Future Challenges of Food Security and Sustainable Livestock Production in India in the Changing Climatic Scenario

1Rupasi Tiwari, 2H. Dileep Kumar, 3Triveni Dutt, 1B.P. Singh, 2K. Pachaiyappan and 3K. Dharma
1Joint Directorate of Extension Education,
2Division of Extension Education,
3Avian Diseases Section, Division of Pathology, Indian Veterinary Research Institute, Izatnagar, Bareilly Uttar Pradesh, India

Corresponding Author: Rupasi Tiwari, Joint Directorate of Extension Education, Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

ABSTRACT

Today about 7.08 billion people inhabit the earth. Presently to feed everyone adequately the world needs 2800 million tonnes of cereals, against which global production is only 2100 million tonnes. This discrepancy in need and production has left over 868 million people undernourished worldwide and 850 million of them live in developing countries. On the other hand rapid urbanization, increasing purchasing power and shift in diet is pushing demand for richer diets and protein of animal origin. By 2050, consumption of meat and dairy products not the butter is projected to increase by 173 and 158%, respectively, as that of 2010. To meet the growing demand and to cope with 9 billion world population by 2050, agricultural production needs to increase by 60% (compared to 2005/2007 production) including of increase in animal production and animal products. Feeding this burgeoning population with the available 0.23 ha of cropland per capita is one of the biggest challenges. Apart from this, the world is facing another biggest challenge of climatic change. Simply, if the “business as usual scenario” continues it requires three earth planets to supply the resources for human population consumption and to assimilate associated wastes it generates in 2050. In the present review, an attempt has been made to throw light on the future challenges of population rise, limited natural resources and climate change to ensure food security in India and the world with major emphasis on sustainable livestock production.

Key words: Food security, climate change, agrobiodiversity, livestock, sustainability

INTRODUCTION

The burgeoning world population, environmental degradation, limited natural resources and climatic change pose a greatest challenge to the food security of the human population. It is estimated that about 870 million people have been undernourished and 98% of these live in developing countries (FAO, WFP and IFAD, 2012). Further, a billion people lack adequate nutrition. Hunger and malnutrition alone is killing almost 6 million children each year (FAO, 2005). In India, situation is far more pathetic, about 17.5% (217 million) of population is undernourished and the country stands at 63 rank of 69 nations in Global Hunger Index (IFPRI, 2013). Prevalence of underweight in children under five years is also alarming with 40.2% of children being underweight and India ranked second to last on child underweight out of
129 countries, second highest prevalence in the world (IFPRI, 2012). The condition of women is not different; 36% of Indian women of childbearing age are underweight, compared with only 16% in 23 Sub-Saharan African countries (Deaton and Dreze, 2009). The widespread hunger and malnutrition has placed the country at 70 of 107 nations in Global Food Security Index (The Economist, 2013). In the human development front also India's performance is poor, it is ranked 136 in Human Development Index (UNDP, 2013). Food security and human development are linked inextricably and that their outcomes are significant co-determined (Misselhorn et al., 2012). Ensuring food security of 17% of world’s human population and feeding 10.71% of world’s livestock with 2.4% of world’s geographical area and 4% of its water resources is the major challenge before India. Hence, we tried to provide an insight into India’s future challenges of food security with special emphasis on livestock production and explore possible strategic options applicable to country to overcome these challenges which have major policy implication on India’s food security and livestock development.

**POPULATION GROWTH**

Today about 7.08 billion people inhabit the earth (www.worldometers.info). Human population has become a malignant process on the planet (Hern, 1999) with doubling time decreasing by 50% or more with each doubling since A.D.0 (Fischer, 1993). Population is growing hyper exponentially (Von Foerster, 1966) for example, it took 1650 years for human population of 250 million at A.D. 0 to become 500 million, but the next doubling to 1 billion took only 200 years and it doubled between 1960 and 1998 from 3.0-6.0 billion in just 38 years. At the turn of twentieth century, population of India was 238.4 million; it has increased more than four times to reach 1210 million in 2011. In absolute terms its population has increased more than 181 million during the last decade (2001-2011) which is almost the size of Pakistan’s population. Average annual exponential growth rate reached its peak at 2.22% in 1981 (CENSUS, 2011) which can be partially correlated with green revolution which induced higher food supply, lowered mortality rate and also increased fertility. India’s population is expected to increase by 1.53 billion in 2050 (United Nations, 2004) when the world population is projected to grow to 9 billion and much of the new population added to the planet will be urban in nature (UNFPA, 2010).

**FUTURE DEMAND**

It was estimated that the current world food system provides adequate nutrition to 85% of its population (Black, 2003) i.e., still 15% of world population is yet to be fed adequately. On the other hand increase in income levels and population growth has led to more changes in the diets like a shift from rice to bread, increased consumption of vegetables and fruits, meat and beverages (Popkin, 2002). Today, animal-derived protein constitutes 40% of the world’s total protein consumption (FAO, 2006) and is expected to increase substantially. By 2050, consumption of meat and dairy products not the butter is projected to increase by 173 and 158%, respectively as that of 2010. The largest growth (209 and 216% for meat and Dairy not butter, respectively) in demand is expected to be from developing countries (FAO, 2006). In India also average Indian food basket is gradually shifting towards animal (livestock and poultry) products. The average monthly per capita expenditure on animal foods has increased rapidly than on plant based foods with the rise in per capita income (Fig. 1 and 2). Particularly, the demand for egg, meat and fish has increased to 485 and 431% for rural and urban household, respectively, between 1993 and 2011. India’s per capita animal protein consumption has increased by 175% between 1961 and 2009 (FAOSTAT).
Fig. 1: All-India rural average per capita monthly expenditure. Various rounds of all-India consumer expenditure survey of National Sample Survey Organization (NSSO)

Fig. 2: All-India urban average per capita monthly expenditure. Various rounds of all-India consumer expenditure survey of National Sample Survey Organization (NSSO)

The per capita meat consumption (kg/year) in the year 2000-2010 was only 5.1 kg (FAC, 2006) and is projected to increase by 17.9 kg in 2030 (Keyzer et al., 2005). As proposed under National Dairy Plan the domestic demand for milk is expected to be 180 million tonnes in 2020, to meet this demand milk production must increase at around 5.5% per annum. Egg demand is also expected to increase by 39.55 billion between 2012 and 2020 (Mohanty and Rajendran, 2003).

This rise in demand for animal protein is difficult to meet with the present livestock farming system, as already India is facing feed and fodder deficiency and shrinkage of grazing land. If much of the new demand has to be met by intensively raised livestock; demand for human-edible food grains for livestock feeding will increase. Presently, over 35% of the cereals produced globally are presently fed to livestock (Trostle, 2008). The use of cereal for ethanol production and rapeseed as feedstock for biodiesel has further increased pressure on global food production system. By 2020,
to meet the food, livestock feed and fuel needs the demand for cereals is expected to reach 5800 million tonnes (Sanderine and Kastner, 2011). Already India is facing shortage of dry fodder, concentrates and green fodder currently which is likely to be 11, 35 and 45%, respectively, by 2020 (Planning Commission, 2012). In India, total consumption of concentrate feed was only 47 million tonne (Dikshit and Birthal, 2010) in 2003 during which food grain production was 174.7 million tonnes (Gol, 2013a). However, demand for concentrate feed will increase marginally to 55.7 million tonnes in 2050 (Dikshit and Birthal, 2010) when demand for grains for food and feed will be 377 million tonnes (Amarasinghe et al., 2007). In India, permanent pasture is only 3.1% of the geographical area and the area under fodder cultivation is estimated to be only about 4% of the gross cropped area. Thus majority of the livestock in the country are maintained on feeding crop residue.

PRODUCTION EFFICIENCY

A major concern in the Indian livestock sector is low animal productivity. In India, average milk yield per cow per day is only 0.92 and 5.42 kg for indigenous and crossbred cattle, respectively (Gandhi and Sharma, 2005), whereas world average is 6.3 kg per day. Furthermore, the actual milk yield of bovines is reported to be 26-51% below the attainable yield under field conditions (Birthal and Jha, 2005). Carcass yield of cattle, buffalo, sheep, goat and pig is 48, 30, 14, 28.5 and 60% less than world average respectively (Table 1). Since 2004, India's livestock production has increased by 23.5 points (Table 2) but this improvement has come from increase in numbers (Fig. 3) rather than increase in production efficiency. The population of cattle, buffalo, sheep, goat and pig has increased 128.19, 242.71, 183.01, 297.75 and 252.95% between 1951 and 2007. This increase in livestock population has serious implications on the limited natural resources of the country as they are one of the significant contributors to environmental problems (Aiking, 2011; Steinfeld et al., 2010). The crop yield per hectare is almost less than 50% that of USA and China. The country employs 47.2% of the work force (World Bank, 2013) in agriculture and contributes only 14% to Gross Domestic Product (GDP) at 2004-05 prices (Gol, 2013a). The poor productivity of crop land, livestock and labor force engaged in agriculture is a cause of serious concern in Indian agriculture.

![Graph showing livestock population trends](image)

Fig. 3: Trends in livestock population, Livestock census, Directorate of Economics and Statistics and Animal Husbandry Statistics Division, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, India
Table 1: Carcass yield of different livestock species (kg/animal)

<table>
<thead>
<tr>
<th>Species</th>
<th>World*</th>
<th>Developing countries*</th>
<th>India**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle and buffalo</td>
<td>202.0</td>
<td>166.0</td>
<td>103 and 108</td>
</tr>
<tr>
<td>Sheep and goat</td>
<td>14.0</td>
<td>13.0</td>
<td>12 and 10</td>
</tr>
<tr>
<td>Pigs</td>
<td>79.0</td>
<td>74.0</td>
<td>35</td>
</tr>
<tr>
<td>Poultry</td>
<td>1.6</td>
<td>1.4</td>
<td>0.92</td>
</tr>
</tbody>
</table>

*Alexandratou and Bruinsma (2012), **Vision (2010). NRC on meat, Hyderabad, India

Table 2: Development indicators of India, China and USA

<table>
<thead>
<tr>
<th>Indicators for 2011</th>
<th>India</th>
<th>China</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arable land (hectares per person)</td>
<td>0.128</td>
<td>0.083</td>
<td>0.514</td>
</tr>
<tr>
<td>Arable land (% of land area)</td>
<td>52.920</td>
<td>11.990</td>
<td>17.560</td>
</tr>
<tr>
<td>Livestock production index (2004-2006 = 100)</td>
<td>123.500</td>
<td>116.200</td>
<td>106.200</td>
</tr>
<tr>
<td>Cereal yield (kg per hectare) (2012)</td>
<td>2959.608</td>
<td>5897.471</td>
<td>5922.467</td>
</tr>
</tbody>
</table>

World Bank (2013)

The productivity of livestock needs to be improved through proper breeding, feeding and disease control programs. National Livestock Policy (GoI, 2013c) of India advocates selective breeding of indigenous cattle and buffalo breeds and cross breeding of nondescript cattle with high yielding exotic breeds and nondescript buffalo with improved native breeds to increase milk production and lifetime productivity. This is also reflected in national dairy plan and national project for cattle and buffalo breeding. However, the availability of bulls of high genetic merit, inadequate artificial insemination coverage (only 54 million animals) and poor conception rate (35%) are some of the major constraints need to be addressed urgently. In India, cattle are dependent mainly on crop residues (De and Singh, 2002). These poor quality roughages can be utilized efficiently by adding legume fodder (Singh et al., 2003) and supplementation of urea molasses mineral block which can stimulate the growth of rumen micro flora (Garg and Gupta, 1992) and improve productivity. India is one of the worst affected regions in the world due to foot and mouth disease (FMD) and it costs US$2.7-3.6 billion to the country (Kumar, 2012). Despite FMD control programme implemented in 221 districts, the country could vaccinate only 53.6% of cattle and buffalo with 150 million doses (Wint and Robinson, 2007; Hamond, 2011; Knight-Jones and Rushton, 2013). Mastitis is another important disease causing huge economic losses to the tune of 7165.51 crores and subclinical mastitis accounts to 57.93% of the total loss (ICAR, 2010). It is estimated to decrease milk yield by 100-500 kg per lactation per cow. The effective control of economically important diseases could further improve production efficiency of livestock and poultry (Dhama et al., 2014; Verma et al., 2014).

LIMITED RESOURCES (LAND AND WATER)

Since the invention of agriculture, ~10,000 years ago, humans have transformed the face of planet. Over the last three centuries, 20% of the world’s forests and woodlands are lost and croplands have expanded by 466% (Richards, 1990). Today, of the total global land about ~20-30% is used for grazing and as much as a third of cultivated land area is used to grow feed and forage (Ramankutty et al., 2008). In India, of the total land mass, 52.92% (Table 2) of land is used for agriculture and the area under fodder cultivation is estimated to be about 4% of the gross cropped area. As per Indian Council of Agricultural Research (ICAR, 2010) estimates, out of total geographical area (328.73 million hectare), about 120.40 million hectare is affected by various kind of land degradation. Between 1990-1991 and 2010-2011, the number of operational holdings
increased from 106.64 million to 137.8 million, while the operational farm size has reduced from 1.57-1.16 ha (GoI, 2007). The problem of land fragmentation, degradation, nutrient depletion, salinization, expanding urban areas pose greater challenge to feed the country’s population with only 0.128 ha (Table 2) of crop land per capita, against world average of 0.23 ha (Pimentel and Pimentel, 2006).

To meet the increasing demand for food and animal protein, extra 5000-6000 km³ of water is required per year, against the current use of 7000 km³ of water to grow food and fodder globally by 2050 (Falkenmark, 2007). Agriculture is the largest consumer of freshwater (~70% of all freshwater) (WWAP, 2009) and it will be the first sector to be affected by increasing water scarcity (Falkenmark and Molden, 2008). By 2025, 64% of the world’s population will live in water-stressed basins (Rosegrant et al., 2002). Water gap in 2050 is expected to increase by about 3300 km³/year (De Fraiture et al., 2007) which may leave food gap and affect global food security if not filled. Therefore, water scarcity is projected to become a more important determinant of food scarcity than land scarcity (UNDP, 2006). Scarcity of water may become the potential cause for conflict at local, national and transnational levels (Giordano et al., 2005). The Government of India has been using a minimum dietary energy requirement norm of 2400 kcal per person per day for the rural sector and 2100 kcal for the urban sector for defining poverty line. For producing 1 kcal for the average diet, 1 L of water is needed (Molden et al., 2007). This means approximately 2300 L/capita of water is required daily to feed an average Indian. The average annual per capita availability of water in the country which was around 5177 cubic meter in the year 1951 has come down to about 1588 m³ in 2010 (CWC, 2010). The availability would further reduce to around 1140 m³ by 2050 (CWC, 2007). Availability of utilisable water in India is estimated to be about 1123 Bm³ (GoI, 2013b) and if the business as usual scenario continues domestic demand of water is expected to be 900 Bm³ in 2050 (Amarasinghe et al., 2007). The country’s 60% of the food is produced using ground water which has already been exploited to unsustainable levels (IPPRI, 2012) and the irrigation efficiencies from surface water sources is only between 35-40% (GoI, 2013b). With current water utilization practices, fast growing population and a nutritional transition towards animal protein diets the demand may soon exceed the availability. For example, the 2025 projections on water scarcity by the International Water Management Institute (IWMI) were reached in 2000 (De Fraiture et al., 2007).

The future expansion of agricultural land can be minimized by increasing the yields (Waggoner, 1994; Lee et al., 2006). As per FAO projections, global agriculture land could expand from 5.1-5.4 Bha in 2030. If the higher livestock productivity is achieved the agriculture land use will decrease to 4.8 billion hectare and if 20% of ruminant meat is substituted by poultry with higher productivity the land use will further come down to 4.4 billion hectare (Wirsenius et al., 2010). Grain feed based intensive livestock production uses more water than crop residue and grazing based livestock production (Peden et al., 2009). Livestock in India is largely dependent on crop residue and hence livestock production is more water efficient. The future intensification of livestock production to meet the increasing demand for animal products and decreasing the land use requires water conservation strategies to prevent unproductive runoff and deep seepage. Increasing the vegetation coverage of the barren and waste land can decrease the unproductive water loss and increase biomass which can be used as fodder. Around the world about 25% of the food produced is lost within the supply chain which amounts to loss of 24% of freshwater, 23% of cropland area and 23% of fertilizer (Kummu et al., 2012). According to ICAR, in India post-harvest loss of agriculture commodities is estimated to be Rs. 44,000 crores (at 2009 wholesale prices).
Halving losses in food supply chain could save enough food for approximately one billion extra people (Kummu et al., 2012) and ensure food security (Godfray et al., 2010). Efficient management of food supply chain from farm to fork and stable to table will further reduce the land and water requirement.

CLIMATE CHANGE
The "best estimates" of temperature increase for the range of scenarios is projected to increase between 1.8-4°C and global sea level is projected as 0.18-0.59 m by the end of the 21st century (IPCC, 2007). Climate change will have major impacts on the more than 600 million poor people depending on livestock for their livelihoods in Asia and sub-Saharan Africa (Thornton et al., 2002). Crop yields are projected to fall in the tropics and subtropics by 10 to 20% by 2050 due to combined effect of warming and drying (Jones and Thornton, 2003). India is very much vulnerable to climatic change due to its large crop sector, very warm springs (Mendelsohn, 2014) and huge dependency ratio on agriculture; it is ranked 18 in Global Climate Risk Index 2014 (Kreft and Eckstein, 2014). Around 68% of the country is prone to drought in varying degrees of which 35% drought prone receiving rain falls between 750 and 1125 mm, while 33% is chronically drought prone, receives less than 750 mm rainfall (Gol, 2011). Small farmers and fisher folk will suffer complex impacts of climate change, due to poor adaptive capacity and other climate-related vagaries, particularly in the Indo-Gangetic Plain (IPCC, 2007). A rise in temperature of 2.5-4.9°C, will reduce rice yields by 15-45% and wheat yield by 25-55% (Parikh, 2002), the largest reduction in yields between 2011-2040 will occur in the upper Indian Ganga Basin (Mishra et al., 2013). If temperatures rise by 2.0°C with an 8% increase in precipitation, agricultural net revenue may fall by 12% or $4 billion/year in India (Sanghi and Mendelsohn, 2008). Grazing and mixed rain-fed systems of livestock production will be the most damaged by climate change (Nardone et al., 2010) which supports India’s 40% of the human and 60% of the livestock population.

In the last twelve years, heat waves have caused substantial mortality in livestock in the USA and northern Europe (Sirohi and Michaelowa, 2007). The increased heat stress will reduce feed intake (Mader and Davis, 2004) and high temperatures in the tropics may reduce the dairy milk yield by half to one-third of the potential of modern cow breeds (Parsons et al., 2001). Johnson et al. (1962) showed a linear reduction of dry matter intake and milk yield when temperature-humidity index exceeded 70. Heat stress compromises oocyte growth in cows by altering progesterone, the secretion of luteinizing hormone and follicle-stimulating hormone and dynamics during the estrus cycle (Ronchi et al., 2001). It has also been associated with impairment of embryo development and increased embryo mortality in cattle (Hansen, 2007). Roy and Prakash (2007) reported that severe heat stress may cause acyclic/infertility in buffaloes during the summer months due to hyper-prolactinaemia. The conception rates of Bos taurus cattle will also decline at high thermal heat index and temperatures above 23.4°C (Amundson et al., 2005). Temperatures above 30°C cause heat-stress in birds (Ensminger et al., 1990) in the hot regions, it results in poor growth performances, high mortality rates (Yahav et al., 1995) and interrupt egg production (Novero et al., 1991). Changes in rainfall and temperature regimes may affect both the distribution and the abundance of disease vectors (Thornton et al., 2009; Dhama et al., 2013). Climate changes especially the increase in global temperature has led to rise and emergence/re-emergence of various infectious diseases in human and animal population particularly the vector borne diseases like blue tongue, West Nile fever, Japanese encephalitis,
Dengue, Chikungunya, Malaria, Plague, Leptospirosis, Lyme disease, Crimean Congo haemorrhagic fever, Filariasis, Cholera, food poisoning, Trypanosomiasis, Cryptosporidiosis etc. To lessen such kind of increasing infectious disease incidences and check their wide geographic spread combined efforts are needed to counter and/or reverse global warming (Dhama et al., 2013). The stratospheric ozone depletion can suppress mammalian cellular immunity due to heightened exposure to ultraviolet B radiation (Baylis and Githeko, 2006).

LIVESTOCK AND CLIMATE CHANGE

Livestock production is environmentally a costly affair. For example, the environmental costs of producing conventional pig meat are estimated to be 1.9 EUR kg⁻¹, whereas private cost is only 1.4 EUR (Nguyen et al., 2010). Greenhouse gas emission from milk amount to 1.2 kg CO₂ eqv kg⁻¹ (Table 3) compared to 0.8 kg CO₂ eqv kg⁻¹ of wheat (Garnett, 2009). Agriculture land use contributes 35% of global greenhouse-gas emissions (Stern, 2007). Much of this emission comes from livestock production which accounts for about 18% of global greenhouse-gas emissions making it one of the top two most significant contributors to the most serious environmental problems (Steinfeld et al., 2006). Indian agriculture sector accounts for 23% of country’s Greenhouse Gas (GHG) emission. The total amount of methane emitted from India in 2008 is 21 Tera grams of which agriculture sector accounts for 61% of the total methane emissions, with 40% from enteric fermentation, 17% from rice cultivation and 4% from manure management (Garg et al., 2011). Much of this livestock related emission in India is “emission for sustenance”, since 87.7% of the livestock holdings are with marginal, small and semi-medium farmers. Moreover, overall greenhouse gas emission from livestock in India is less than entire North America (Table 4) despite having 10.71% world’s livestock.

Much of the livestock related GHG emissions can be mitigated by adopting proper feeding, manure management and improving productivity (Steinfeld and Gerber, 2010). Improving roughage digestibility (Gerber et al., 2010), supplementing feed with prebiotics

Table 3: GHG emission (kg CO₂ eqv kg⁻¹ product)

<table>
<thead>
<tr>
<th>Product</th>
<th>FCR</th>
<th>GHG emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Beef</td>
<td>19.8</td>
<td>22.6</td>
</tr>
<tr>
<td>Pork</td>
<td>4.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Poultry</td>
<td>3.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Eggs</td>
<td>2.8</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Lesschen et al. (2011)

Table 4: Emissions of major livestock greenhouse gases (million tonnes of CO₂ eqv year⁻¹)

<table>
<thead>
<tr>
<th>Category</th>
<th>World</th>
<th>India</th>
<th>North America</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enteric fermentation (CH₄)</td>
<td>1929</td>
<td>218</td>
<td>136</td>
</tr>
<tr>
<td>Manure (CH₄)</td>
<td>235</td>
<td>23</td>
<td>43</td>
</tr>
<tr>
<td>Manure (N₂O)</td>
<td>211</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Soils (N₂O)</td>
<td>2299</td>
<td>58</td>
<td>300</td>
</tr>
<tr>
<td>Total GHG</td>
<td>4674</td>
<td>259</td>
<td>501</td>
</tr>
<tr>
<td>Livestock population (bn)</td>
<td>3.437402</td>
<td>0.467472</td>
<td>0.120222</td>
</tr>
</tbody>
</table>

EPA (2006)
AGROBIODIVERSITY LOSS

Genetic diversity is the basis of global food supply (Hoffmann, 2011). The loss of genetic and cultural diversity in agriculture has been reported by Ehrenfeld (2005). Sudarshan (2002) commented that, "over the last 50 years, India has probably grown some 30,000 indigenous rice varieties. In 20 years' time, it will be reduced to 50 varieties, the top 10 of these accounting for more than 75% of the country's rice area." Large number of rice varieties in Orissa, some rice varieties with medicinal properties in Kerala and a range of millet species in Tamil Nadu, are no longer cultivated in their native habitats (Chaudhuri, 2005). Such genetic erosion is also seen in livestock species, of 8262 breeds reported worldwide; 628 breeds are classified as extinct and 1881 breeds are classified as being at risk (CGRFA, 2012). For developing regions, the proportion of mammalian species at risk is lower (Pilling and Rischkowsky, 2007). Much of this genetic erosion is caused by global livestock production practices and the increasing marginalization of traditional production systems and associated local breeds. Global warming also takes its toll on genetic diversity, the fourth assessment report of Intergovernmental Panel on Climatic Change (IPCC) estimates that a 2.5°C increase in global temperature above the preindustrial level may put 20-30% of all plant and animal species assessed so far at high risk of extinction. The cost of biodiversity loss is difficult to measure; the loss in terms of cultural value, ecological services, loss of genes for disease and pest resistance, for environmental adaptation and for other desirable traits in both plants and animals cannot be ignored.

India is one of the mega biodiversity countries in the world, it is a home of 167 species of important crops and their 320 wild relatives and 298 breeds of 14 livestock species. But the promotion of cross breeding in cattle with European breeds for decades has led to dilution of local breed’s gene pool (Mathias and Mundy, 2005). Moreover, disease susceptibility, poor conception rate and high cost of maintenance of cross breeds have made them unsuitable for average Indian dairy farmer (Gautam et al., 2010). Wherever, crossbreeding is advocated there is a need to completely assess the native breeds called 'non-descript' against cross breeds in terms of their economic value, cultural value, interaction with local ecological communities, ecological services, draught capabilities, option value etc., before going for crossbreeding. In order to conserve livestock biodiversity at gene level, maintenance of 25-50% local breed inheritance in crossbreeds is recommended. This is however difficult to maintain due to absence of breeding records with farmers. This problem can be overcome by employing automatic identification and data capture technologies like radio frequency identification in artificial insemination centers and veterinary dispensaries. Government of India has already taken initiatives to conserve and promote indigenous livestock breeds. Mobilizing farmers as breeder’s organizations, transfer of technology, market opportunities (Djemali et al., 2009) and organizing native livestock breed fairs can be a promising option to conserve native breeds. Besides conserving agricultural diversity, conservation
of crop wild relatives is also important as they contain a wealth of traits adaptable to diverse ecosystems (Vollbrecht and Sigmon, 2005) and contribute to food security (Vincent et al., 2013).

**Sustainability**

The demand for the nature’s services has increased enormously that, humanity’s Ecological Footprint exceeded the Earth’s biocapacity by more than 50% in 2008 itself. In the same year, humanity’s ecological footprint was 18.2 billion global hectare (global hectare per person) while, the Earth’s total biocapacity was 12.0 billion global hectare (1.8 global hectare per person). This deficit means, ecological foot print of humanity is equivalent to 1.5 earth planets to support its activities. If the business as usual scenario continues humanity needs three Earth planets in 2050 (WWF, 2012) to meet its demands. India is running on ecological deficit of 0.4 global hectares; its per person footprint is 0.91 global hectares whereas it’s per person biocapacity is only 0.51 global hectares (Ewing et al., 2010). The country has performed worse in the environment protection; it stands 155th of 178 countries in 2014 Environmental Performance Index (Hsu et al., 2014). The growing stress on the country’s natural resources is reflected in the fact that eleven states of the country are rated less (5 states) or least (6 states) sustainable (Dash, 2011) which together covers 54.81% of the country’s land area. The problem of sustainability can be addressed by stringent environmental laws and improving the productivity of agriculture. The optimal integration of crop and livestock is the one best option (Salton et al., 2013; Rai et al., 2014). It will increase agriculture productivity and improve environmental sustainability (Rao et al., 2005). Crop-livestock integration improves soil fertility by accumulating organic matter (Salton et al., 2010), improving nutrient cycling (De Faccio Carvalho et al., 2010) and increasing fertilizer use efficiency (Assmann et al., 2003). Crop rotation together with livestock can disrupt disease, pests and weed cycle. Planting trees and improving vegetation cover in barren and waste lands can provide feed and fodder besides controlling soil erosion, improving soil structure and fertility and increases ecosystem stability (Mekoya et al., 2008).

**Conclusion and Future Perspectives**

The current system of livestock production system may not respond to the future demands since too many animals are producing at low levels when compared to natural resource base. Food security can be achieved by closing ‘yield gaps,’ increasing crop and livestock production efficiency, reducing waste in the food supply chain; crop/livestock diversification and integration; conserving crop wild relatives and agrobiodiversity and by adopting greenhouse gas abatement and production enhancement technologies in agriculture and animal husbandry. Application of these measures together could double the food production with available resources without increasing environmental impacts. Smallholder’s intensification and linking them with corporate bodies and modern retail food supply chains needs urgent attention since they hold majority of livestock in the country and can play a major role in food security and environmental stability. To avoid harmful effects of global warming, small changes in our day to day life style is a crucial turning point which need due attention. Techniques of remote sensing and Geographical Information System (GIS) need to be fully explored against various unpredicted outcomes because of fluctuating climatic conditions. The recent advances in science and novel technologies/concepts need to be fully explored for their optimum potentials like genetic engineering, disease resistant varieties, embryo transfer technology, artificial insemination, superior genetics and breeding practices, cloning, nutrigenomics,
immunomodulatory among others. These altogether may help increase and boost both agricultural and animal products including of crops, cereals, foods, milk, meat and other products and ultimately lead to production of healthier, safer and high quality food apart from boosting production and safeguarding food security for everyone. If the crop livestock system has to respond in an ecologically sound and sustainable manner to the future demands, there is a need to tailor the research and extension for climatic resilience, sustainability and food security.

REFERENCES


Hamond, J., 2011. FMD vaccine: Practical applications from an international perspective. WRLFMD, Institute for Animal Health, Surrey, UK.


Trostle, R., 2008. Global Agricultural supply and demand: Factors contributing to the recent increase in food commodity prices. WRS-0801, Economic Research Service/USDA.


