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Challenges and opportunities of livestock development in Hot Arid Zone of India

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ABSTRACT

Arid regions constitute 12% of total geographical area of India ranging from cold arid areas in northern parts to hot arid areas in western and southern parts of country. Climatic stresses (drought, extreme temperatures, sand blasting), edaphic factors (sandy soil with low organic carbon content and poor water holding capacity), and relatively higher biotic pressure (human and livestock population) in these areas are major contributing factors to degradation of natural resources and lower productivity resulting in greater risk of farming per se. The farming systems in hot arid zone are quite diverse with a variety of crops and cropping systems, agroforestry and livestock. Livestock production is an important component in arid zone, as it is considered an instrument to socio-economic change to improved income and quality of life with equity. The sustainable development in arid zone can only be achieved through optimum utilization of its natural resources. Though technologies to improve livestock productivity do exist, however, the awareness and rate of adoption of technologies in arid production systems is consistently low, because of the existing research and extension set up and related other constraints. There is tremendous scope of increasing livestock productivity of indigenous breeds by improving nutrient availability from locally available feed and fodder resources. The long term sustainability and profitability of livestock production system depends largely on how efficiently the farmer manages his limited resources. The paper discusses the status of livestock production systems in hot arid zone of India, contribution to farmer's livelihood, challenges and future strategies to make livestock farming in arid regions more profitable and resilient to climatic stress.

Arid regions cover about 12% geographical area of India, comprising of 31.7 m ha hot arid and 7.0 m ha cold arid region. Nearly 90% of hot arid region of India lies in northwestern states of Rajasthan (19.6 m ha), Gujarat (6.22 m ha), and Haryana and Punjab (2.75 m ha). Some small pockets (3.13 m ha) of hot arid zone are in southern states of Andhra Pradesh, Maharashtra and Karnataka. The arid region of northwest India constitutes the major part of the Great Indian Desert or the Thar Desert. About 85% of the Thar Desert lies in northwest India and the remaining part is in southeast Pakistan. The Thar Desert accounts for 89.6% of the total hot arid regions of India[11].

The climate of hot arid regions is characterized by low and erratic rainfall, high potential evapotranspiration, wide diurnal and annual temperature range, high solar radiation, low relative humidity and high wind velocity. The annual rainfall ranges from about 100 mm in extreme west to 500 mm in the east and southeast side[32], while the potential evapotranspiration is about 1650 mm in the east which increases to over 2000 mm in the west. The coefficient of variation of annual rainfall varies from 35% in the east to 65% in the west. Most of the rainfall (80-85%) is received during the southwest monsoon season (June-September) of the Indian sub-continent. However, monsoon rains start in the first week of July and usually withdraw by September beginning in the hot arid zone of northwest India. The region experiences extremes of temperatures. Air temperature increases sharply from April and peaks during May to mid-June. Maximum temperatures

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during summer season vary from 36 to 43°C in the eastern and 39 to 45°C in the western parts but occasionally may reach up to 50°C. During winter season, the maximum air temperature varies from 24°C in the east to about 26°C in the west. Sub-zero temperature is not uncommon and minimum temperature during winter may be as low as -5°C in sandy terrains. Soil temperature fluctuations reflect the diurnal and annual cycles of the air temperature.

FARMING SYSTEMS IN HOT ARID ZONE OF INDIA

The farming systems in arid zone are quite diverse with a variety of crops and cropping systems, agroforestry, and livestock production. The changes in the quantity of rainfall received and its distribution pattern are leading to intermittent droughts during the crop period resulting in crop failures leading to debts and migration. Droughts occur once in 3 to 5 years either due to a deficit in seasonal rainfall during the main cropping season or from inadequate soil moisture availability during the prolonged dry spells between successive rainfall events[37].

Several farming systems involving trees, fruits, grasses and crops have been studied by CAZRI for their suitability in arid agro-ecosystem and compatibility of selected farming system components in agroforestry, silvi-pasture, agri-silvi-pasture, agri-horticulture, horti-pastoral systems. Feed resources provide a direct link between crops and animals and the interaction between the two largely dictates the development of such systems. It has been observed that the areas falling in <250 mm rainfall zone have predominance of grasses and shrubs (Figure1); hence range/pasture development with livestock rearing is the major proposition for such areas. Areas in 250-350 mm rainfall zone are suitable for agroforestry and mixed farming; while areas receiving more than 300 mm rainfall are suitable for agroforestry, arable crops, crop diversification and livestock rearing. The crop productivity is low mainly due to aberrant weather conditions and poor soil fertility. Livestock gives much more stable income than crop farming since the possibility of out-migrating avoids localized scarcity conditions, making it much more adapted to uncertain and erratic climatic conditions. Even in terms of rentability of investment, livestock farming surpasses crop farming. In general, pastoralism is predominant practice in arid regions and arable farming receives less importance with few exceptions[13]. With the increase in aridity fromirrigated tract to dry farming to pastoral, the households owning sheep, goats, and camels have increased. In spite of frequent droughts and famines, there is an increasing tendency among the farmers to keep large number of animals as walking capital.

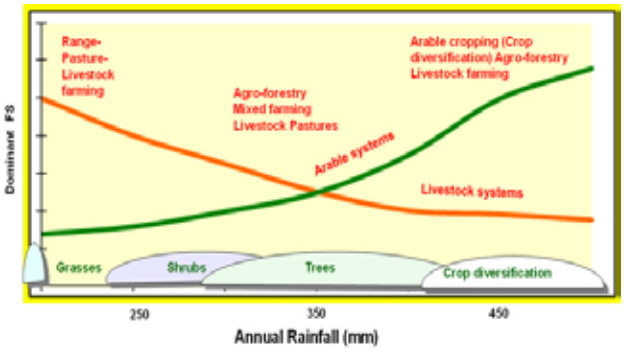

Figure1. Predominant farming systems vis-à-vis annual rainfall

LIVESTOCK RESOURCES

The diversity of livestock resources in arid areas is very wide, both in variety and variability in terms of species, breeds, populations and unique genotypes. This diversity has been recognized as a vital resource for sustenance of mankind. Judicious utilization and enhancement of the quality of these resources is important to ensure their sustainability to meet future demands. The nature has endowed arid areas with some of the best breeds of cattle, sheep, goats and other species of livestock (Table 1). Livestock breeds in the region have been developed and owned by local people over many generations and are the product of local knowledge about animal breeding. Indigenous breedsof arid environment are not only heat tolerant but are able to survive, grow and reproduce even with poor seasonal nutrition, high parasite and disease pressure[21].

Table 1. Livestock breeds of arid zone

Cattle	Tharparkar, Rathi, Kankrej, Red Sindhi, Nagouri
Goats	Marwari, Sirohi/Parbatsari, Jhakarana, Kachehhi
Sheep	Marwari, Magra, Nali, Pugal, Chokla, Jaisalmerti, Kheri, Patanwadi
Buffaloes	Graded Murrah, Surti, Mehsana, Banni
Camels	Bikaneri, Jaiselmeri, Kuchchi and Mewati and lesser known breeds Marwadi, Mewadi, Sindhi, Shekawati
Horses	Marwari (Malani), Kathiawad, Bikaneri, Jaiselmeri

More than half (57.73%) of total livestock population of Rajasthan inhabits in the arid district of the state (Table 2).The larger number of small ruminants is present in the arid districts. The ratio of livestock and human is equal in the western arid parts and is about 0.8 in the semi-arid parts of Rajasthan. The number of livestock in the arid zone increased by 41 % between 1951 and 1961 and by 15 % between 1995 and 2012. The density of livestock increased from 50 animal per 100 hectares of grazing land in 1951-52 to 154 during 2012.

Table 2. Livestock population of arid and non-arid districts of Rajasthan (in millions)

Zone	1956	1961	1966	1972	1977	1983	1988	1992	1997	2003	2007	2012
Total Livestock												
Rajasthan	32.43	33.51	37.48	38.88	41.36	49.65	40.92	48.45	54.35	49.45	56.66	57.73
Arid	13.40	13.72	16.21	16.29	19.02	23.35	17.76	23.18	28.57	21.93	29.11	30.18
Non-Arid	19.02	19.79	21.27	22.59	22.34	26.30	23.15	25.27	25.77	27.14	27.55	27.55
Cattle												
Rajasthan	12.07	13.14	13.12	12.47	12.90	13.50	10.92	11.67	12.16	10.85	12.12	13.32
Arid	3.92	4.38	4.69	3.48	4.03	4.57	3.39	3.91	4.96	4.12	5.05	6.18
Non-Arid	8.15	8.76	8.43	8.99	8.86	8.93	7.53	7.75	7.20	6.74	7.06	7.14
Buffaloes												
Rajasthan	3.44	4.02	4.22	4.59	5.07	6.04	6.34	7.78	9.76	10.45	11.09	12.98
Arid	0.77	0.97	1.06	1.11	1.38	1.76	1.76	2.30	3.16	3.20	3.45	3.95
Non-Arid	2.67	3.05	3.17	3.48	3.69	4.28	4.58	5.48	6.60	7.24	7.64	9.03
Sheep												
Rajasthan	7.37	7.36	8.81	8.56	9.94	13.43	9.93	12.49	14.31	10.03	11.19	9.08
Arid	4.75	4.35	5.54	5.16	6.68	8.77	6.48	8.36	10.49	5.76	8.43	6.88
Non-Arid	2.62	3.01	3.27	3.40	3.26	4.66	3.45	4.13	3.82	4.27	2.76	2.20
Goat												
Rajasthan	8.73	8.05	10.32	12.16	12.31	15.48	12.58	15.28	16.94	16.80	21.50	21.79
Arid	3.49	3.43	4.26	5.81	6.17	7.44	5.42	7.83	9.53	8.37	11.70	12.79
Non-Arid	5.24	4.62	6.07	6.35	6.13	8.04	7.16	7.46	7.41	8.44	9.80	8.88
Camel												
Rajasthan	0.44	0.57	0.65	0.75	0.75	0.76	0.72	0.75	0.75	0.50	0.42	0.32
Arid	0.36	0.48	0.56	0.63	0.64	0.64	0.57	0.60	0.53	0.40	0.35	0.28
Non-Arid	0.07	0.10	0.10	0.12	0.11	0.12	0.15	0.15	0.21	0.10	0.07	0.04

LIVESTOCK AND LIVELIHOODS

Crop production is risky in arid area due to erratic and low rainfall; therefore, livestock rearing became a major occupation for the livelihood of the rural people. Despite limitations of an arid environment, there is an increasing trend in the human and livestock population in the region. Between 1961 and 2011 census, human population has increased by > 250 % while between 1956 and 2012 census, the animal population has increased by about 125.2 %. The expanding market for livestock products offers an opportunity for the small farmers and even for those who do not have access to land and capital resources to augment their income and livelihood through livestock production.

Livestock is an important household's asset in arid zone that provides the basis for people's livelihoods[18, 31], and have crucial role in food security and as risk aversion mechanism for sustaining family, whenever there is crop failure[19]. More than 80% rural families keep livestock in their households. They enable poor and landless farmers to earn income using common-property resources, and provide a constant flow of income and reduce the vulnerability of agricultural production system. Households' asset endowments are constantly changing, influenced by 'external' factors such as markets, government programmes or natural disasters, etc. Those with more assets tend to have a greater range of options and a buffer to secure their livelihoods. The different livestock may have multiple livelihood functions[4], and the relative importance of these factors varies according to peoples livelihood and livestock production systems (Table-3). There are three major categories of livestock-keepers in arid zones of India:

- ***Labour-pastoralists*** (the landless or near-landless who depend mainly on wage labour, but keep a few animals); and
- ***Agro-pastoralists*** (large, small and marginal farmers who keep livestock as secondary income generating activity);
- ***Landless livestock-specialists*** (people with little or of no land for which livestock production is the main livelihood activity).

The economic importance of livestock within the production systems is considerable and is often underestimated. According to the Rajasthan state livestock policy document, in arid areas, the contribution of livestock is as high as 50% and goes up to two third of the total earning to the farmers' income during drought years[1]. This value increases with a shift from subsistence agriculture to the more open market economics, to include specialization and intensification of the production systems. For landless livestock specialists, livestock may be the principal livelihood activity and source of income. However, these people are heavily dependent on common grazing resources including farmers' field for grazing at certain times of the years. Agro-pastoralists, particularly small and marginal farmers are relatively more dependent on livestock than large farmers. This means that for them livestock are relatively more important as a source of planned income and as a buffer to poor crop yields. Large farmers are less dependent on common grazing resources, as they produce larger quantity of crop residues and also have large areas of private wastelands[4].

Table 3. Contribution of livestock in different livelihood systems

Type of Contribution	Landless livestock specialists (herds of 10-50 animals)		Labour pastoralists (keep 1-3 goats)	Agro-pastoralist	
				Small and marginal farmers	Large Farmers
	poor	Very poor			
Source of planed cash income	****	*	_____	**	**
Liquid asset	*	****	_____	*	_____

Agricultural inputs to owner's farm: Draught power and manure	_____	_____	_____	**	**
Utilization of other's land by poor	****	****	****	***	*
Diversification of risks/ buffer to crop yields	_____	_____	*	***	*
Source of food	*	*	*	**	*

* Importance is shown on a scale of 1-5

LIVESTOCK PRODUCTION SYSTEMS

Traditionally, the arid zone farmers have integrated their livestock with crop production. The livestock production systems are complex and generally based on traditional and socio-economic considerations, mainly guided by available feed resources. These traditional production systems are designed to be self-sufficient at the household level and are dependent on the low-cost agro-by-products as nutritional input to animals for producing quality food of high biological value. The general characteristics of livestock production of small farmers under village condition are:

- as a complement to crop production,
- utilization of marginal land and non-marketable farm products,
- utilization of readily available/surplus family labour,
- required minimal cash inputs as well as simple and traditional technology,
- non-market-oriented production,
- very low degree of economic risk.

The prevalent livestock production systems of arid zone of India can broadly be classified in to:

***Mixed crop-livestock production system (Agro-pastrolism)*:** The traditional, resource-driven and labour intensive ruminant production system (sheep, goat, cattle, buffalo, etc), which produces a multitude of services to subsistence farm. This kind of livestock production system is very common in rural areas and practiced by small and marginal farmers or landless people. Low technology uptake, insufficient market facilities and infrastructure and small economies of scale are common. Small farm animal rearing involves little external inputs such as feeds, medicines or breeding stock, and are relatively well adapted to the surroundings.

***Commercial livestock production system*:** The modern, demand-driven, and capital intensive system of livestock management, which is more relevant to poultry and to some extent dairy cattle and buffalo in cities and peri-urban areas. This system is very efficient and has good market access. Increasing intensification and concentration of animal increases pollution and disease risk to humans.

***Nomadism/Pastoralism*:** The large numbers of poor and vulnerable people live in drylands and practice livestock rearing as 'Nomadism/ Pastoralism' (migration of domestic animals) that allows livestock keepers to maintain their herds because of better fodder and water availability in neighbouring areas. Pastoralists, derive most of their livelihood from raising livestock on natural forages or crop residue, rather than on specifically cultivated and stored fodder or fenced pastures. They have developed traditional migration routes and a partition of responsibilities, with some castes specializing in animal herding and others in cropping. Over the centuries, herders also developed traditional knowledge of animal husbandry and natural resource management. This knowledge has allowed them to endure periodic severe droughts on their communally-managed rangelands[3,24]. Mobility is the crucial management practice which allows obtaining benefits from marginal environments, characterised by climatic variability, and low and variable biomass and water availability. The degree of mobility depends on flock/ herd size, and the location of the

family or village, as well as on the amount of fodder produced in a given year.

CHALLENGES TO LIVESTOCK DEVELOPMENT

The poor natural resource base of arid lands makes the people and livestock vulnerable to environmental stress and impacts livelihoods of people directly. Many factors affect livestock production in arid areas. Climatic environment is one of the main limiting factors of production efficiency in these areas. The feed supplies and nutrition are limited by spatial and seasonal variability of rainfall and is the major constraint to livestock productivity. Major nutritional stress occurs during dry months, when animals are depending almost entirely on poor quality roughages[16]. The other major concerns for low productivity of livestock are insufficient coverage of artificial insemination, low conception rates, non-availability of quality males for breeding, poor management practices, high mortality and morbidity losses due to diseases, inadequate marketing infrastructure and unorganized marketing, poor extension services and linkages with associated departments, inadequate credit facilities and weak institutional and policy support, besides adverse climatic conditions[21].

THE WAY FORWARDS: STRATEGIES FOR IMPROVING LIVESTOCK PRODUCTIVITY

An understanding of the production factors (livestock, capital, feed, land and labour) and processes (description, diagnosis, technology design, testing and extension) that affect livestock production is a pre-requisite for enhancing livestock productivity in arid zone. The livestock production tends to be more complex than crop production because livestock too often play a pivotal role in the overall farming system. Any constraint imposed on livestock may also restrict the system as a whole[19]. In general, the aims of livestock production in arid farming systems are, to:

- conserve the natural resource base;
- raise productivity through better utilization of available resources;
- expand production where there is a sufficient demand and resources can be utilized at reasonable cost to the environment
- optimize the allocation of development resources through rational management.

The selection and application of livestock production technologies should confirm with the framework of sustainability criteria, they should be ecologically sound, economically viable, socially acceptable and technically appropriate. It is of course never easy to find a technology that will meet all these requirements. However, the potentially important technologies that can make a significant increase in productivity both of crops and animals with in the system should be adopted, which consequently increase farmers income and total food supply to meet the demand of raising human population[19,24].

STRATEGIES TO INCREASE FODDER PRODUCTION

The system of forage production varies from region to region, farmer to farmer depending upon availability of resources and inputs. An ideal forage production system is one which gives the maximum output of digestible nutrient per unit area or maximum livestock productivity from unit area, and should ensure the availability of succulent, palatable and nutritious fodder throughout the year for livestock feeding[27]. The following approaches may be adopted[22,24].

Forage cropping systems /sequences

In drylands with uncertain rainfall intercropping or mixed cropping are widely practiced to reduce complete crop failure. The productivity of these lands can be raised through intercropping of short duration forage in long duration crops such as sorghum+ cowpea, sorghum + clusterbean, bajra +cowpea, bajra + clusterbeanetc. The all India Coordinated Research Project on Forage Crops has suggested the following forage production systems under dry land conditions (Table- 4)

Table 4. Forage production system under dry land conditions

Cropping Systems	Sowing Time	Forage Availability	Green Forage Yield (q/ha)
Jowar + Guar - Fallow	June-July	Sept.-Oct. (excess quantity	250
Bajra – Senje Japan rape	June-July October	Sept. Dec.-Jan.	350
Guar + Fallow	June-July	Sept.-Oct	200
Cerichrusciliaris	With the on-set of monsoon	throughout the year except winter	150
Cerichrusciliaris + *Siratro*	With the on-set of monsoon	Throughout the year except winter	100-150
Panicumantidotale + S. hamata	With the on-set of monsoon	Throughout the year except winter	100-150
Lasiurussindicus	With the on-set of monsoon	Throughout the year except winter	100-150

Food-fodder production systems

With the increasing demands of food as well as cash crops, increase in area under fodder crops is not possible. Hence the alternative is to increase the productivity of dual purpose crops which provide grain as well as fodder. Dual purpose cultivated crops like pearl millet, sorghum, barley and legumes contribute about 60-70 % of fodder availability in arid region[27]. Pearl millet, sorghum and guar are major dual purpose crops grown during kharif season and barley during rabi season. In most of the irrigated areas depending upon the water availability double or triple cropping is practiced. In such areas there is scope for growing short duration fodder crops during the fallow periods or in between two crops. The short season fodder crops like cowpea; guar can yield 20-25 t /ha of green fodder within 45-50 days, can be grown without affecting the main crops. Barley can be grown as food cum fodder crop by adopting the simple practice of harvesting the crop at 55 days after sowing for fodder and managing the ratoon for grain purpose. In case of maize it is possible to obtain both grain and fodder by sowing the crop at 30 cm spacing with 50 kg/ha seed rate and harvesting alternate rows at 50 days for fodder and allowing the remaining rows for grain[26] .

Restoration of Common Property Resources

Most of the community grazing resources (CGRs) is degraded. Local governing bodies of the villages need be involved in their improvement as the CGRs are common resources. Improvement of CGRs may involve adoption of soil and water conservation measures, sowing/planting of grasses, shrubs and trees and restriction on grazing during establishment stage. Once established properly, CGR may be subjected to continuous grazing or deferred grazing or rotational grazing or deferred and rotational grazing as per requirement and condition of CGR. In the arid grazing land situation, 22% increase in dry matter yield of Cenchrus celiaris was observed[7] under deferred rotational grazing compared to only 6.3% under continuous grazing. In a *Lasiurussindicus* dominated grassland in western Rajasthan, deferred rotational grazing gave higher body weight gains of heifers compared to continuous grazing system[7].

Livestock integration with agroforestry

In many situations, ruminant livestock are associated with ecological degradation and deforestation. There is no doubt that the inappropriate use of animals and poor management leads to many environmental problems. However, this does not necessarily have to be the case. If planned and managed properly, appropriate kinds of animals can be key components in sustainable farming systems[29]. Animals, when selected carefully for the right agroforestry system can carry out many of the maintenance functions through their normal behavior. Some products and services of agroforestry systems for animal husbandry are: favorable habitat; access to a diverse diet; access to medicinal plants and insects; natural population

densities[12]. The agroforestry systems relevant to livestock production in arid parts of India are: silvi-pastoral system, agri-silvi-pastoral system, and agri-horti-pastoral system[35,36,30]. Tree and grass species suitable for different land form and rainfall situations are presented in Table 5.

Table 5. Suitable species of grasses and trees on the basis of rainfall

Rainfall	Grasses	Legumes	Trees/shrubs
150 - 300 mm	*Lasiurussindicus, Cenchrusciliaris*	*Lablab purpureus, Clitoriaternatea*	*Prosopisjuliflora, Acaciatortilis Acacia Senegal, Zizyphusnummularia. Colligonumpolygonoides, Dichtrostahysnutans*
300 - 500 mm	*Lasiurussindicus, Cenchruscilaris, Cenchrussetigerus, Panicumantidotale*	*Lablab purpureus, Clitoriaternatea*	*Acacia. tortilis, A. nclotica, P. cineraria Tecomella undulate, Ziziphus spp. Colligonumpolygonoides. Azadirachtaindica H. binnata, Ailanthus exelsa, Albizialebbek, Colophospermummopone*
>500 mm	C.*cilaris, Dichanthium*annutatum, *Chrysopogonfulvus, sehimanervosum, panicumantidotale, HeteropogonContortus*	Stylosanthes *Atylosiascarabaeoides*	*Acacia nilotica, Acacia catechu DalbergiasissooLeucanaleucocephala, Albizia spp. AlianthusexcelsaHardwickiabinnata*

STRATEGIES TO ENHANCE FEED UTILIZATION

Scarcity of feed is one of the primary constraints to improve livestock production in arid lands. Livestock diets, usually dominated by crop residues and other low-quality feeds, require inclusion of more energy-rich feeds to increase productivity. Various feeding strategies have been tried to enhance the feed utilization with varying degrees of success. These could include the chopping, urea treatment, supplementation, use of multi-nutrient block, etc.

Chopping of fodder

Chopping of fodder should be popularized for judicious use at farm level. The advantages of feeding chaffed feed are that it avoids wastage and prevents selective consumption. Feeding of chopped roughage reduces the energy wasted while chewing, increases the feed intake and improves digestibility. The net biological value of the feed also improves.

Urea treatment of low-grade roughages

Low grade roughages such as paddy straw, wheat straw, sorghum stover, maize stover, dry grasses and other edible farm waste contain negligible amount of digestible crude protein and higher amount of non-digestible cell wall constituents. Through urea treatment, nutritional value of poor quality herbage could be improved and made more palatable. Four percent urea, 50 liters water per 100 kg straw/ herbage and 15 to 21 days incubation period are optimum for treatment. Urea treatment is quite flexible, as it can be adapted to local conditions. Urea treatment, apart from being a source of nitrogen for microbial synthesis, also provides additional energy due to the weakening/ loosening of the lingo-cellulose bonds in the treated straw. Treatment improves dry matter intake by 7 to 10 units and digestibility by 4 to 15 units[20]. For daily feeding required quantity of treated forage be removed from the heap and fed to the animals.

Strategic supplementation

A variety of supplements exist that can be used for feeding animals. These include oil meals and cakes as well as leguminous tree forages such as Leucaena and Gliricidia. Purchased concentrates (mainly energy and proteins) are expensive and their use can only be justified in relation to (i) scarcity or inadequacy of dietary nutrients for milk production (quantity and quality) (ii) restriction in energy uptake

imposed by bulky roughages (iii) relatively low price of alternative mixed feeds, home grown or purchased concentrates (iv) increased milk yield where monetary value is greater than the cost of the concentrates required to produce it.

Urea molasses mineral block (UMMB) commercially available and can be used to supplement the low quality roughages to balance the deficient nutrients in the ration. UMMB contains soluble and fermentable nitrogen from urea, highly fermentable energy from molasses, and essential minerals. Natural proteins sources such as groundnut or cottonseed extract have also been added to provide preformed peptides and amino acids. UMMB has been found to improve the dry matter intake of the basal roughage and the feed digestibility[23,23]. The nutrients from the block are well utilized by the animals and UMMB supplementation improves reproductive performance of livestock due to enhanced availability and utilization of nutrients, particularly micronutrients[27].

Under extreme climate conditions of Jaisalmer, maintaining grazing sheep exclusively on pasture of *Lasiuruss indicus* reduced animal production, which could be mitigated by adopting scientific feeding and health management practices[15]. Concentrate @ 200 g/animal/day and health care resulted in increase in live body weight and wool yield of sheep under same grazing condition. Inclusion of alternate feed resources in livestock feed could be a useful strategy to minimize nutritional stress during lean period. Feeding of cactus pear to livestock reduced their water requirement and increased nutrients digestibility without affecting health of the calves[14]. Similarly, feeding *Blepharisindica and Anabaena azollae*also holds promise to provide feed as well as water to animals during feed-scarce summer season[33]. Inclusion of *Prosopisjuliflora* pods in concentrate mixture or feed blocks improved the production and reproduction of animals during summer without any adverse effect on health[2,3].

Strategies to minimize effects of heat stress

The livestock employ behavioral changes complemented by physiological mechanisms to counter the heat stress. For example, buffaloes wallow during summer to reduce thermal load and maintain thermal equilibrium.The adverse effects of heat can be reduced by adopting simple and basic rules of animal shed design (shape, orientation and thermo-physical properties of construction material, ventilation, etc.). The environmental modifications attempt to reduce heat stress by reducing the solar radiation and temperature around the animal. The provision of shade (natural or artificial) is one of the simplest and cost-effective methods to minimize heat stress. Trees provide shade to animals and have cooling effect due to transpiration of water from their leaves. The silvi-pasture system or plantation of fodder trees in grazing area provides feed as well as shelter during summer[34]. Artificial shades have been used with success for heat-stressed animals in confinement or in intensive situations. Major design considerations like orientation, space, and height and roof construction must be taken into account for shade structures. East-west orientation is most suitable design of shed under hot arid condition[2].

Water management

Water is an essential nutrient for livestock animals, especially during a thermal stress. Water intake during heat stress is a limiting factor for survival and performance, as water has a fundamental role in the heat exchange system for temperature regulation and maintenance of hydration balance. The response of increased temperatures on water demand by livestock is well-known. For *Bosindicus*, for example, water intake increases from about 3 kg per kg DM intake at 10°C ambient temperature, to 5 kg at 30°C, and to about 10 kg at 35°C[25]. In hot conditions, water losses increase (evaporation by panting and sweating) and water ingested in feed and generated by metabolism is reduced. Consequently, drinking water consumption has to increase to cover the requirements of a heat-stressed animal.

In warm climate, a key husbandry practice is to provide an abundant and clean source of drinking water close to the feeding area. Studies have demonstrated that a provision of cool water would improve animal performance through absorbed heat energy. The average water intake of Tharparkar

cattle was 49.1 and 52.9 litre/day for stall fed and grazing animals which was lower than the Rathi cattle (58.2 and 59.4 litres/day). In dry regions an increased need of drinking water, as a consequence of prolonged exposure to high environmental temperature, is often coincident with a reduction of water availability and forage water content and quality. The sheep and goats can be watered on alternate days without any serious effect and rather with some improvement in nutrient digestibility and wool production[38,17]. In a comparative study on the effect of water deprivation, it was observed that while Marwari sheep almost ceased taking food on the third day the feed consumption in Barmer goats was reduced only by 40% even after four days of absolute water deprivation under arid climatic conditions of Jodhpur[9].

Strategies for breed improvement

An unfortunate feature has been the indiscriminate cross breeding of indigenous desert livestock breeds with high yielding exotics, without taking into account the environmental and edaphic conditions of the home tracts of the breeds. The results are that the progeny, while they prove to be better yielder, are often unable to cope with the environmental harshness of the desert and with the parasites that infest then village ponds and *nadies*. Besides, the high yielding crossbreeds need higher inputs of feed and water - both of which are scarce commodities in the desert. Selective breeding of indigenous, high yielding livestock would avert many of these problems. In addition, livestock breeding need to account for higher indigenous cattle, breed temperatures, lower quality diets, and greater disease challenges that are better suited to survive the mitigation strategies and food demand. The rectal temperature reflects the animals' ability to maintain thermal equilibrium. It is the only parameter for which heritability has been ascertained with a rather good accuracy. Studies conducted on genetic variation of adaptation to heat at CSWRI, Avikanagar have revealed that the exotic fine wool breeds arising from temperate/sub-temperate environments are less suitable to hot semi-arid zone of the country as they showed higher increases in cardinal physiological responses, greater depression in food intake per unit body weight and poor survival. On the other hand, the native breeds were better adapted since they exhibited smaller increase in physiological responses and had higher food and water consumption per unit body weight.

Health management

Livestock diseases seriously reduce productivity and also cause major economic losses. There are certain diseases, which are more common in drylands, need more attention so as to prevent its outbreak. Epidemiological studies indicate occurrence of infectious diseases such as FMD, rabies, sheep and goat pox, tuberculosis, enterotoxaemia mycoplasmal infections, blood protozoa, coccidiosis, brucellosis, HS, BQ, anthrax, rickettsial and chlamydial diseases, nematode infestations, mange, and pica. High incidence of subclinical mastitis has also been reported from drylands. Current programme plagued with two main problems. Firstly, it does not cover whole of the population of the species due to less doses available/produced by the BP laboratories of the states. Secondly, some of the important species like goat and camel are not usually covered under this programme. Therefore, this programme needs to be extended in whole of the susceptible population. There is need to properly follow the schedule of FMD vaccination at least twice in a year, yearly pre-monsoon vaccination for BQ for cattle and buffaloes. HS vaccination needs to be extended to camels beside cattle and buffaloes, Antharax vaccination also need be provided to sheep, buffalo and camel beside cattle and Enterotoxaemia and Sheep pox vaccination need be extended to goats in addition to Sheep with routine schedule.

Preventive measures are usually the only practicable approach in parasitic diseases as many of the clinical conditions might be either uneconomical or rather difficult to treat. Though a host of parasitic diseases has been identified, its control and prophylaxis is difficult because of traditional rearing practices and large population, thus, their management must be done as part of routine husbandry practice. At least biannual deworming with a broadspectrum anthelmintic like

albendazole, fenbendazole, tetramisole, levamisole, closantel, Ivermectins etc. for all species of animals need to be done[8]. Promotional campaigns needs to be launched for conducting animal health camps to encourage farmers to adopt a regular preventive measure.

Policy and support services

For livestock producers, credit is most critical input, as they require cash for day-to-day management of their household enterprise. Access to credit can enable the farmers' access to technologies. No intuitional mechanism exists in the drylands for giving them cash/micro credit. It was pointed out that even Kishan credit cards deny livestock farmers access to cash credit, while as a mixed crop-livestock farmer the same farmer has access to cash through Kisan credit card for crop production. It is therefore, suggested that Kishan credit card should include credit for livestock production inputs as well. In some parts of the drylands, particularly Andhra Pradesh and Karnataka, women's self-help groups (WSHGs) have emerged as effective institutions for providing instant cash credit for small enterprises and that they have very good track record on credit supply and timely recovery[5]. Therefore, WSHGs as institutions for cash/micro credit for livestock production should be promoted as a part of livestock schemes under rural development programmes.

Short and medium range weather forecasts are important for livestock farmers to plan the farm operations[6]. In India, weather forecast-based agromet advisory services (AAS) are being implemented successfully through collective efforts of India Meteorological Department, Indian Council of Agricultural Research institutes, State Agricultural Universities, NGOs and private partners. The AAS bulletins include medium range weather forecast and advice by experts to farmers on 'what to do' or 'what not to do' for maximizing the advantages of likely favourable conditions and minimizing the losses in production due to adverse weather conditions. At present, the AAS bulletins are issued at district, state and national levels which are disseminated through newspapers, televsion, radio, internet, SMS, personal contacts etc.

Creation of conducive environment and providing policy and technical support to facilitate the emergence of private extension and service providers in areas where sufficient demand exists. A village based livestock service delivery mechanism; community driven needs to be promoted because timely availability of vaccination and dewarming could reduce production losses, drastically cut down mortality of livestock, increase output, protect farmers investment and will help to appreciably increase households income. Village service providers should equip themselves with mobility and communication facilities. Extension approach should be need based with problem-solving dimensions and participatory in nature. Encourage farmers training and field visits to the progressive farmers filed to improve their skills and understand the all aspects of new technologies facilitating the up-scaling. A massive campaign to launch capacity building and empowerment of village communities that will act as the harbinger of change and technology adoption and to establish the foundation for a farmer-to-farmer livestock extension mechanism.

CONCLUSIONS AND RECOMMENDATIONS

Arid zone in India occupies about 12 % of the total land area, and are characterized by low rainfall and high evaporation, resulting in lack of water and limited soil fertility. The farming systems in arid zone are quite diverse with a variety of crops and cropping systems, agroforestry and livestock production. Livestock production has become an important component in arid zone, as it is considered an instrument to socio-economic change to improved income and quality of life with equity. The sustainable development in arid zone can only be achieved through optimum utilization of its natural resources. There is tremendous scope of increasing livestock productivity of indigenous breeds by improving nutrient availability from locally available feed and fodder resources.

The recommendation of National Agricultural Policy that 10 % of cultivated land be brought under

fodder production needs to be implemented. Fodder based cropping systems for different zones needs to be developed and promoted with promising crop species and varieties for optimizing productivity of arid production systems. There should be focused programme on regeneration and development of silvipasture on commons and wastelands, which will not only meet shortage of feed and fodders but will also provide equal access to poor and improve environment too. Rangelands development needs integration with ongoing projects like watersheds/wastelands, MNREGA programm adopting participatory approach to assure grazing and top feed supply round the year. Fodder banks at strategic locations (preferably at Block level) for providing fodder during emergencies needs to be established involving PRI/NGOs/SHGs in its management. Veterinary first aid facilities with pedigreed males should be established at Panchayt level which can ensure tremendous increase in livestock productivity.

Livestock based integrated farming system models should be developed for different situations to balance livestock; environment and human needs. Conservation of local biodiversity is necessary through need based policies and programmes. Low-producing males should be castrated and selection of genetically superior animals within local breeds may be ensured for future breeding programs. Availability of key inputs and veterinary services needs to be strengthened and improved to enable the arid land farmers for livestock development. A favorable policy environment in terms of access to micro-credit and assured market will have to be provided and a socio-economic and technical constraint needs to be addressed.

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