has also taken steps in this regard like import of cattle feed premixes at concessional tariffs (Ministry of Finance, Pakistan, 2019). Enhancing production efficiency and improving animal health is strictly dependent on the government for which government of Pakistan, Under the "Prime Minister's Initiatives on Livestock Sector", has decided to initiate following Programs in all four provinces, (1) Save the buffalo calf Program and (2) Calf fattening Program. The approved "National FMD Control Program" at a cost of Rs.763.9 million (Ministry of Finance, Pakistan, 2019)

for the period of six years and other initiatives like this indicate health of livestock in the country will be improved. Reducing temperature of stored manure and solid-liquid separation are still not viable options for Pakistan due to high cost and required skill but the anerobic reparation and production of biogas is sustainable option for which government seems interested because it provided support (for the fixing of biogas plants) Rs.100,000 to the farmers consuming land up to 5.1 acre, Rs.75,000 for farmers consuming more than 5 acres and up to 12.5 acres, and Rs. 50,000 for farmers having more than 12.5 acres and up to 25 acres (Government of Punjab, Pakistan, 2020). So, it can be said that in the forthcoming climatic challenges livestock sector in Pakistan could be promoted using smart ways of mitigation and educating farming community about these challenges.

DISCUSSION

Based on the results of ARIMA model, this study forecasted substantial increase in population of cattle, buffalo and goats while forecast about population of other species like sheep and camel confirmed that they are not increasing at a significant rate. A policy focused for ensuring production of good quality livestock species is necessary to be formulated so that climate change aspect should be considered along with meeting food security challenge through livestock products. Feed and fodder production are decreasing (as shown in results) due to decrease in area under fodder crops and degradation of rangelands. It appears that feeds and fodder shortages will result in a big challenge for the future livestock industry, similar concern was showed by Younas and Yaqoob (2005). As a result, planning for new feed and fodder choices at the national level is essential for both supporting the present livestock population and generating new high-quality breeds of cattle. To draw repercussions and successfully target funds for impact-specific adaptation measures, it is vital that research begin looking at the effects of climate change as well as livestock keepers' adaptation together.

Livestock distribution is also unequal to a big extent; some farmers have enormous herds, while others have a small number of animals. There is also a need for reducing this inequality for producing better quality animals and income equality among farmers. Food security is mainly linked with livestock because major protein rich food items have animal origin. Only increasing number of livestock without considerable increase in productivity is not good option in the era of climate change. The trends of Livestock Production Indexes for the region (China, India, Bangladesh and Pakistan) and its relationship with Consumption Expenditure (PPP) and GNI per capita exhibit that Pakistan can meet its food security challenges as well as earn foreign exchange through promotion of its livestock sector by considering the suitable adaptations related to climate change.

Conclusions and policy implications for food security and climate change: It can be deduced from the present study that the populations of some livestock species have been significantly increasing with time. Forecasts for 6 years say that many livestock species will increase in quantity while sheep population will decrease in future. The shortage of feed and fodder availability (along with future declining situation) and insufficient animal health care facilities are major challenges to the future of livestock in Pakistan. Distribution of animals is also unequal to a great extent; some farmers have large herds and others possess a limited number of animals. The realistic forecasts for Pakistan's inland livestock production obtained through ARIMA model could be of massive support to policy makers in formulating appropriate policies. This in turn will also benefits the farmers for producing optimal quantities of livestock. All this will ultimately lead to efficient management of livestock production in Pakistan through sound strategies. This in turn would provide sound basis for policy formulation to effectively support this sector possession in assessment of the influence of this sector in food availability in the wake of increased population pressure. If we only prefer major field crops with minimal focus on good quality livestock, it may have several implications for rural economy and its sustainability. Many farmers linked with this activity are often landless households but effectively contribute to the provision of food to the common man in the form of milk, meat and mutton. These landless families have been ignored in the previous policy interventions and this warrants an integrated policy framework considering both commercial and subsistence livestock farmers but at the same time marginal herd-owners must be the focus of any future policy target. This is essential partly because they earn major part of their livelihood from this activity while their productivity remains relatively higher as they use cheaper inputs and abandoned feed and grasses which otherwise would waste or cause pollution. In the similar vein, role of livestock in the sustainability of rural livelihoods is highly acknowledged with the statistics on its contribution in agricultural GDP, i.e., substantial policy focus on safeguarding animals and uninterrupted fodder availability as well as value added feed lots considering the adaptation/mitigation options to climate change impacts produced by livestock can prove highly beneficial in improving rural farming and landless livestock owners enabling effectively to ensure food security of urban masses.

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