

Approaches for Improvement of Livestock Production System as affected by Climate Change in Dry Lands

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Abstract: In the arid and semi-arid regions, the livestock husbandry is playing pivotal role in the economic sustenance and employment generation, but is also suffering due to recurrent droughts and other unfavorable conditions of climate, soil and water, which also adversely affect the crop husbandry. Despite higher animal number and significant contribution to the livestock production at national and regional levels, the low productivity remains a matter of concern. The low and non-productive animals need to be curbed in number as these contribute to climate change and global warming. There is a need for effective conservation and improvement of native breeds, stop uncontrolled animal breeding, which results in loss of precious genetic material due to prevalent extensive rearing and transhumance practice followed in the region in search of food. There is also need appropriate feed security measures to address the issues of degradation of grazing resources, which need protection and rejuvenation and also policy support for creation of feed, fodder banks and complete feeds like CFBs and TMRs to take care of productivity improvement. The issues of management of livestock, nutritional measures to reduce methane emission from enteric digestion and also management of health under changing climate need proper consideration as new emerging and re-emerging diseases of livestock in the region have an adverse effect on livestock productivity. The value addition to the marketable animals and their produce need an extensive support of the government to provide real benefit to the poverty stricken small, marginal and landless labourer section of the rural society who have livestock rearing as the main activity and which thrive well despite the threats from climate change issues.

Key words: Ruminants, sheep, goat, camel, methane, climate change.

India occupies 2.4% of the world's geographical area and supports about 16.2% of the world's human population. Similarly it has only 0.5% of the world's grazing area, but has to support nearly 17% of the world's cattle population. India's 228 Mha (69%) of the geographical area (about 328 Mha) fall within the dry land (arid, semi-arid and dry sub-humid) as per Thornthwaite and Mather (1955) classification and is covered by large number of States. Major parts of the dry land regions in the country are rainfed and most difficult to manage. In the very harsh areas in the arid tropics or hot arid regions of India, involving seven states viz., Rajasthan, Gujarat, Punjab, Haryana, Andhra Pradesh, Karnataka, and Maharashtra, where technologies of agriculture and animal husbandry have proved successful can be adopted in other dry regions (Narain and Tewari, 2005).

In dry lands, which are prone to recurrent droughts as a result of frequent climatic

aberrations, livestock production system provides sustenance to agriculture dependent livelihood for the people. Higher livestock population in dry lands compared to other regions suggests its dependable role for economic stability. It provides quality nutrition as milk, meat and eggs, industrial raw material as wool, leather and also provides draught power and manure, which cannot be underestimated. Animal husbandry besides enhancing the economic viability and sustainability of farming systems diversifies production and management options; increase total farm production and income. Therefore stable and consistent growth rate in animal husbandry sector is required in this region. This will help in increasing employment and bring about income redistribution in favor of small and marginal farmers and landless laborers and the extensive system of livestock rearing being practiced need to be addressed. Under climate change role of livestock in supporting economic conditions of farmers and also nutritional security of human beings,

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the present traditional livestock rearing system which is low in productivity has to be relooked and modified so as to improve and economize production.

With appropriate management, livestock enable sustainable use of marginal lands for food production, transforming fibrous biomass not suitable for human consumption into high quality protein. But when poorly managed, particularly in fragile production environments, livestock contributes to desertification. This is not due to the livestock *per-se*, but due to human inability to manage the livestock and vegetation resources in an integrated manner. It is therefore, necessary that sustainable use and further development of these resources is well planned and managed. Human population growth, progressive urbanization and larger purchasing power of people will increase demand of livestock products. It is projected that a growth in consumption of meat and milk will be at 2.9 and 4.3% per year, respectively, for India. In absolute terms this converts to 170 Mt of milk and 40 Mt of meat by 2020 AD.

Prevalent Livestock Production Systems in Dry Lands

Livestock sector presently contributes over 25% to agricultural sector output of the country, up from 16% in 1970-71. Its contribution increased at an annual rate of 4.3%, higher than the growth in the agricultural sector as a whole (2.8%) and its contribution increases proportionately with increase in aridity of the location. The inhospitable agro-climatic condition of the region renders the conventional agriculture always a gamble hence the farmers' dependence on animal husbandry increases proportionately. In dry arid regions like Rajasthan the animal husbandry is mainly grazing-based and is a predominant occupation of small and marginal farmers and landless labourers and is a major source of livelihood sustenance, whereas in semi-arid regions dry land farming is major occupation of farmers and the livestock rearing is subsidiary occupation.

Based on the size of animal and main function of production, two systems viz., large and small animal production systems exist in the dry region. In the large animal production system buffalo and cattle are particularly important in the rain fed areas, where greater supplies of crop residues and agro industrial

by-products (AIBPs) are available in addition to grazing. Milk production is also very important in these areas, both as a source of income and nutritional security of the family. In the small animal production system small ruminants like sheep and goats are found and more concentrations are found in the extensive pastoralist and agro-pastoralist systems where nomadism and transhumance are practiced. These animals are reared for wool, meat and milk production on almost zero input basis.

For the management of ruminant in the dry lands there are three main systems in operation viz., extensive range management system, system combining arable cropping (road side, community grazing land tethering and cut and carry system) and the system integrated with tree cropping. These production systems are unlikely to change in foreseeable future and all three systems have significance in the arid and semi-arid regions of the country. In a very small areas with intensification of dairy production a gradual shift is being noticed from extensive range management to intensive production under stall-feeding in cattle and buffalo. The peri-urban areas in semi-arid and in arid parts of the country are leading in this type of management for large ruminants, but the remote areas in large numbers away from the market still rely on semi-intensive or extensive type of management. In sheep and goat production organized feeding can increase the growth rate of lambs/kids three times providing quality carcass for high-end consumers (Karim, 2004), while organized flock health can reduce the mortality from 12 to 5% amounting to net economic advantage of 7% (Singh *et al.*, 2004), but has not largely taken up due to poor socio-economic status of small ruminant farmers.

Issues and Technological Options for Improvement of Animal Production

Breed improvement and conservation of indigenous livestock

The arid and semi-arid zones of the country are rich repository of livestock genetic resources (Acharya, 1980), but uncontrolled breeding is common under widely prevalent extensive grazing situation. There is an urgent need for conservation and propagation programs. The best milch breeds. Tharparkar and Rathi of cattle, Jakharana, Beetal and Jamunapari breeds

of goat, and Malpura, Chokla and Jaisalmeri breeds of sheep are at the risk of extinction (Nivsarkar, 2000). There is immediate need for breeding/preservation policies to save the existing germplasm. *Ex-situ* preservation of genetic material in the form of cryogenic preservation of semen, embryos, ova and DNA and *in-situ* preservation of live animals may be practiced in its natural environment (Joshi, 2000). Breeding of farm animals need to be based on marker-assisted selection for different traits. The advance reproduction technologies viz., embryo transfer, embryo sexing and sperm sexing, nuclear cloning transgenic animals, identification of fecundity gene and their use for improving prolificacy need be the part of genetic selection and breeding and would replace the conventional breeding methods in near future (Mishra and Prasad, 2005).

Increasing human population pressure, growth economic development is leading to growing demands for foods of animal origin, and environmental factors adversely affecting lands will require sustainable intensification of livestock production to meet increasing human demand. This can be achieved only when the livestock genetic resources are adapted to the prevailing production environment, where changes in the production circumstances occur steadily over time and the indigenous adapted livestock genetic resources possess better biological capacity to respond to such changing conditions. Where major production system changes are proposed to be introduced within short periods, superior genetic resources from elsewhere in the country or from similar production environments of other countries will be required. For example, with much improved genetic evaluation and deployment, genetic material developed under high-input, low-stress, short life-cycle production environments of developed countries has made valuable contribution to expanding the higher input, 'softer' production environments of India.

Two main considerations will guide future activities: (i) the conservation of livestock genetic resources and maintenance of diversity, and (ii) substantial increases in rate and efficiency of livestock production. The current and future challenge is how to effectively generate increased output per unit of input from livestock sector without losing

genetic diversity and preventing environmental degradation.

In the climate change scenario when the blame game is played by developed nations to accuse the developing countries like India for higher methane generation due to higher livestock population reared under extensive system, there is a need to consider that the low and non-productive animal numbers be decreased and also considering future trends in demand and supply of livestock products and services, attention for genetic improvement will be required both for indigenous and exotic breeds. There are some indigenous breeds which are genetically endowed with low methane production. These breeds need to be identified and used in breeding programs. Although there is need to utilize between-breed genetic differences through crossbreeding for higher yields, greater emphasis is required on improvement of adapted indigenous breeds/types because of valuable adaptive traits they have developed over long period through natural selection.

Nutritional considerations during climate change situations

In both extensive and intensive system of animal production, feed remains to be one of the important factors deciding the economics of production system. Changes in the temperature and water availability in the affected area due to climate variability have significant impact on vegetation and agriculture productivity which ultimately affect feed and fodder availability. Therefore the following measures to expanding feed resource base and intensification of production systems remain key areas for increasing livestock productivity.

Protection and development measures for rangeland resources: The rangelands are and will remain to be the major source of feed for the livestock because traditionally the extensive rearing system is being followed in dry lands. But the community rangeland, particularly in critical semi-arid and arid environments, is undergoing rapid and progressive degradation due to increasing grazing pressure and climate change factors like high temperature causing early maturity of local grasses, increasing population of non-palatable weeds and reduced top feed availability in the rangelands. Further the area under community grazing is

also shrinking due to rapid expansion of crop land to support growing human population. Under reforestation program, the plantation is mainly for soil conservation, fuel and timber wood, while the interests of poor livestock farming community for top feed resources are ignored. The rangeland resources of semi-arid and arid regions of Rajasthan have been extensively studied by ICAR institutes (CAZRI, CSWRI and IGRI) and SAUs located in the region.

Several management and biological options are available to rejuvenate rangelands and also to expand feed and fodder base like-protection and suspension of open grazing, bush cleaning, introduction of improved perennial grasses and pasture legumes in dry lands, intercultural operations and application of fertilizers and manure have improved biomass yield of the rangelands. Ahuja (1977) observed that natural succession of superior pasture vegetation is a slow process, hence reseeding with high yielding variety is essential and that the improvement in pasture yield due to protection was considerably higher in poor than other grades of pasture.

As the major fodder resources in the arid and semi-arid regions are forest areas, barren, uncultivated pasture lands, land under miscellaneous trees, crops and grooves, culturable waste and fallow lands, for continuous availability of fodder, re-vegetation with perennials is a better alternative. Some of the suitable perennials are:

Grasses: *Sehima nervosum*, *Chrysopogon fulvus*, *Heteropogon contortus*, Legume grasses, *Cenchrus ciliaris*, *C. setigerus*, *Panicum antidotale*, *Dichanthium annulatum*, *Panicum maximum*, *Pennisetum pedicellatum* *Alyosia scarabaeoides*, *Stylosanthes hamata*, *S. scabra*, *S. seabrana* *Macroptilum atropurpureum*

Shrubs/trees: *Dichrostachys cinerea*, *Ziziphus numularia*, *Anogeissus latifolia*, *Anogeissus pendula*, *Leucaena leucocephala*, *Azadirachta indica*, *Acacia tortilis*, *Hardwickia binata*, *Albizia species*, *D. sissoo*, *Acacia species*, *Alanthus excelsa*, *Acacia nilotica*.

Introduction of *Clitoria ternatea* with grasses in silvopasture system improved the biomass and protein yield in combination of *Cenchrus* + *Subabul* + *Clitoria*. Introduction of legumes

as a nurse crop in the natural system is also one of the best options for degraded lands for reducing the soil erosion and improving the fertility status of the soil.

Use of proven traditional agro-forestry systems for feed security: Dry land farmers have been following agro-forestry since centuries. Farmers in arid region in India encourage growing *Prosopis cineraria* (khejri), *ber* and *babool* trees in the crop fields. There is a common belief that crop productivity increases in association with khejri trees and in addition it provides a good feed for small and large animal production system. In a survey on agro-forestry systems, Gupta and Sharma (1989) observed lower density of khejri in the range of 30-40 trees ha⁻¹ in Jodhpur, and Nagaur, having an average annual rainfall of 300-500 mm, but in regions with a rainfall of 450 mm in Sikar region the density of khejri increased to as high as 104 trees ha⁻¹. Pearl millet, mung bean, moth bean, clusterbean and sesame crops are mainly grown in association with trees in these regions and their straws are best feed resources.

As khejri is slow growing, the availability of fodder and fuel from this tree takes a long time. There are other multipurpose trees, which have compatibility with crops and grasses in arid regions and can provide early returns. Tree species like *Acacia nilotica*, *Acacia senegal*, *Tecomella undulata*, *Hardwickia binata* and *C. mopane* could be useful components for agroforestry systems in arid regions. Barring *Tecomella undulata* and *Acacia senegal* (which are slow growing, but have economic value), others are relatively fast growing and have fodder and fuel value and thus, could be used for agroforestry purpose. The seed yields of mung bean and clusterbean crops grown under eight-year-old unlopped *Holoptelia integrifolia* trees were lower than those of crops in the open field, but were at par when the trees were lopped. *Prosopis cineraria* did not affect the crop yields (Shankarnarayan *et al.*, 1985). In semi-arid zones *Ailanthus excelsa* is being planted extensively on farm boundary and even with crops due to easy marketability of foliage for its fodder and wood for industry. The traditional practices of lopping the tree leaves as fodder for small ruminants and also their storing with cereal straw and grasses serve as traditional feed/fodder banks during droughts and famine when feed supply is scarce.

Use of agri-horticulture systems for more fodder/feed production: *Ziziphus rotundifolia* is an important fruit tree of the dry and arid areas. *Z. nummularia* (Jhar ber) grows naturally at the farmers' fields and does not compete with the crops. However, budded ber (*Z. mauritiana*) has also been found to grow very well under arid conditions when planted either with water harvesting system or with supplemental irrigation. This system, however, is generally recommended for areas with rainfall more than 250-300 mm. Like *P. cineraria*, *Ziziphus nummularia* is another important top feed species. Even in drought years when the crops fail, the top feed of this species comes to the rescue of livestock. In recent past the intensive use of tractor has wiped out this deep rooted bush from the farm field. The results of studies in sandy rangelands at Samdari (Western Rajasthan) have shown that plantation of two jujube species, viz. *Ziziphus rotundifolia* and *Z. nummularia* each with *Cenchrus ciliaris* as pasture grass gave forage yield varying from 624 kg to 844 kg ha⁻¹ in different treatments (Sharma and Vashishta, 1985). Different densities of jujube in the pasture, had no significant effect on the yield of pasture indicating that even 280 trees ha⁻¹ can safely be planted. *Z. nummularia* started providing top feed and brush wood after 4 years.

Establishment of silvo-pastures; An assured method for feed security: To rehabilitate the degraded lands silvo-pasture development is the viable option for meeting the fodder and fuelwood needs by rural masses and conservation of natural resources. Silvo-pastoral system is suitable for the management of degraded and rangeland, as this is a low input technology (Deb Roy and Pathak, 1974, 1984). The establishment of silvi-pastoral system on rangelands not only improves the soil health and microclimate, but also provides forage.

Leucaena, Acacia, Albizia, Hardwickia and Dalbergia; Cenchrus, Panicum, Sehima, Dichanthium, Bothriochloa and Heteropogon and Stylo and Siratro are the most suitable trees, grasses and legume species for silvipasture on degraded lands in the central India. The nurse crop technology has shown that adapted legumes like *Stylosanthes hamata*, besides producing the nutritious forage, can also improve growth and production of trees and grasses due to their synergistic effects.

Grasses like *Panicum maximum* have shown high adaptability to shade and maintained high carbohydrate and crude protein levels, indicating potential to optimize quality forage to support the animal production (Pathak *et al.*, 1995).

Identification and use of alternate feed resources: Dry regions have many unconventional feed resources in the form of crop residues, weeds, by-products from agro-processing, etc. Some of these have been fed to livestock and found to reduce cost of feeding without any adverse effect on their health and productivity of livestock.

Tumba (*Citrullus colocynthis*) seed cake is a cheap feed resource for livestock in arid region. Tumba plant is an annual creeper, which grows abundantly in hot arid areas with minimum water. It grows and multiplies very fast during monsoon season and its fruits; tumba fruits are available in the month of October-November. Mature fruits are golden yellow in color, 10-12 cm in diameter. The taste of the fruit pulp is bitter. Tumba seeds are rich in fat, having up to 16% oil. Tumba seed cake (TSC), a by product of the oil extraction industry, is nutritionally rich as it contains 16 to 22% CP. Presently TSC is available in abundance in arid regions and is being wasted as a fuel for furnaces in factories. A simple practice of inclusion of 25% TSC in concentrate feed is found to lower the cost of animal feeding by 18% to 35% without any adverse effect on the production, general health and reproductive performance. In addition, it would result in the utilization of locally available non-conventional cheaper protein source, abridging the gap between demand and supply of the scarce protein, thus, appreciably benefiting the marginal farmers (Mathur *et al.*, 1989; 2000; Mathur 1996).

Salty shrub lani (*Salsola baryosma*) of arid region available at vegetative stage can be a good source of fodder. Shoots consist of mainly fleshy stem, since leaves are very minute, and are less than 5-7% of the total biomass. The fresh cut shoots of lani are palatable (Mathur *et al.*, 2007). Lana (*Haloxylon salicornicum*) salty weed available in the arid region produces seeds having 18.6% CP found to be good source of protein in the concentrate part of lactating cows replacing about 25% of the conventional sesamum cake.

Although feeding sole fresh *Colophospermum mopane* leaves to goats is not possible, but it can very well be fed as a part of complete rations at 35-40% of whole ration (Patil *et al.*, 2007). But it was observed that the palatability of dry *C. mopane* leaves was low and decreased with progress of feeding from 15 to 5% from 1st to 5th week and the traditional local *P. cineraria* leaves were better source of supplementation even in the dry form supporting the milk yield of goats (Mathur *et al.*, 2006b). Leaves of *Hardwickia binata* can be used as a supplement in goats and are available in plenty in the arid region having rainfall more than 300 mm. The study showed that the fresh leaves are palatable to goats and sole feeding supports the body weight gain of growing kids (Patil *et al.*, 2009). *Prosopis juliflora* (vilayati babool) pods powder (PJPP) can be used up to 35% in the concentrate of lactating goats with maintenance of milk production without any detrimental effect on health (Mathur *et al.*, 2003). Similarly *P. juliflora* pod husk can be used up to 50% level in the concentrate along with tumba (*Citrullus colocynthis*) seed cake as low cost ration in the sheep without any adverse effect on animal health (Mathur *et al.*, 2002). A new fodder source *Opuntia ficus indica*, a thorn-less cactus, introduced in Indian arid region was found to have the fodder value as a maintenance feed and reduced the water requirement if fed along with the dry roughages to goats, sheep and growing cattle. In addition its high mineral

content may reduce the mineral requirement. Similarly the monsoonal weeds available in the rocky and sandy habitat of arid region have a distinct relative preference index for grazing sheep and goats and it was studied to be in the order of (1) Kanti (*Tribulus terrestris*), (2) kagio (*Tetrapogon tenellus*), (3) santo (*Trianthema protulacastrum*), (4) lolaru (*Digeria muricata*) (5) bekario (*Indigofera cordifolia*), and (6) gangan (*Grewia tanax*) for varieties tested in the region (Patil *et al.*, 2007).

Top feed resources: Top feed resources have greater significance in semi-arid and arid regions of the country particularly for sheep and goats. The top feeds are fed in the field as green forage after lopping, or the harvested foliage is conserved after drying for lean season. The farmers of the region have realized the importance of top feed resources, which have been imbibed in their religious/cultural day-to-day interactions. The tree foliage are rich in CP and low in fibre component. Bhatia (1983) reported that the CP and fiber component of top feeds of the region ranged from 10-12 and 10-13% while in some plants these are reported to be as high as 24 and 32%, respectively. The top feed resources are rich in tannins that adversely affect protein utilization. The farmers with their wisdom and experience have been using the top feed resources as supplements, thereby restricting the total tannin content of the diet to less than 3%, which the ruminants can tolerate. This practice has now been validated to be efficient method to reduce the methanogenesis and control global warming. The fodder trees suitable for different agro-climatic conditions of the country have been detailed by Patil *et al.* (1983). It is estimated that the full-grown tree on an average yields 25 kg dry fodder in annual lopping. Hocking (1993) listed common arid and semi-arid trees as a source of leaves and pods in Rajasthan (Table 1).

Policy decisions for meeting the challenge of drought through establishment of feed and fodder bank: With recurrent nature of drought in the dry regions the fodder production technology alone cannot meet the challenge. The concept of fodder banks, which includes bailing; densification, storing and transport of fodder to cater the needs during lean period need to be implemented with involvement of farmers in a participatory mode. The area wise surplus feeds, fodders, agro-industrial

Table 1. Some promising tree resources of arid and semi-arid regions (Hocking, 1993)

Botanical name	Common name	Dry fodder yield (kg tree ⁻¹)
<i>Acacia nilotica</i>	Babool	10 kg leaf, 12 kg pod
<i>Acacia senegal</i>	Kheri	3.0
<i>Acacia tortilis</i>	Israeli babool	40 kg
<i>Ailanthus exce/sa</i>	Ardu	150-200 kg
<i>Albizia lebbek</i>	Siras	15 kg
<i>Azadirachta indica</i>	Neem	40-60 kg
<i>Colophosphemum mopane</i>	Mopane	2.5 kg
<i>Dichrostachys nutan</i>	Dichros	2.6
<i>Ficus bengalensis</i>	Bargad	80-120 kg
<i>Ficus religiosa</i>	Pipal	60-100 kg
<i>Prosopis cineraria</i>	Khejri	12.0
<i>Gymnosporia spinosa</i>	Kakera	4.5
<i>Bauhinia racemosa</i>	Zinja	6.7

feeds during better or flush season need be used and processed as either supplementary or complete feeds and such feed banks need to be created for it is possible to use it in feed scarcity periods to sustain productivity of small or large livestock.

Fodder bank could be ultimate solution and contingent plan to meet the fodder demand during the lean period, particularly during drought and floods. The following types of feeds and fodder can be stored for meeting the above emergencies:

- Feed bank from ingredients not fit for human consumption.
- Grasses from periphery of forest area, wastelands and farmlands may be harvested and stored as hay in briquettes and high density stacks.
- Crop residues like stover are more important for this purpose. The coarse cereals, legumes, haulms left after removing grains should also be stored in these banks.
- Government should provide support to farmers for making stacks, briquettes and bailing and storage by Mechanized Bailing Machines, developed at IARI, IGRI, CIAE, BAIF & ANGRAU. This should be regular program to meet the fodder needs during extreme winters and snow covered seasons.
- The chief sources of essential amino acids, vitamins, minerals and other animal feed grade should be manufactured inadequate quantities, stored and their use may be promoted during the deficit period. Stylo leaf meal, stylo feed block, lucerne leaf meal and *Leucaena* leaf meals, pala, leaf meal from *Prosopis* and *Ailanthus*, etc., are the emerging options to be promoted in the fodder bank to replace the costly concentrates and meet the challenge of drought.
- There should be “Bhandaran Yojna” for storing feed and fodder at divisional level to encourage needy farmers having organized dairy and livestock enterprises.

Biomass conversion/conservation and storage: Due to the availability of high-fodder-yielding varieties of annual and perennial fodder crops, enough fodder is available during the peak growth periods and during scarcity in other

periods. The best way to regulate the supply of palatable and nutritious fodder during the lean periods of October and November, and May to July is to conserve the surplus fodder in the form of hay and silage. Similarly during monsoon period the green and dry biomass is abundant in pasture lands and there is scarcity in the post monsoon and in summer seasons. Thus it is essential that surplus fodder should be conserved during the period of excess growth, in the form of hay, silage, etc., especially in the drought-prone areas where crop failures are frequent.

Improvement of nutritional quality of crop residues: Large livestock population depends on crop residues of the cereal or other grain crops. The chief sources of residues are paddy, wheat, barley, maize, sorghum, pearl millet and *ragi*. The stover of these crops are deficient in protein and some minerals, but are fairly rich in carbohydrates.

The quality of the straws of *jowar*, *ragi*, wheat, paddy, and pearl millet, and that of sugarcane trash is also improved by treating them with urea alone (3-4%) or a mixture of urea (1-2%), molasses (10-15%), salt (2%) and mineral mixture (1%). After chaffing the dry straw into fine pieces, urea, salt and mineral mixture are mixed with the chaffed material and later sprayed with molasses and mixed thoroughly before feeding, which either can be fed fresh after treatment or later once it is stored scientifically as detailed in urea treatment process of straws. The improved nutritional quality of fodder can be beneficial for the livestock lacking in the protein and energy nutrients as these treatments improve the nutrient utilization. Similar treatment to produce haylage in dry areas is also found beneficial.

Complete feeds as blocks (CFBs) or total mixed ration (TMR) during droughts: Complete feed is a system of feeding concentrates and roughages blended together with all dietary essentials. This system of feeding has reduced labor cost and helped in maintenance of uniform roughage concentrate ratio, uniform feed intake favoring uniform supply of nutrients and maintenance of rumen environment. This system of feeding is well suited to our country particularly for dry arid and semi-arid areas as it helps utilizing locally available crop residues, agro-

industrial by products and nonconventional feeds. Complete feed supplies readymade, balanced, low cost ration for ruminants for the benefit of landless laborers and small farmers. The most common complete feed blocks (CFB) can be promoted at large scale on the CFBs were found to be nutritious, and handy to transport. In arid region the blocks made of proportionate mixture of local feeds like pearl millet grains, wheat bran, rice bran, tumba seed cake, mustard cake, guar korma, 1-2% urea, molasses, minerals and salt along with the local roughage source of grass - *C. ciliaris* and top feed-loong (*P. cineraria* leaves) were used in weaner kids found to provide marketable body weights at 9-month-age and were found to be economical (Patil *et al.*, 2006). The CFBs can be used during famine and flood situations due to easy transport. Agriculture ministry is presently giving 25% subsidy (maximum up to 25 lakh) for starting CFB making plant.

For making CFBs Chopped crop residue is mixed thoroughly with other concentrate ingredients. One of the ingredients should be molasses as it helps in better block making and also acts as a binder. Molasses could be avoided along with leguminous fodders, as these fodders have inherent qualities of blocking under pressure. Pressure application appears to be most critical factor in process of block making. The block texture and compactness improved progressively with increasing pressure. A force of 15 to 20 tons (15 mpa) was considered satisfactory. The moisture content higher than 13% resulted in loose blocks. The alkali treated straw blocks were more compact (340-470 kg m⁻³) than from untreated (280-370 kg m⁻³) straw.

The blocks of complete feed can be replaced with feed pellets, which have been found to be better as far as feed utilization is concerned. The feed wastage is reduced to less than 2% in large ruminants and it is better than the CFBs as the feed choice and selection by animals is avoided resulting in better intake and utilization of various feeds of unconventional nature as a part of complete feeds, which helps in economizing the feed cost. The feed banks with pelleted complete feeds could help in reducing the transport cost and also economizing the feeding cost of animals if the local feeds are selected and processed and the complete feed pellets at village level are prepared on a community

basis. The complete feed plant as managed at Harsolav, Distt. Nagaur under NRAA supported program can be used as model for such activities of community involvement for feed security measures.

Precision feeding for improving productivity of livestock in arid regions: Arid and dry region livestock, although seem to be low producing due to its traditional system of rearing, which remains extensive with use of very little or no inputs for improving productivity, but there remains scope to use technologies of precision feeding like region-specific feeding plan for the livestock targeting optimum nutrition for better productivity. In this regard there is need to study the livestock production systems in different areas, assess the productivity level of livestock, study the factors impacting livestock productivity like climate change affecting feed fodder availability, survey the disease scenario and plan suitable management interventions needed on short and long term basis to take care of productivity and production losses. The approach of precision feeding to productive livestock can be planned for livestock reared in extensive, semi-intensive and intensive systems depending upon the goal of production. The approach could be to have assessment of various feed, fodder resource available, planning their integration and use in complete or supplementary feeds. In case livestock has inadequate feed supply from rangelands the policy of supplementary feeding need be developed and practiced for which depending on the assessment of critical nutrient requirement, supplementary feeding plan can be developed on an area basis and the formulations like urea molasses mineral blocks, urea treatment or supplementation with sources of energy/protein/mineral individually or in combination can be developed and used for large and small ruminants. The approaches of using UMMB for large livestock and UMM mixtures for small ruminants have been developed and tested in field situations under Farmer's Participatory Action Research Program at CAZRI. Such feed supplementation programs, however, need critical evaluation of animal production system with knowledge of feeding status of the animals and economical feeds available locally, which need be advised to take care of productivity or health related issues.

Many complete feed rations have been formulated area-wise as per availability of various farm residues like straw, fallen tree leaves, by-products from other crops like cotton seeds, maize, groundnut, subabul, forest goods like dry grass, pods and some by-products from agro-industries. The complete feeds have been tested in several experiments on small ruminants to find that there is an increased DM intake and improved nutritive value supporting the growth rate of 58-92 g day⁻¹ with optimum levels of various residues (Patil, 2006).

Under an All India Coordinated Project to improve the growth rate of Indian sheep and goats for the mutton production, it was aimed to achieve 30 kg finishing weight by 6 months of age with about 20% feed conservation efficiency. The project stationed at Avikanagar and in Andhra Pradesh involved use of native and cross-bred sheep germ-plasm. The results at Avikanagar under intensive feeding on 50:50 roughage and concentrate ratios of complete feed indicated that the desired body weight could be achieved, but the feed efficiency was higher than 20% because of higher carcass fats. In this study, the cross-bred weaner lambs maintained on these diets had higher ADG (180 g) compared to 127 ADG in native lambs. Continuation of the work with Malpura (M) and Sonadi (S) and crosses of Malpura and Sonadi (MS) also indicated that the crosses had higher ADG. Since intensive feeding of lambs was associated with higher deposition of carcass fats and with higher feed requirement (FCR - > than 20%), the reduction of weaning age from 90 to 60 days with intensive feeding resulted in gain of 160 and 151 g ADG and 16 and 12% feed efficiency in lambs weaned at 60 days than 139 and 146 g ADG and 16 and 14% feed efficiency for lambs weaned at 90 days. Subsequent studies indicated that 25 kg finishing weight could be achieved in 73, 91 and 136 days of intensive feeding with 160, 135 and 112 g ADG and 18, 16 and 14% feed efficiency, respectively, in MS, M selected and M control lambs (Karim, 2004). In another study the lambs fed intensively on 50:50 RC based complete feed attained 33.5 kg finishing weight with 11% feed efficiency at 6 months of age (Shinde *et al.*, 1996). In a study conducted on Marwari kids, Patil *et al.* (2006) observed that the kids weaned at 2-month age had comparatively better growth

rate than the kids weaned at 3 and 4-month age when these were fed on complete feed diets (CFB) having roughage to concentrate ratio 30:70 utilizing local concentrates and *P. cineraria* leaves and masoor straw in equal proportion as a roughage source. The average weights achieved at 9-month age were 17.30, 17.64 and 17.34 kg in the kids weaned at 2, 3 and 4-month age, respectively, and fed with CFB. The efficiency of feed conversion was 9.03, 9.66 and 9.83 kg per kg body weight gain. The cost of feeding was economical for kids reared on CFB after weaning at 2-month age (Rs. 65.37 per kg) as compared to those weaned at 3 months (Rs. 70.40 per kg) and at 4 months (Rs. 71.27 per kg). Similarly in the intensive management system the Marwari kids fed on CFB along with goat paneer whey gained higher body weight than the kids fed on CFB only.

The results of the above study indicate that small ruminants-goat and sheep can be reared intensively without sending the animals for grazing and these can achieve the targeted body weights during minimum possible time. It also helps to achieve the gainful use of crop residues and locally available agro-industrial byproducts by formulating and processing complete rations. Similarly the new concepts of nutritional enhancers of improving DM intake, improvement of live body weight and efficiency of nutrient utilization can be incorporated in the intensive feeding system for the commercial benefit of meat production. The feed security measures thus mentioned above can be practiced to ensure availability of fodder source for most of productive stage of animal's life.

Assurance of Appropriate Market Realization of Animals and their Produce

The existing animal production system in the arid and semi-arid regions, although provides economic sustenance to the marginal and landless laborers in the drought situations, still the system is not remunerative due to poor market structure and exploitation of the producer by the middlemen. There is need for organized marketing of sheep and goat products. Further the efforts made at the institutional level regarding preparation and marketing of edible products from low value

goat, sheep milk/meat at CAZRI, CIRG, CSWRI need promotion at the farmers level so that the whole animal production system becomes profitable. The goat milk products-like paneer and kulfi have been found to be very delicious and profit earning in the arid region (Khan *et al.*, 2005) and need wider propagation. Similarly from the large ruminant and camel production systems additional advantages need be exploited as by default these are organic production systems due to feeds and feeding practices followed and also the functional food value of the products like milk from these species be convinced to the consumers and accordingly the products be valued higher and for it appropriate robust marketing and programs of scientific validity of value added products be undertaken.

Management of Harsh Climatic Factors for Improvement of Livestock Productivity

In order to protect livestock from extreme summer and winter stress situations the modified housing system developed, using local available materials, provide protection and improve productivity. The low cost housing with east-west orientation with long axis on north side more open and south side having less open side, helps controlling temperature stress and ultimately benefitting livestock and helps in increasing milk yield, and growth in small and large animal production systems as evident in experiments conducted at CAZRI, CSWRI, NRCC. These may be implemented for managing the climatic stress factors in field situations. Similarly underground shelters are practiced for managing cold and summer stress need be convinced and taken to farmers who are interested in semi-intensive or intensive type of management of livestock in the arid region.

Management of Disease Conditions in the Livestock

With climate change involving changes in temperature and rainfall there is increase in the incidence of bacterial, viral, parasitic and fungal diseases due to favorable conditions arising in the dry lands for the growth of organisms in particular as well as increase in disease spreading vectors. Therefore various disease controlling measures need be evolved and practiced so as to protect the precious

livestock of dry lands. The management measures include timely diagnosis, appropriate treatment of ailing livestock and taking preventive steps to control spread of diseases and avoid exposure of healthy livestock through vaccination and other management programs.

Management of Methane Gas Emission from Livestock

The dry lands holding about two-third of the livestock population of the country need to be thought for large quantity of methane production emanating from these animals as the animals are maintained mostly on feeding systems dominated by straws, stovers or other fibrous byproducts and its control is also necessary as methane remain main GHG to have potential 23% higher than CO₂ for global warming. There are some proven technologies of reducing methane production like management of diets--by addition of low CH₄ producing feeds or CH₄ reducing substances like tannins, secondary plant metabolites, feed antibiotics, some inorganic compounds in diets, improving digestibility quality of feeds or using rumen modifiers like acetogens, methanogen inhibitors--HMG-S-CoA etc. However all these technologies need to be standardized for practicing in the field situations and the technologies already being practiced traditionally in arid region with use of tree leaves as part of composite diets need to be seen practicable method of reducing methane emission from enteric fermentation. The techniques like lopping of tree leaves and their feeding to small ruminants may be an effective policy to reduce and control CH₄ in field situations and use of dried lopped tree leaves need be promoted to other regions as a dilution method to reduce CH₄ emissions.

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