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Fodder Production and Utilization Strategies for Sustainable Livestock Development in India

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Abstract: Feed resources for livestock in India are becoming important due to scarce supply particularly in dry regions because of seasonal variability in rainfall. Due to increasing human and livestock population, the pressure on land is increasing day-by-day and the existing natural resources are deteriorating and creating land degradation. Livestock production systems are complex and mostly based on indigenous traditional knowledge and socio-economic considerations, often guided by available feed resources at their disposal. Integration of fodder production with existing cropping system has tremendous promise to sustain the ever-growing livestock population. In this paper an attempt is being made to review the fodder availability, and discuss the various options for fodder production and their utilization for sustainable livestock production in India.

Key words: Forage yield, common property resources, socio-economic.

Livestock is an integral part of agricultural economy of India and plays a multifaceted role in providing livelihood support to the rural people. They not only contribute to their income but also play an important role in their nutritional security (Misra and Ponnusamy, 2019). They represent an important option for landless and marginal households where the size of land holding is too small to provide an adequate livelihood and where operational costs of livestock maintenance are low due to (i) a considerable proportion of feed and fodder requirement being met through grazing on common lands and (ii) the cost of labor required for maintenance being low due to limited opportunities for employment elsewhere (Birthal *et al*., 2002; Misra *et al*., 2012). According to NSSO 66th Round Survey (Annual Report 2013-14), total number of workers in farming of animals is 20.5 million. Quite often, livestock is the only source of cash income for subsistence farms and also serves as insurance in the event of crop failure. Areas with a high share of livestock husbandry have low poverty percentage (Emond, 2019). Hence, development of livestock sector would be more inclusive.

India is the world's largest producer and consumer of milk. In the last four and half decades, milk production grew eight fold, from about 22 million tons in 1970-71 to 176.35 million tons in 2017-18, and even has excellent potential for still higher growth (Rath, 2019). Urbanization has brought a marked shift in the feeding habits of people towards livestock products with resultant increase in demand for milk and its products. Rapidly developing peri-urban livestock farming, vibrant cooperative dairy sector and livestock product-based super markets are indicators of fast changing economic scenario in livestock sector. Strong farm-gate prices and rising demand for value-added products due to increasing consumer income are stimulating increased milk production in India (Emond, 2019; Misra and Ponnusamy, 2019).

However, the productivity of animals adapted to various agro climatic regions is low due to shortage of quality feed and fodders and inadequate knowledge on appropriate management of livestock. Analysis of production data suggest substantial gap between actual and potential yields across the animal types within India. Birthal and Jha (2005) found average gaps of 49% for crossbred animals, 43% for indigenous breeds and 34% for buffaloes in major milk producing states. The major factor constraining yield was determined to be use of feed and fodder, followed by breeding problems, diseases and management issues. Technologies to improve livestock and fodder productivity and its contribution to the livelihoods of the rural poor do exist. However, the rate of adoption of technologies in smallholder farming systems is consistently low (Francis and Sibanda, 2001;

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Misra *et al*., 2010). The economic viability of livestock is dependent on the genetic potential, good health care, balance feeding of animals and efficient marketing of the produce. While genetic improvement and health care are the prerequisites for sustainability, efficient feeding and marketing will help in increasing the profitability. However, the profitability is directly dependent on the sources of feed and fodder, as about 65-70% of the total cost of livestock farming is attributed to feeding. Therefore, any saving in feed and fodder cost would directly contribute to increase in profitability. Balanced feeding of milch animals is more critical, as the results are reflected within a short span, almost immediately, in the form of milk production. Hence feeding of milch animals has greater significance for dairy farmers. In order to solve this problem, approaches that guarantee effective linkages among researchers, NGOs, extension workers, decision-makers and farmers, who have a complex knowledge base and widely dispersed expertise, are needed (Parthasarthy Rao *et al*., 2005; Misra *et al*., 2010).

In this paper an attempt is being made to examine the issues of fodder availability and suggests strategies for fodder production and utilization based on participatory on-farm research conducted at government and non-government organizations for meeting the challenges.

Scenario of Feed and Fodder Availability and Requirement

India faces tremendous pressure on its natural resource base with about 18% human and 15% of livestock population of the world being supported only by 2.4% of geographical area, 1.5% of forest and pasture lands and 4.2% of water resources (Misra and Ponnusamy, 2019). The three major sources of fodder supply in India are crop residues, cultivated fodder and fodder from common property resources like forests, permanent pastures and grazing lands. A number of studies report feed and fodder scarcity to be a major constraint to the growth of livestock sector, although actual deficit estimations vary widely. NIANP reports countrywide deficit of 12, 34 and 64% in crop residues, green fodder and concentrates, respectively (Ramchandra *et al*., 2007). The shortfalls in actual feed use from recommended rations for cattle and buffaloes are estimated at about 11% for dry fodders, 33% for green fodders, and 35% for feed concentrate (Planning Commission, 2012). IGFRI reports that the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients (IGFRI Vision, 2050). These estimates are based on what is being supplied and not on what could potentially be supplied with reallocation of land resources, application of improved technology, or feed imports. Supply and demand scenario of forage is presented in Table 1. Another source reports that use of feed concentrates or compound feeds for dairy animals is rare throughout India and estimated that only 11% of dairy feed requirements are met through compound feed (India Infoline News Service, 2014). These reports show an alarming gap between demand and supply, and deficit in green and dry fodder is increasing every year, while for concentrate the gap is almost static. This gap is critical and is going to determine the type of animal and husbandry practices to be followed in future (Planning Commission, 2012).

Some researchers, however, have also questioned the increasing short fall in feed and fodders reported in the literature (Parthasarathy Rao and Bhowmik, 2001; Misra and Ponnusamy, 2019). They argue that the impressive growth in milk production would

Table 1: Demand and supply estimates of dry and green forages (million tons)

Year	Demand		Supply		Net deficit		% Deficit	
	Dry	Green	Dry	Green	Dry	Green	Dry	Green
2010	508.9	816.8	453.2	525.5	55.72	291.3	10.95	35.66
2020	530.5	851.3	467.6	590.4	62.85	260.9	11.85	30.65
2030	568.1	911.6	500.0	687.4	68.07	224.2	11.98	24.59
2040	594.9	954.8	524.4	761.7	70.57	193.0	11.86	20.22
2050	631.0	1012.7	547.7	826.0	83.27	186.6	13.20	18.43

Source: IGFRI Vision: 2050.

not have been possible with such huge deficits in feed availability. They concluded that on a per animal basis at the all-India level, feed availability had increased during the last 20-25 years mainly due to increase in crop residues from fine cereals and concentrates from oilseeds. This was despite a decline in the availability of grasses from grazing lands and green fodder from cultivated fodder crops that had remained stagnant or declined in several regions. Nonetheless, availability of balanced feed, quality of feed and feed shortages in drier years is still a major limiting factor in increasing livestock productivity.

Livestock and Fodder Production

Livestock rearing in India is changing with the requirement of time as it is evident that demand for milch breed of cattle is going up as compared to dual or draught breed. As per 19th Livestock Census of 2012, the number of milch animals (in-milk and dry) has increased by 6.75% in 2012 as compared to the 2007 census (GoI, 2012). Population of indigenous dual and draught purpose breeds (Haryana, Nagori, Khilar, etc.) has declined more than milch breeds. The most common livestock fodder resources are cereal crop reduces, grasses from grasslands, forest lands, community lands, cultivated fodders and unconventional feed resources like top feeds and agro-industrial by-products. The Planning Commission documents indicate the largest category of feed supply is crop residues (about 64% of total feed supply on a DM basis), followed by cultivated green fodder (18%), pasture and grazing (12%), and grain and oil cake concentrates. Ghosh *et al*. (2016) observed that 54% of the total fodder is met from crop residues, while 18% fodder is met from grasslands and only 28% fodder is met from cultivated fodder crops. Therefore, crop reduces were considered as very valuable feed component by the livestock keepers, however, they cannot support high level of production due to low nutritive value of feed. In urban areas, particularly around Hyderabad and Bangalore, dairy animal owners purchase chaffed sorghum stalk/stover even at high price. However, in many regions of Punjab, Haryana and Uttar Pradesh, farmers have been burning these crop residues. This clearly showed that there is no demand for fodder in agriculture-rich areas, while other regions are facing fodder shortage.

The cultivated fodder crops have significant role in feeding of ruminants, as they provide all critical nutrients required like highly digestible protein, carbohydrates, fats, B-carotene (precursor of vitamin A) and minerals. Cereal fodder crops like maize, sorghum and oats are that rich in energy and the leguminous crops like lucerne, berseem and cowpea that are rich in proteins, are a good source of major and micro minerals that not only meet their nutritional requirements but also fill the rumen to satisfy the needs of animal system. The economics of milk production is heavily dependent on the quantity and quality of forage fed to milch animals. The green fodders are known to be cheaper source of nutrients as compared to concentrates and hence useful in bringing down the cost of feeding and reduce the need for purchase of feeds/ concentrates from the market. As evident from several reports green fodder mixed with coarse roughages, like wheat straw improved its intake and digestion. The moisture and nutrient contents of the crop decreases and fiber content increases with maturity and hence harvesting at proper stage is crucial. Through feeding of good quality forage, particularly leguminous fodder, feeding of concentrate can be reduced significantly. Animals yielding upto 7-8 kg milk per day can be maintained exclusively on leguminous green fodder (lucerne or berseem), as a substitute for 4-5 kg concentrate (Misra *et al*., 2007). However, there are not many dairy animals, having genetic potential to produce high milk yield, by efficiently converting the fodder. In-spite of feeding good quality fodder, the milk yield of inferior quality animals remains low, and the farmers find it uneconomical to feed such animals. Therefore, farmers remain reluctant to cultivate fodder exclusively on fertile lands, without owning high yielding animals. Studies have shown that it is only with improved livestock, the owners will have an urge to feed good quality fodder (Kumar *et al.,* 2015). The improved animals respond well to the feeding of better quality feeds and forages, while the benefits of feeding low productive livestock are marginal. Hence farmers owning inferior quality livestock do not feed them properly, while letting them out for free grazing. Hence, fodder cultivation is closely linked to the productivity of livestock and the available critical veterinary support services. The use of concentrate remains

low though it is slightly higher in the more commercialized oriented production systems in the leading states. In the lagging states and in crop-livestock and pastoral systems, in which crop residues and green fodder from CPRs are the main feeds, both spatial and temporal scarcity of feeds are quite high.

Major Issues in Fodder Production

The issues in fodder production are more complex than food crops. The shortage of fodder on one side and neglect of available resources in the absence of better quality livestock on the other side is a matter of great concern. At micro-level, for farmers that invest in maintaining quality animals for income generation through animal husbandry, procurement of good quality fodder is a major challenge. Over 90% farmers being marginal and small holders and own about 90-95% livestock, are not able to devote their lands for cultivation of fodder crops, as their priority is to produce food grains. Moreover, in case of forages, the regional and seasonal deficits are more important than the national deficits, as it is not economical to transport the forages over long distances. Major nutritional stress occurs during dry months, when animals are depending almost entirely on poor quality roughages (Misra *et al.,* 2009).

The lack of knowledge about cultivation practices and paucity of marketing opportunities to sell the surplus fodder at remunerative prices are crucial problems related to fodder production. The area under cultivated fodder crops has remained almost static since 3-4 decades and is only 8.4 million ha (about 4.4% of the total cropped area), and 2.7% of total irrigated area. There is very little scope for increasing the area under fodder production due to the pressure on land for food crops and also to divert the area for other uses. Fodder cultivation is common practice only in selected regions that are more advanced in milk production such as Punjab, Haryana, Western Uttar Pradesh, and parts of Gujarat and Rajasthan. The area under fodder crops is more than 10% in these states. Sorghum, and Berseem are cultivated in 50% of the land under fodder, followed by Lucerne, maize, bajra, oats, and hybrid Napier in lesser extent. Most of the farmers are aware only of few fodder crops like sorghum, maize, lucerne and berseem, which are cultivated in a isolated pockets. Many farmers are not aware of other forage crops, which have special advantages under adverse agro-climatic conditions. Non-availability of good quality seeds of fodder crops is another constrain. Seed availability of forage crops is just 15-20% of the national requirement. There is also lack of seed standards for perennial grasses and legumes. Mission mode approach with a multi-pronged strategy and research interventions are required to take care of all aspects of seed production technology, quality, seed standards, certification, distribution and marketing (Kumar *et al.,* 2015).

Farmers in many regions have been wasting the crop residues, either by feeding the stalk without processing or by burning. The important reason for such wastage can be attributed to forage surplus conditions in certain regions, particularly where green revolution was launched successfully. Farmers in these areas take two to three crops in a year and they have very little time available for forage production between two crops. Furthermore, the cost of labor being high, these farmers have no interest in diverting their energy to process and store the crop residues till they complete the sowing of the next crop. Lack of space, hazards of fire and damage caused by rains are other factors influencing the farmers to dispose off the crop residues as early as possible. The easier option for them is to either burn or sells it off to local buyer irrespective of any price realization.

Climate change and its impact on fodder production is another important issue. The forage production per unit area is a consequence of the interactions between genotypes and environment. Forage species particularly perennials and trees have ability to produce more forage yield under changing climate and reduce the ill-effect of climate through carbon sequestration. Therefore, emphasis need to be given on development of area-specific newer crops, and cropping systems that can break the yield barriers and meet the challenges of climate change for efficient resource use and enhanced farm productivity.

Presently both public and private sector support in development of fodder resources are limited, because it is a part of animal husbandry department and for them it has never been a priority. Public extension services have played

a major role in technology transfer in the crop sector, but in livestock sector extension service delivery has been weak. There has also been a wide communication gap between the forage development program and the livestock extension department. As a result, technologies of forage based livestock production have percolated at very slow pace to the end users. Only 5% of households have ever accessed any kind of information on animal husbandry from formal extension services. A public extension activity by the state department of Animal Husbandry suffers from inadequacy of resources and the lack of expertise to operate technology transfer packages. The services are mainly run by veterinarians who operate from veterinary dispensaries to treat animals, rather than educate and inform farmers about feed, fodder, management and health issues. Some of the SAUs, ICAR institute and KVKs provide some form of extension, but this does not constitute a national extension service comparable to the nationwide extension support available for crop production.

Strategies for Increasing Fodder Production

It is necessary to address the opportunities related to increasing the fodder yield of cultivated fodder crops and efficient use of crop residues. The selection and application of fodder production technologies should conform with the framework of sustainability criteria. Potentially important technologies that can make a significant increase in productivity of both crops and animals within the system should be promoted. This shall consequently increase farmers' income and also meet the demand of raising human population (Misra *et al.,* 2007; 2015). The participatory approaches for introduction of forage production technologies with smallholder farmers in selected areas are to be advocated based on experiences gained through conduction of on-farm research. Emphasis should be placed on farmer-led, farmer-to-farmer extension, with volunteer farmers serving as resource persons in development and promotion of interventions. Exposure visits and dialogue can also used as a guiding principle, involving open discussion among farmers, NGO workers and researchers. Apart from this, focused group discussions and diagnostic surveys should also be undertaken in order to obtain full information at various stages of implementation. Thus, making available several intervention options allowed the farmers to choose what was most appropriate in their circumstances (Misra *et al.,* 2007, 2010).

Increasing Forage Yields

Enhancing the productivity per unit land area through efficient natural resource management and also integration of fodder crops in the existing cropping system are only viable options to meet the growing fodder needs of livestock sector. 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 (Misra *et al.,* 2010; Patidar *et al.,* 2014). The strategy to increase fodder availability within systems should have the final objective of developing sustainable all-year-round feeding system appropriate to the prevailing situations and the availability of feeds (Misra *et al.,* 2015).

Crop sequences and cropping systems

Improved crop sequences and crop management practices for irrigated and rainfed conditions should be developed to ensure the maximum resource use efficiency (Ghosh *et al.,* 2016). Intensive forage production systems include multiple cropping, intercropping, overlap cropping and relay cropping. Under assured irrigation multiple crop sequences like sorghum (multicut) + cowpea - berseem + mustard - maize + cowpea and sorghum (multicut) + cowpea - berseem + mustard are promising. Overlap cropping system developed involving seasonal and perennial forage crops like guinea grass and napier bajra hybrid intercropped with cowpea during summer and kharif and berseem in rabi, has the capability of providing round the year green fodder (200-300 t ha^{-1}) to the dairy animals and is also feasible for small farmers having limited land holdings for food and forage production. In uncertain rainfall and dry areas, intercropping or mixed cropping are widely practiced to reduce complete crop failure. The productivity of these land can be improved through intercropping

Table 2. Forage production system under dry land conditions

Cropping systems	Sowing time	Forage availability	Green forage yield (q ha^{-1})
Jowar + Guar - Fallow	June-July	Sept.-Oct. (excess quantity may be preserved as silage or hay)	250
Bajra - Senje Japan rape	June-July October	Sept. Dec.-Jan.	350
Guar + Fallow	June-July	Sept.-Oct	200
Cenchrus ciliaris	With the on-set of monsoon	throughout the year except winter	150
Cenchrus ciliaris + *Siratro*	With the on-set of monsoon	Throughout the year except winter	100-150
Panicum antidotale + *S. hamata*	With the on-set of monsoon	Throughout the year except winter	100-150
Lasiurus sindicus	With the on-set of monsoon	Throughout the year except winter	100-150

of short duration forage in long duration crops such as sorghum + cowpea, sorghum + clusterbean, bajra + cowpea, bajra + clusterbean etc. The all India Coordinated Research Project on Forage crops have shown that fodder based crop sequences have potential for realization of higher monetary returns over food based crop rotation in majority of the agro-ecological regions (Table 2).

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. Introducing leguminous fodder crops in the wider spacing of the grain sorghum is an excellent example of food-fodder cropping systems (Misra *et al.,* 2007). In Bundelkhand region, maize-berseem cropping sequence recorded maximum wheat equivalent yield as compared to groundnut – wheat + mustard and black gram – wheat + mustard. The combination of cereals and legume fodder crops improves the herbage quality substantially in terms of protein and mineral balances as the legumes component contains high amount of protein, calcium and phosphorus This system of cropping also helps to maintain soil fertility over a long period due to addition of root organic matter and better utilization of plant nutrients from different soil depth (Kumar *et al.,* 2017). 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^{-1} 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^{-1} seed rate and harvesting alternate rows at 50 days for fodder and allowing the remaining rows for grain (Patidar and Rajora, 2009).

Restoration of Common Property Resources and grassland

It has been a tradition in India to have common property resources (CPRs) and community pasture, about 5 to 10% of the land area in each village, which has been an important source of feed and fodder for livestock particularly of weaker sections of the community. Each family has equal access to these resources in the village. In the past, group of villagers were taking care of such lands and maintaining them, but after abolition of this system, these CPRs became no body's property and are now in denuded condition and encroached upon by influential or sold by pachayats to mobilize resources (Misra *et al.,* 2015). In India current land use provides 12 million ha areas under permanent pasture and grazing lands which is lying as wasteland. Out of 75 million ha area under forest, half is at the last stage of degradation. Similarly, different surveys have pointed out 155 to 175 million ha as wastelands. Restoration of these CPRs and wastelands is most important not only for providing regulated grazing but also for protecting valuable resource. Local governing bodies of the villages need be involved in their improvement and management. First step in

Table 3. Suitable species of grasses and trees on the basis of rainfall

Rainfall	Grasses	Legumes	Trees/shrubs
150-300 mm	*Lasiurus sindicus, Cenchrus ciliaris*	*Lab lab purpureus, Clitoria ternatea*	*Prosopis juliflora, Acacia tortilis Acacia senegal, Ziziphus nummularia. Colligonum polygonoides, Dichtrostahys nutans*
300-500 mm	*Lasiurus sindicus, Cenchrus cilaris, Cenchrus setigerus, Panicum antidotale*	*Lab lab purpureus, Clitoria ternatea*	*Acacia. tortilis, A. nclotica, P. cineraria, Tecomella undulate, Ziziphus* spp. *Colligonum polygonoides. Azadirachta indica H. binnata, Ailanthus exelsa, Albizia lebbek, Colophospermum mopone*
>500 mm	*Cenchrus cilaris, Dichanthium annutatum, Chrysopogon fulvus, Sehima nervosum, Panicum antidotale, Heteropogon contortus*	Stylosanthes	*Acacia nilotica, Acacia catechu, Dalbergia sissoo, Leucana leucocephala, Albizia* spp. *Alianthus excelsa, Hardwickia binnata*

improvement of the CPR is the necessary soil and water conservation measures. This is done by dividing the whole area into four to five equal compartment, every year one such compartment is taken up for development and closed for grazing, half taken under silvi pastoral development and the other half for grassland/pasture development (Pathak and Roy, 1994). In the second year, the second half the development area is open to grazing and the next compartment is taken up for development. First half, i.e. silvi pasture area closed for grazing in the first year, may be open to grazing at the end of the third year. The process is repeated every year so that in the fifth year, the whole area is developed. In order to maintain the vigour of the grass and legumes, and also to meet the needs of the livestock. CPR may be subjected to one of the grazing systems namely (i) Continuous grazing, (ii) Deferred grazing, (iii) Rotational grazing and (iv) Deferred rotational grazing for a given site at a specific period as per requirement.

There is huge potential to meet feed and fodder shortage through these CPRs. It has been possible to increase land productivity from 0.5-1.5 t ha^{-1} yr^{-1} to about 10 t ha^{-1} yr^{-1} on a rotation of 10 years through such interventions on degraded rangelands (Ghosh *et al.,* 2016). Many studies have supported the view that grasses, legumes and trees in a silvipastoral system provide effective land cover as well as produce nutritious fodder for livestock, sequester carbon and upgrade the environment (Misra *et al.,* 2015). Tree and grass species suitable for different rainfall and land form situations are presented in Table 3 and 4.

Table 4. Suitable species for silivipastoral development system under different land use systems

Type of land	Suitable species		
	Grasses	Legumes	Trees/shrubs
Desert land and sand dunes	*Lasiurus sindicus, Cenchrus ciliaris, Cenchrus setigerus*	*Lab lab purpureus, Clitoria* ternatea, *Atylosia scarabaeoides*	*Acacia tortilis, Acacia nilotica, Acacia senegal, Prosopis cineraria, Prosopis juliflora, Azadirachta indica, Ziziphus nummularia, Colophospermum mopane, Dichrostachys nutans, Colligonum polygonoides*
Ravine lands	*Cenchrus ciliaris, Cenchrus setigerus, Dichanthium annulatum, Pannisetum pedicellatum, Saccharam spontaneum, Chrysopogon fulvus*	*Stylosanthes* spp. *Stizolobium decrigenum, Macroptilium atropurpureum, Atylosia* spp.	*Acacia tortilis, Acacia nilotica, Acacia catechu, Albizia lebbek, Albizia amara, Dalbergia sissoo, Zizyphus* spp. *Ficus* spp. *Emblica officinalis, Eugenia jambolana*
Cultivable waste lands	*Cenchrus ciliaris, Cenchrus setigerus, Pennisetum polystachyon, Panicum antidotale, Sehima nervosum, Clrysopogon fulvus, Dischanthium annulatum*	*Macroptilium atropurpureum, Glycina jaranica, Clitoria ternatea*	*Albizia* spp., *Hardwickia binnata, Leucaena leucocephala, Acacia* spp. *Sesbania* spp., *Dichrostachys nutans, Prosopis cineraria, Ziziphus mauritiana*
Salt affected area	*Cynodon dactylon, Paspalium notatum, Chloris gayana, Lasiurus sindicus, Brachiaria mutica, Sporolobus marginatus, Urochloa* spp.	*Glycine javanica, Macroptillum* spp. *Phaseolus junatea, Stylosanthes* spp.	*Acacia tortilis, A. nilotica, Prosopis juliflora, Salvadora* spp., *Zizphus* spp., *Sesbania* spp., *Albizia amara, Atriplex* spp.

Researchers at IGFRI have shown that 2.9-7.9 t ha^{-1} dry forage could be produced under the silvipastoral system without affecting the growth of associated trees (Dhyani *et al.*, 2010). Silvipastoral technology, proved to be successful in areas receiving less than 800 mm rainfall with nine months of dry season. Legumes like *Stylosanthes hamata* can provide fodder with high nutritive value and also provide complete ground cover. Studies conducted in arid regions of India have shown that *Acacia tortilis* with *Cenchriis ciliaris* in a silvipastoral system gave maximum returns as compared to different other combinations (CAZRI, 2014). Therefore, even if 50% of the land is brought under silvipastural system, there is potential to produce 200 million tons of dry matter to meet shortage of fodder.

Strategies for Enhancing Feed Resource Utilization

The scope for reducing the wastage and increasing the efficiency of feed utilization in production system is enormous. Post-harvest processing of surplus fodder is the best management strategy for abating regular phenomenon of seasonal and regional deficit of forages. Timely harvesting of crop residues, proper processing and storage can enhance the quality of the forage and prevent wastage. Harvesting of stalk before it turns fibrous for feeding or converting into silage, can keep the nutritive value high while reducing methane generation by the ruminants. Some of the strategies are chopping of fodder, bailing and enrichment of crop residues particularly paddy and wheat straw for proper storage, balanced feeding with green fodder to minimize wastage and strategic supplementation of nutrients to enhance the feed utilization efficiency.

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. The net biological value of the feed also improves. Misra *et al.* (2010) reported that by using the chaff cutter, wastage of the fodder could be reduced upto 30%. Feeding of chopped roughage reduce the energy wasted while chewing and helps in adopting strategic supplementation, improves palatability of less preferred roughages by mixing with highly palatable fodder, improves digestibility and the net biological value of the feed (Singh and Prasad, 2002).

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. There are various methods of treating these crop residues before feeding so as to improve its nutritional value, such as:

- Urea treatment
- Alkaline treatment
- Ammonia treatment
- Thermal treatment (steam pressure treatment)

Through treatments, nutritional value of poor quality herbage could be improved and made more palatable. The net effect of any treatment is a result in reduction in rigidity of cell structure and swelling of cell walls, so that electrolytes and cellulolytic enzymes from rumen microbes can penetrate these cells. These microbes can then colonize the vegetal matter and decompose it more quickly after hydrolysis. It has been reported that even chaffing of stalk before feeding, can reduce the emission of methane by 10% while saving the wastage by 25-30%. Though different methods of treatment have been developed but have not been adopted by farmers yet due to several reasons.

Strategic supplementation

A variety of supplements exist that can be used for feeding animals. Most common supplements include urea molasses based strategic supplements, oil meals and cake as well as leguminous tree forages such as Leucaena and Gliricidia, minerals and anti-oxidants. 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) is commercially available and can be used to supplement the low quality roughages to balance the deficient nutrients in the ration. UMMB contains soluble 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 (Misra *et al.,* 2007). 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 (Patidar *et al.,* 2014).

Establishment of Feed Processing Unit and Fodder Banks

To avoid the wastage and burning of crop residues, it is necessary to set up the post harvest feed processing units and fodder banks in fodder surplus areas and process into compact feed blocks either directly or after addition of concentrates and minerals. The main aim of feed processing is to add value to the poor quality roughages. Use of leaf meals from leguminous fodder, crop residues from pulses (lentil, gram, grass pea, stylo) and tree leaves (subabool, gliricidia, khejri, etc.) will substitute costly concentrate. Such enriched fodder blocks can easily be transported to different parts of the country under scarcity situation as per demand of the fodder. Transport losses are not properly documented; however, transporting bales of different products (grasses, wheat straw and paddy straw) causes 1.5 to 4.0% reduction in weight and 15.5 to 43.9% reduction in volume. If densified, about five times of the paddy straw can be transported in comparison to loose paddy straw in a single trip of truck (Pathak *et al.,* 2008). CAZRI has installed complete feed block making machine with feed mixture and grinder at Sant Bhuria Baba Gaushala, Harsolauv, Naguar, Rajasthan, and has demonstrated that poor quality crop residues could be converted into mineral and protein rich quality feeds. These blocks comprised all the essential feed ingredients in suitable proportion and can be fed to productive animals as complete ration. The field trial of complete feed block has been initiated first time at farmer's door in the arid area of Rajasthan with active participation of people. Large number of farmer's from 12 villages are benefited from the technology. These fodder blocks helped animal to maintain their health and production during feed and fodder scarcity period (Patidar *et al.,* 2014).

The Way Forward

Changing agriculture production practices and globalization of economy have its impact on livestock production system also. The recommendation of National Agricultural Policy that 10% of cultivated land be brought under fodder production need to be implemented. Fodder based climate resilient cropping systems for different zones needs to be developed and promoted utilizing promising crop species and varieties for optimizing productivity of existing systems. Selection of new genotypes and varieties of food crops having high forage value without reduction in food grain yield needs to be developed on a continuous basis. There is need to promote fodder production through improved agronomic practices and use of improved seed.

Forage cultivation on agricultural lands is least attractive, unless farmers own superior quality livestock. Hence the return is mainly influenced by the quality of livestock. Thus efforts should be made to promote fodder production in the areas where livestock husbandry is progressing well and the productivity of animals is high. In the long run there is also a need for developing a fodder market where farmers can sell their surplus forage. A fair market can motivate the farmers to study the price movement and opt for cultivation of fodder crops, if the prices realized are remunerative. The rural entrepreneurial capacity should be build up to enable farmers to earn more. There should be focused programme on regeneration and promotion of silvipasture on *Gochar*, and wastelands, which will not only meet shortage of fodders but will give equal access to the poor and also improve environment. The policies and programmes of central government related to poverty reduction and livelihood promotion such as Horti-Mission, MNREGA, National Rural Livelihoods Mission and Watershed Development Programme provide an excellent opportunity for promoting fodder production.

An array of technologies- feed, fodder and feeding interventions have been developed and tested to improve the productivity of animals with varying degrees of success. Several of them have been successfully demonstrated at field level. There is need to upscale and out scale their adoption through state government departments, *Krishi Vigyan Kendras* (Farm Science Centres) and other extension agencies. Information technology platform may be used extensively to reach to the farmers with information related to feed, fodder and feeding interventions at individual farm level. A well established communication network would help the forage scientists to understand the problems of the dairy farmers and offer suitable interventions.

Green fodder production is constraint by limited acreage and lack of availability of quality fodder seeds. Serious thought should be given for developing a forage seed distribution network, at least in selected pockets where dairy/animal husbandry has developed as a major economic activity. Fodder conservation and processing technologies should be promoted so as to enable round the year feed supply. Farmers are also growing forages in many innovative ways including intensively managed cut and carry systems, contour barriers, pastures, and cover crops. Farmers have been able to adapt forage systems according to their own needs, resulting in sustainable improvement of their farming system. These initiatives need to be popularized and disseminated for wide adoption.

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