Invited article

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Feed and forage resources for sustainable livestock development

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Indian agriculture and animal husbandry are integral part of each other and this scenario is expected to continue in the foreseeable future. Perhaps nowhere in the world do man and animals come together in such a rich and diversified cultural environment as attitudes and behaviour towards the animals are interwoven with the intricate fabric of Indian society. The bulk of livestock production takes place in rural areas, although specialized peri-urban dairy and goat enterprises are also emerging. It is predicted that meat and milk consumption will grow at 2.8 and 3.3 per cent per annum respectively, in developing countries like India. In fact, sustained economic growth, increasing urbanization and a shift in diets in favour of high protein foods are fueling the growth in demand for animal foods. Again demand for animal food is more income elastic. It has been estimated that the expenditure elasticity for milk is 0.6 and that for meat 0.9, compared to the negative or marginally positive elasticity for cereals. Livestock production is backbone of Indian agriculture contributing 7 per cent to national GDP and source of employment and ultimate livelihood for 70 per cent population in rural areas. Thus the livestock has been growing faster than the crop sector. If these trends continue, the livestock sector could emerge as an engine of growth of Indian agriculture. The human population in India is expected to reach over 1400 million by 2025. The 27.8 per cent urban population is poised to increase by over 58 per cent by 2025. Urbanization has brought a marked shift in the lifestyle of people in feeding habits towards milk products, meat and eggs with resultant increase in demand of livestock products. Peri-urban livestock farming and emerging fodder markets are indicators of fast changing economic scenario in livestock sector. Livestock population is around 500 million and is expected to grow at the rate of 1.23 per cent in the coming years.

There are significant regional variations in the composition of livestock population. For instance, buffaloes are often found in more well- endowed and irrigated regions; while cattle, sheep and goat are predominant in rainfed areas. The buffalos ability to adapt to a wide range of climates has made it popular even in its nontraditional breeding tracts. As a result, its population has been increasing at about 2 per cent a year, while that of cattle is heading towards stabilization. However, the distribution of livestock as asset is more equitable than land. In numbers, marginal and small landholders (<2.0 ha) comprise 63 per cent of rural households but account for only 34 per cent of the arable land. In contrast, they account for 67 per cent of the cattle and buffalo, 65 per cent of the sheep and goat, 70 per cent of the pigs and 75 per cent of the poultry. Livestock in such households not only serves the purpose of augmenting income, employment and food security, but also acts as a storehouse of capital and an insurance against crop shocks. Besides, livestock enterprises being women-oriented, they promote gender equity.

Today, we are proud to stand first in milk production (127 million tonnes) in the world. However, due to poor productivity and performance of livestock, the animal husbandry by and large is an enterprise with limited resource returns. This is not a happy situation for a country where majority of rural people derives their sustenance to great extent from animal husbandry. In India, average milk yield of a cow is 1014 kg/animal/year, which is 48 per cent of the world average and 13-16 per cent of that in the USA, Canada, and Israel. Beef yield (103 kg/ animal) and Chevon yield (10 kg/animal) are 52 per cent and 80 per cent of the world average, respectively. There is also a large gap between realized and potential yield. While for indigenous cattle the average yield is one-third to one-half of the potential yield, for crossbred cattle and buffalo, it is about two-thirds. Thus growth in livestock output, with the exception of milk, has primarily been driven by an increase in animal numbers.

Availability of Forage

There is tremendous pressure of livestock on available

total feed and fodder, as land available for fodder production has been decreasing. At present, the country faces a net deficit of 63 per cent green fodder, 23 per cent dry fodder and around 64 per cent feeds (Table 1). To meet the current level of livestock production and its annual growth in population, the deficit in all components of fodder, dry crop residues and feed has to be met from either increasing productivity, utilizing untapped feed resources, increasing land area (not possible due to human pressure for food crops) or through imports. In animal feed supply, coarse cereals have a major role and four major cereals *viz;* maize, barley, sorghum and pearl millet account for about 44% of the total cereals. Production of these cereals is stagnating at around 30 million tonnes. To meet the feed requirements there is a need to improve productivity of these cereals. By the year 2025, the demand will reach to 1170 million tonnes of green fodder and 650 million tonnes of dry forage and 152 million tonnes of concentrate feed. At the current level of growth in forage resources, there will be 65 per cent deficit in green fodder and 25 per cent deficit in dry fodder. Green forage supply situation has to grow at 3.2 per cent. Diversion of crop residues for packaging and other industrial requirement as well as incorporation of crop residues into soil will worsen the demand and supply situation. There is need for policy for utilization of crop residues for industrial and agricultural sectors allowing only non-edible crop residues for packaging and other industrial use.

Development Programmes on Forage Resource

In last decades, programmes relating to feed, fodder and pasture development in the country have been quite limited. In many programmes of government and private agencies, importance of forages is being realized. Recently the accelerated fodder development programme has been initiated by Department of Agriculture and Cooperation (DAC), Govt. of India from 2011-12 with total outlay of Rs, 300 crore. In this scheme an emphasis has been laid on distribution of dual purpose seed for human consumption and other by products roughages for livestock feeding rather than high fodder yielding crops. Livestock with forage based farming is being recognized as important strategy of natural resource management for enhancing agricultural productivity, abating adverse effect of climate change and livelihood enhancement to small and marginal farmers and landless laboures. In watershed programmes and wasteland, problem soil based research and development agenda on fodder aspects are considered important.

Table 1. Projected supply and demand scenario (million tonnes) of forages

Year	Supply		Demand		Deficit as % of demand	
	Green	Dry	Green	Dry	Green	Dry
2010	395	451	1061	589	63 (666)	24 (138)
2015	400	466	1097	609	64 (696)	24 (143)
2020	405	473	1134	630	64 (728)	25 (157)
2025	411	488	1170	650	65 (759)	25 (162)

Figure in parenthesis indicates actual deficit
Source: Based on Draft report 10th Five Year Plan

Feed Resources

The scenario in feed resources availability is no different from that of green forages. The deficiency in concentrate feed requirement is almost half of the required quantity The situation has improved marginally over the years.

- Crop residues (Straw, stover, haulms *etc*)
- Grassland, alpine, sub-alpine, pasture land
- Community lands, Common property resources, wasteland
- Cultivated fodder
- Forest lands
- Cut and carry grasses
- Novel unconventional feeds, top feeds, famine feeds
- Coarse grain
- Oil meals
- Cereal bran, hulls, husks
- Agro products
- Fish meals
- Bone meals

Livestock population

The above requirements have been worked out on the projected livestock population (Equivalent to adult cattle unit) as below: -

Year	Cattle	Buffalo	Sheep	Goat	Equine	Camel	Total
1995	180.5	82.8	4.0	9.2	0.5	0.9	278.0
2000	187.1	87.7	4.1	9.9	0.4	1.0	290.0
2005	192.2	92.6	4.2	10.5	0.3	1.0	301.0
2010	197.3	97.5	4.3	11.2	0.3	1.0	312.0
2015	202.3	102.4	4.4	11.8	0.1	1.1	322.0
2020	207.4	107.3	4.5	12.5	0.1	1.1	333.0
2025	212.5	112.2	4.6	13.2	0.1	1.1	344.0

The estimated livestock population was converted to ACUs assuming that 350 kg of body weight=1 ACU in cattle, 450 kg= 1 ACU in buffalo, 10 goats= 1 ACU, 10 sheep= 1 ACU
Source: Draft report of working group for X plan for AHCD, Planning Commission, August

Quality of Feed and Fodder

Livestock rearing in India is changing with the requirement of time as is also evident that demand for milch breed of cattle is going up as compared to dual or draught breed. Population of indigenous dual & draught purpose breed like Haryana, Nagori, Khilar has declined more than milch breeds. In this globalized market economy dependent agri-economy, milk production has to compete for growing fodder on good arable land. Thus milch animals have to be of high productivity and reproductive efficiency.

1. Role of cultivated fodders:

- Feed & fodder cost constitute about 60-70% of cost of milk production thus cultivated fodder has an important role in meeting requirement of various nutrients & roughage in our country to produce milk most economically as compared to concentrates
- It has been postulated that fodders are 5-14 times cheaper source of digestible crude protein and total digestible nutrients than concentrates. It has been established that the cost of milk production can be significantly lowered by improving feeding system based on green fodder and replacing ingredients of concentrate with leaf meal and enriched complete feed block.
- In view of the peculiar digestive system, ruminants need feeds, which not only meet their nutritional requirements but also fill the rumen and satisfy the animal.
- In view of microbial digestion system the feeds have to meet requirements of the animal, its production as well as the needs of microbes for promoting digestion.
- The fodder crops meet these requirements very effectively and hence are important for ruminant production system.

2. Fodder crops provide all the critical elements like highly digestible protein, carbohydrates, fats and minerals. Green fodders are a very good source of ß-carotene (precursor of vitamin A).

- Common cereal fodder crops like maize, sorghum and oats are rich in energy and the leguminous crops like lucerne, berseem & cowpea are rich in proteins.
- Leguminous crops, like berseem, lucerne & cowpea, are a good source of major & micro minerals, so critical for rumen microbes as well as animal system
- Fodder cultivation has been traditional in most parts of the country since farmers feel that the fodder crops have some factor, which keeps the animal healthy and productive. Hence since generations farmers have marked out certain varieties and crops for fodder production and cultivate these depending on availability of land and water.

3. Harvesting at proper stage is crucial as the moisture and nutrient contents of the crop decreases and fiber content increases with maturity.

4. Fodder production programme should aim at selecting crops and varieties, which produce highest quantities of Nutrients per unit of land and time periodô and hence a continuous search for improved varieties is crucial.

- Perennial grasses like Hybrid Napier and Guinea grass are known for high yields and their new varieties produce good quality fodder.
- ii) Shrubs and small trees (like *Gliricidia, Desmanthus, Leucaena, Sesbania* spp.) have multipurpose utility and are very good and cheap source of protein and minerals and can be introduced between farm plots.

5. Surplus fodder can be stored in form of silage or hay for lean season.

6. Leguminous crops like Lucerne and Berseem are useful in promoting ruminal development in calves.

Generation of Fodder Production Technology

***Crop improvement*:** Crop improvement programme should be oriented towards exploitation of indigenous and exotic resources potential through selection and breeding for improving the forage productivity and nutritive values of different cultivated fodder crops and pasture species from different agro climatic regions of the country. Though intensive researches in plant breeding augmented with allied disciplines resulting in development of varieties with a high genetic yield potential have contributed to this success, the demand for future are expected to increase several folds. The problem in forage crop improvement especially perennial forage grasses emanates due to frequent occurrence of polyploidy, self incompatibility and apomixis resulting into various degree of sterility, poor seed setting and difficulty in desirable and controlled hybridization. Pasture production depends on herbage yield, its seasonal distribution, nutritive value, seed production and persistence. The tropical pasture species are very poor in these attributes. There has been constant effort for genetic improvement for pasture grasses and legumes on these fronts but to a very little success. Plant breeders using the primary gene pool of various individual forage crops should further reorient breeding efforts and develop the varieties for higher biomass production and fodder quality. The varieties should be free from diseases and pests, photosynthetically efficient and abiotic stress tolerant and reduce need of fertilizer *etc*. The new techniques provided by biotechnology are relatively fast, resource efficient and highly specific. It may offer opportunities to increase sustainability and profitability *vis-a-vis* international competitiveness.

Plant breeding efforts are being carried out in several forage species such as sorghum, maize, cowpea, pearl millet, berseem, oat, Cenchrus and other forage crops with the efforts of allied disciplines. More than 250 forage crops varieties in berseem, lucerne, cowpea, guar, field bean, oats, pearl millet, *Cenchrus*, Dinanath Grass, Guinea grass, *Sehima, Chrysopogon, Heteropogon etc*. have been released through national network. Some advances in biotechnological approaches have been made such as development of interspecific crosses using embryo rescue in *Trifolium sp.* regeneration protocols through tissue cultures in *Cenchrus, Dichanthium, Trifolium* and *Medicago*, development of protocol for transgenic in *Dichanthium* and *Medicago*, identification of quality QTLs in sorghum, development of SSR markers in berseem, molecular characterization of genes involved in expression of components of apomixis, ploidy series in guinea grass using components of apomixis, identification of sexual plants in grasses, use of molecular markers in improvement of *Stylosanthes* for quality and drought tolerance. Now there is a need for judicious use of PGR resources and conserve them for future. Breeding dual purpose cereals and grain crops, breeding specifically for stress tolerance and degraded lands and finding new niches for fodder production are the keywords. Furthermore, these breeding strategies should be supplemented with appropriate pre-breeding procedures, biochemical and physiological basis of improved production.

Forage Production from Arable Lands

Looking to the various competing land uses, the increased productivity per unit land area and also integration of fodder crops in the cropping system are only viable options to meet the fodder needs of livestock sector. Management practices for fodder crops differ widely from those of food grain crops in many respects. Promising crop production technologies from cultivated lands may provide sufficient fodder in different agro-ecological regions.

(i) Intensive forage production approach

Intensive forage production systems aims at efficient utilization of land and other inputs for maximum fodder production per unit area per unit time with equal quantum of increase in animal productivity. Intensive forage production systems include multiple cropping, intercropping, overlapping cropping and relay cropping. The system of multiple cropping ensures regular supply of forage by manipulating the sowing and harvesting schedules. These crop sequences are tailored with an objective of achieving high yield of green nutritious forage and maintaining the fertility of the soil. Under assured irrigation, multiple crop sequences like Sorghum (multicut) + cowpea - berseem + mustard -maize + cowpea and Sorghum (multicut) + cowpea - berseem + mustard are promising. Overlapping cropping system involving seasonal and perennial forage crops like guinea grass and napier bajra hybrid intercropped with cowpea during summer & *kharif* and berseem in *rabi*, provides round the year fodder to the dairy animals. NB hybrid becomes fibrous when the harvesting is delayed. Alternatively, thin stemmed, soft and leafy Setaria/guinea grass may be better in humid and sub-humid climate. Berseem can be replaced by lucerne in western region for utilization of interspaces. Except for high water table areas, rotations based on perennial crops are most suitable, whereas, in other cases annual crops in rotation are suitable.

(ii) Mixed & intercropping in rainfed areas

In India with warm climate, most of the grasses and cereals do not have enough protein to support animal growth and production. The combination of graminaceous and leguminous fodder crops improves the herbage quality substantially in terms of protein and mineral balances as the legumes component contains higher 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. In risk prone areas such as rainfed and dryland, mixed/intercropping, ratooning and over seeding grain crops provide insurance against crop failure. For mitigating occasional long droughts and supply of regular fodder, in western and southern regions of the country, where sorghum is grown both during *Kharif* and *Rabi*, ratooning of *kharif* sown crops produces good yield. In risk prone areas like drought-affected areas, grass and tree-based approaches, *viz.,* ley farming and alley cropping systems hold promise to increase the overall productivity of marginal and sub-marginal lands and strengthen the livestock enterprise and conserve the land-water resource.

(iii) Food-fodder cropping system under irrigated conditions

Efficient forage based cropping systems with respect to biological potential along with increased efficiencies of land and water may provide a viable option for specific regions. At farmerôs level, potential productivity and monetary benefits act as guiding principles while opting for a particular crop/cropping system, which are further narrowed down under influence of several other forces related to infrastructure facilities, socio-economic factors and technological developments, all operating interactively

at micro-level. Studies under AICRPFC network 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. Inclusion of forages in any of the season was equal or superior than food based systems. Any effort to integrate forage crops in the established food crop based cropping systems with more remunerative prospects in present entrepreneurial scenario needs a promotion at policy and development level. Introducing the leguminous fodder crops in the wider spacing of the grain sorghum is an excellent example of food-fodder cropping systems. In Bundelkhand region, maize-berseem cropping sequence recorded maximum wheat equivalent yield as compared to groundnut-wheat + mustard and black gram-wheat-mustard. Under Tarai region, rice-wheat and rice-berseem - forage maize + cowpea system have been found to be at par. Besides this, soil fertility status with the inclusion of legume was either maintained or improved over a period of five years.

(iv) Forage production from problem soils

More than 50 per cent of net cultivated area is affected by land degradation. These soils cannot be economically used for the cultivation of crops without adopting proper reclamation measures and management. These niches provide options for extension of forage resource developmental activities without much competition. Under such conditions, adoption of holistic approach by integration of efficient soil, plant, water and nutrients management practices offers a sustainable option for improved fodder production. Utilization of marginal or problem soils for diversification of rice based mono-cropping through forages will lead to amelioralive effects on soil acidity, sodicity and sustainability of agricultural production system. Such effort will not only improve the net return per unit area but also supplement the green fodder to livestock population which survives on poor quality straw and roughages in these regions. Growing of acid tolerant forage species and varieties is recommended for acidic soils. For higher yield and better soil health, liming is standard management practice to be adopted for increasing productivity of such soils. The continuous addition of lime @2.4 t/ha in soil maintains soil pH near neutrality enabling optimum availability of nutrients and higher production of multicut grasses like Guinea, Napier hybrids, Setaria *etc*. In saline-sodic soils, suitable tree shrub species have been identified from the viewpoint of fodder-cum-fire wood production and also, their ability to combine well with grass species. For highly sodic soils (pH> 10.0), suitable sodicity tolerant grasses are Para> Karnal> Rhodes for higher biomass production, increase in the Ca content and infiltration rate and marked reduction in soil pH, EC& ESP after 4 years of establishment. Thus, the lands that could hardly produce 0.5 t/ha in terms of forage or brush wood were able to produce over 7 t/ha/yr. This quantum jump in the production of biomass is accompanied with higher nutritive value of the forage also. In sodic soils, food forage based systems like rice-berseem are more remunerative (15-25%) than traditional systems of rice-wheat.

Sustainable Forage Production

(i) Total factor productivity

Inefficient inputs fertilizer use is a key factor pushing the cost of cultivation and pulling down the profitability in farming. Total factor productivity (TFP) is used as an important measure to evaluate the performance of a production system and its declining trend is a serious issue. A fatigue in the ratio between the inputs and output is indicative of TFP decline with resultant un-sustainability of crop production.. Forages are often considered low value and low priority crop for allocation of inputs like fertilizers for their cultivation. Therefore, use of microbial fertilizers for nutrient saving to such crops may have enough potential for enhancement in crop productivity and improvement of soil health. Since most of the single cut forages are of short duration and multi-cut forages have shorter defoliation interval of 30-40 days, they require adequate nutrients in readily available forms to enable them to produce sufficient foliage in a limited period. Application of FYM (@6-7 t/ha/yr in two split (1:1 *Kharif: Rabi*) during conversion period is effective in soil fertility build up and meeting the nutritional requirement of Guinea grass + (cowpea berseem) cropping system at its optimum productivity. Phosphorus is essential for root development and provides strength to the plants. Shallow rooted fast growing crops respond better to phosphate nutrition than deep rooted slow growing crops. Plants require higher amounts of phosphorus at initial stages of growth. The optimum N: S ratio in forages for ruminants is considered to be 10:1 or less. When the ratio is wider, the ruminants fed on such herbages adjust by wasting nitrogen resulting in decreased efficiency of feed protein utilization. Therefore, forages may be fertilized with sulphur especially if the available S content in the soil is less than 10 ppm. Problem of micronutrient deficiency especially Zn in soil and plant is widespread across the globe. In India about 50% soils are classified as Zn deficient. In several study at Indian Grassland and Fodder Research Institute, Jhansi, it was observed that most of the cereal crop residues are deficient in the Cu and Zn. Lactating

and mature cows were unable to meet its requirement of Ca, P, Cu and Zn from the feed and forages. Specially, availability of Cu and Zn was below the requirement in the entire feeding situation. Recent experimental results showed that seed priming with 0.05% Zn + Cu + Mn solution and VAM application with 50% recommended dose of micronutrients (RDM) were effective in producing green and dry forage yield of sorghum + cowpea and oat equivalent to 100% RDM (Zn:Mn:Cu-20:10:5) resulting in 50% saving of the micronutrient fertilizer recommended for these crops.

(ii) Water management in forage crops

Enhanced water productivity will hold the key to intensive forage cultivation in milk shed areas. As water is scarce input, its scientific management for higher water use efficiency will define the cropping pattern. In most of the intensive systems, perennials multi-cut forages need to supplement irrigation in frequent intervals. For better water productivity, first approach has to be development of varieties requiring less water and adaptable to moisture stress in different crop growth phases. Second strategy has to be soil and water management in conjunction with cropping system management. In various studies, it has been found that irrigation scheduling coinciding with physiological stages, results in higher water use efficiency. The lysimetric approach has generated scientific information for better understanding of water in the soil-water-plant-atmosphere continuum. Variation in crop ET in relation of growth stages of forage crops and identification of the peak period of water use helps in proper scheduling. Under limited water supply, magnitude of reduction in ET of forage crops will determine the suitability of criteria for irrigation practices. Under a particular moisture regime, the irrigation interval needs to be advanced during summer and delayed during rainy months by 3-5 days due to variation in evaporative demand and associated environmental conditions. In future the development and use of non-conventional water resources like, natural brackish water, agricultural drainage water & treated sewage effluent offer great promise for water scarce areas. Forage production from marginal water needs to be researched upon to know the real potential and overcome the threat of contamination from metallic and pathogen load in food chain as well as impact on soil quality. Water use efficiency for fodder production can be improved by employing water conservation technologies in rainfed production system.

(iii) Precision farming

Precision farming is modern eco - friendly technologies which offer opportunities to optimize yields and profits and reduce pressure on natural resources. This will eventually lead to total quality management under heterogeneous management of mixed-farming situation. It involves the best use of farmerôs local knowledge with tools like GPS, RS and ICT. Two major components i.e. site specific nutrient management and precision water management are adopted with due considerations to spatial variability in order to maximize crop production and minimize cost of production and environmental damage.

Capitalization on Non Arable Lands

(i) Characterization of grazing resources

In India active growth in grazing lands occurs only during monsoon months, with surplus fodder available during rainy months and deficits of various levels in other months. The natural calamities like drought and flood create imbalances in fodder supplies. The total potential area of grazing lands in India is 85.9 million ha. Considering the total arable lands to be 147.38 million ha and calculating that croplands one tenth of its organic produce as fodder, total arable land can be put as equivalent to 14.73 million ha of grazing lands bringing up total to 100.3 million ha. Taking average potential above ground net primary productivity as 500 g/m^2/yr, the total fodder production will come down to 501.5 million tonnes of dry fodder per year with a total bovine population of 239.09 million, excluding sheep, goats, horses, camels and donkeys and also assuming that a normal healthy cattle consumes 7 tonnes dry herbage per year, the normal annual consumption will come to 1673 million t/yr. Thus, the net primary production level of grasslands in India is far below the total requirements. The overgrazing and continuous degradation of grazing lands along with loss of fertility is further decreasing their productivity. The problems of grazing lands are related to ecological and socio-economic causes. In arid areas, water is the limiting factor, in semi-arid areas, proper land utilization and excessive grazing are the main problems and in high rainfall zones, it is the lower nutritive value of the herbage. Another serious problem is low proportion of legume component in the herbage.

(ii) Availability of grazing land

In India, grazing based livestock husbandry continues to play an important role as around 50 per cent animals depend on grazing in forests and other grazing areas. Total area available for grazing in the country is in the range of about 40 per cent of the land area. Pasture lands constitute the main grazing resources of the country, available over an area of 12 million ha (3.94 % of the geographical area).

There is a lot of difference in the extent of grazing lands in various states. In some states, namely, Himachal Pradesh, Jammu & Kashmir, Meghalaya, Nagaland and Arunachal Pradesh, the grazing land availability is as high as 70 per cent. Nearly 30 pastoral communities in northern and western parts of the country depend on grazing based livestock production. Based on the practice followed by these pastoral communities in various regions, the grazing systems may be categorized either on the basis of methods of grazing or patterns of migration.

(iii) Rangeland restoration

Rangeland includes grasslands and regions where even woody vegetation is dominant. It is important from the viewpoint of livestock production and it also serves as a habitat for wildlife. Productivity of grazing lands has declined to a great extent, on account of demographic pressures. So the efforts in restoring the rangeland productivity and arresting land degradation are very important. The restoration package may be worked out as per the intended major use. In order to increase the pasture productivity in dry areas, it is essential to replace low yielding annual grasses with high yielding perennial grasses adaptable to the prevailing conditions of that region. As the use of fertilizers in these lands is of little practical value on account of high costs, introduction of suitable pasture legumes is one of the best ways to improve the quality.

In the present scenario, land degradation due to over grazing and illicit tree felling is a major environmental issue. Excessive run-off leading to soil erosion and nutrient loss could be effectively checked by development/restoration of degraded rangelands. It has been possible to increase land productivity from 0.5-1.5 t/ha/yr to about 10 t/ha/yr on a rotation of 10 years through such interventions on degraded rangelands. Many studies have supported this 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. The concept of hortipasture, utilizing land in the orchards by developing pasture stands, is also finding applicability with the famers. The additional forage availability through such systems is likely to reduce grazing pressure.

(iv) Grass - legume mixtures

Grass-legume mixtures have been used in many countries for realizing higher total herbage yield by growing them in association, rather than in individual swards where no fertilizer N is applied. The legumes in the pasture increase N content and digestibility of the herbage. In the diet of animals, grasses and legumes have also greater beneficial associative effect through rumen than when they are fed separately. Further, the adopted legumes in the mixture provide a simple and practical means of meeting the nitrogen need of the associated grasses as most of the legumes fix atmospheric nitrogen. The plant interaction in the mixtures often becomes competitive for available water, nutrients and light, thus affecting the overall yield. Studies have shown the nitrogen equivalence of legume to the tune of 40- 60 kg N /ha ad when introduced in natural grasslands. This means that 40-60 kg N /ha can be added to the grassland soil as microbial fertilizer manufactured by legumes, which in turnalso influence total dry matter production and crude protein yield.

(v) Alternate land use management on watershed basis

Alternate land use systems like Agroforestry technologies (silvipasture, hortipasture, etc.) hold promise not only for bioremediation of degraded habitats but also forage production. Soil conservation techniques with greater emphasis on water harvesting in grassland and silvi/ hortipasture production system may prove boon to livestock keepers. This system aims at optimizing land productivity, conserving plants, soils and nutrients and producing forage, timber and firewood on a sustainable basis. It involves replantation, substitution or intervention in the existing vegetation by desirable species. It has been possible to increase land productivity from 0.5-1.5 t/ha/ year to > 10 t/ha/yr (10-year relation) by developing silvipastures. Now, the concept of hortipasture is also gaining popularity with the farmers for utilizing their degraded lands. The additional forage availability through such systems is likely to reduce grazing pressure and thus have important environmental implications. Efforts to design silvipasture systems to produce >15 t/ha/year through species introduction, planting geometry, canopy manipulation and sustainable management through in-situ grazing or cut and carry system are continuing.

Silvipastures integrate pasture and/or animals with trees. Woody perennials, preferably of fodder value, are introduced deliberately and systematically and managed scientifically. The tree selection is based on its easy regeneration capacity, coppicing ability, fast growth, nitrogen fixing ability, palatable leaves (fodder), high nutritive value and less toxic substances, short rotation and high fuel value. The grasses and legumes should have easy colonizing ability, high production efficiency and high nutritive value. The biodynamics of silvipastoral systems involves four major distinct life forms, *viz.*, the herbaceous

vegetation (mostly grasses and legumes), the woody foraging component (fodder trees), the domesticated animals surviving on the vegetation, and the man who controls the other three components. In addition, soil and climate have their own roles to play and compliment the diversity. Since these systems are close to nature, they offer an ecologically viable and sound approach. The tree loppings/ prunings are also used as top feeds.

Seed production

The availability of good quality seeds is estimated to be around only 15-25% for cultivated fodders. The productivity and availability of seed is vital because the crops have been bred for vegetative purpose and are shy seeders. Recent estimates put the current demand for seeds of cultivated fodders at 355000 tonnes/year based on the area under cultivation (8.3m ha) and a target replacement rate of 10%. The availability of quality seed is only to the tune of 5-6 per cent. The estimated requirements in respect major fodder crops *viz.,* maize, berseem, oat, lucerne, sorghum and pearl millet in near future is likely to increase. It indicates that there is considerable scope of improving seed production through Breeder Seed-Foundation Seed-Certified Seed/TFL seed chain. The activities in the area of seed production of range grasses are not properly organized. Whatever seed of range grasses and legumes are produced by different agencies is being primarily used by the forest departments.

With the development of a number of improved and high yielding varieties in forages, it has become important that quality seed should be readily available and supplied to the farmers. There is need to prepare a seed production ñatlasô for the country for commercial seed production and marketing. In this endeavour disease free zones should be mapped. There are demands for import of forage seeds, especially in respect of hybrid sorghum (from Australia and USA) and berseem (from Egypt) in the recent years due to absence of institutional arrangement of multiplication of breeder-foundation-certified/truthfully leveled seed, economically unviable venture of seed production of forage crops as well as absence of organized marketing channels.

The demand can be fulfilled only through continuous evaluation of released varieties for seed production potential and sufficient production of quality seeds in participatory mode. Unlike the other agricultural crops, forage crops have some unique phenomenon making it challenging to address the forage seed requirement of country. Non - availability of sufficient quantity of quality fodder seeds as the crop is harvested before seed set necessitates the development of dual purpose varieties. Non synchronous flowering / anthesis and spikelet maturity, abscission of spikelet after maturity in grasses and presence of large number of sterile glumes in grasses and inverse relationship between grain and vegetative biomass are the other issues needs to be addressed. Following measures will go a long way to solve the crisis of forage seed availability in the country ï

- Sufficient allocation of resources and area to forages in milk shed regions
- Mission mode approach to maintain the seed chain (Nucleus-breeder-foundation - certified /TFL) Participatory approach for semi/full-mechanized seed collection of range grass and legumes
- Organizing forage seed market, participatory forage seed production & farmers training for forage seed production.
- Development of seed production technologies with an emphasis to address specific agronomical/physiological measures to improve seed yield per unit area
- Networking, generating demand of new varieties through awareness programme, grass seed production-tie up with agencies /stakeholders
- Production of seeds of range grasses and legumes in mission mode for at least five years and make all forest areas compulsory for spreading of these in forest areas. Common property resources should also be effectively re-vegetated with range grasses and legumes
- Incorporation of range species in social forestry programmes
- Farmers are to be encouraged for maintaining grasses like NB hybrid, Guinea grass, Cenchrus for supply of rooted slips for local demand.

Integration of Livestock in the Continuum

Studies pertaining to plant animal relationship have acquired the edge in forage evaluation, conservation and utilization for optimum and economical production in ruminant animals. Aspects related to Animal Nutrition, Livestock Production & Management, Animal Breeding, Organic Chemistry and Biochemistry had enabled to take up the programmes related to forage evaluation and economic feeding in ruminants and has generated significant information and technologies.

Feeding System Research

Ecologically and economically sustainable feeding systems developed have shown that milch cows sustained up to 17-18 kg milk yield/day under forage based feeding system. Dietary combinations of grasses with tree leaves/

shrubs in 75:25 and 50:50 ratios were found optimum in sheep and goats, respectively. Studies on grazing animals are also conducted with holistic approach to find out sustainable feeding system. Grazing management practices *viz.,* rotational, deferred rotational, continuous and cut & carry have been compared for overall sustainability of the systems and productive performances of livestock in cattle, sheep and goats. Strategic supplementation of concentrate/ forages can also be used for grazing goats, possessed by resource poor farmers.

Contaminant in Food

Recently 'Food Safety' has emerged as a concern. Livestock products are often contaminated with chemicals entered into the animal system through feeds and fodder. Experimental feeding of endosulfan in goats indicated that endosulfan isomers and along with endosulfan sulfate transferred from feed to milk though the transfer coefficient was very less (0.23% to 0.33%) as compared to DDT and HCH. In view of these emerging food safety concerns, work on organic livestock production for milk as well as meat is going on. In India, a considerable area is still under rainfed agriculture with meager use of fertilizers and pesticides in a number of agro climatic regions. Such areas can be identified and earmarked for organic livestock production for export in years ahead.

Predicting Regional Crop Residue Availability- A Modeling Approach

Numerous reports on the status of feed and fodder in the country are available. In view of development and adoption of newer crop varieties, cropping pattern and harvesting methods, these estimates vary across the regions. The straw to grain ratio worked out from the plant samples of major cereal crops (wheat, rice, sorghum, maize, bajra, barley) collected across the country, showed significant regional variation in grain: straw ratios in all the major crops sampled. The varietal differences within the crops were also observed. In case of rice, the grain to straw ratio varied from 1:0.90 to 1:1.76. Sorghum showed the straw to grain ratio of 1:10 to 1:1.70. Data base on crop residues will be of immense use for strategic planning for creation of fodder banks in deficit zones of the country.

Forage Conservation and Quality Concern

Screening and identification of secondary metabolites like total phenolics and proanthocyanidines are made in range shrubs and tree leaves, so that these can be exploited judiciously and economically in the ration of sheep and goats. Similarly, works are going on to develop technologies to conserve surplus green fodder of flushing season either as silage or hay in an efficient way to cater the needs of forage during lean periods. These efforts have to be utilized in comprehensive manner while devising forage resource development programmes. The fodder supplementation from non-conventional sources will be of great bearing on the reduction of fodder crisis on regional and seasonal basis.

Dispelling the Myth of Methane Emission

Some doubts have recently been raised that large number of Indian livestock is emitting large amount of methane in the environment. On the basis, India was advised to reduce the livestock population of the country which may not be acceptable. Studies conducted in India have shown that methane from Indian livestock is not that much as has been claimed, rather total contribution of green houses gases is very low as compared to developed countries like USA, Japan *etc.* A number of ways and means to reduce the enteric methane production through dietary manipulation, feed and fodder processing and genetic modification of rumen microbes have been successfully demonstrated by researches. Mixing berseem with wheat/ paddy straw reduce methane production up to 30 per cent depending on the proportion of berseem mixed. Increased use of tree leaves will reduce green house gas emission. Feeding of oat, wheat straw combinations to ruminants reduce methane production by 8-23 per cent. However; systematic efforts should be made to develop economically viable and practically feasible technologies to reduce the methane emission with better livestock nutrition.

Socio-economic Issues in Forage Resources Development and Utilization

Like the other sector of agriculture this sector also finds major involvement of farm women. It has been observed in many studies that in peak agriculture season farm women activities were upto 18 hrs/day. Agriculture is still the bread earner of the 2/3 rural population. Improved forage production and livestock management technologies are percolating to the end users slowly. Recent study shows that more than eighty percent of knowledge gaps exist in fodder production practices. In sub-humid ecosystem, small farmers and large farmers were having lower knowledge gap (48%) and (51%) respectively towards animal production practices. Efforts made in terms of fodder technology demonstration/ on-farm trials will definitely help in disseminating these technologies related forage production conservation and utilization, at faster pace in days to come.

Livestock Production and Livelihood

The reports from survey indicated that resource poor farmers preferred sheep and goats in arid region since rearing of small ruminants need less input and is mainly grazing based. But, in semi arid and sub humid ecosystems, more emphasis is on buffaloes. Contribution of animal husbandry component to the livelihood is more in case of resource poor farmers compared to medium and large farmers. The contribution of Animal Husbandry, in farmerâs income in arid (39%) and semi arid region (41%) was higher compared to other ecosystem. Horticulture component was found strong in humid region.

In all ecosystems, the grazing is being done in almost all season though grazing hour variation exists. During summer, in arid ecosystem, more than six hours of grazing was done by all categories of farmers while it was less in sub humid (4.81 hrs) and humid (5.33 hrs). The farmers were also offering concentrate to productive animals. The frequency of feeding by majority of farmers was 2 even in case of resources poor. In arid ecosystem, the kadvi of maize/bajra/sorghum was major dry fodder while in other ecosystems wheat/rice straw was major dry fodder. Among concentrate ingredients, mustard cake, sorghum, bajra, wheat flour, barley flour, maize grain, and cotton seed cake were major ingredients along with compound feed. Dry animals were offered very less concentrate. The feeding frequency ranged from 1 to 3 but in majority of cases it was 2 in rainy and winter season. In all ecosystems, major green fodder was weeds and local grasses. This information has to be taken into account for regional planning and government policy interventions to support the forage based livestock production.

Farm Mechanization in Forage Production

There is need and great scope for use of machines in fodder production, conversation and post harvest management of fodder. Conservation tillage machinery like mixed cropping enabled zero till drill and tractor drawn raised bed planter are being promoted for forage production. Similarly, tractor drawn high capacity chaff cutter, movable type baler and field baler are used in post harvest management. Tractor operated movable baler has been tested for making bales of dried hay material including natural grasses, maize stalks, sorghum stalks and cowpea hay. Tractor operated field baler has been able to carry out baling in the field conditions. This machine is useful for the areas with high amount of hay material. Modern seed processing plants, a complete unit of cleaning and grading of forage crops need to be installed at seed processing plants. At village/block level, creation of custom hiring centre for use of costly machinery on payment basis is being adopted in progressive areas of agriculture operations.

Post Harvest Technologies

Technology has been developed to conserve surplus green fodder for use during the lean period either as hay or silage. Manually operated hay baler having a baling capacity of 2.5 tonnes ha/day has been developed. The weight of bale is 25 kg and density is 150-165 kg/m^3. The IGFRI densifying machine produces high density (350-400 kg/ m^3) bales of wheat *bhusa*, chaffed stovers, grasses and tree leaves for economic storage, handing and transport. Complete feed block rations in the form of block for grazing calves, heifers and milking animals have been standardized. Study conducted on the nutritional quality assessment of stored crop residues showed that IGFRI developed storage system can be recommended for the safe storage of grass bales up to one year. Final CP content of stored leucaena leaf meal (LLM) for one year storage was 19.87 per cent as against initial value of 22.01 per cent. Anti nutritional factor Mimosine content of LLM during storage was reduced from 2.90 to 2.53 percent.

Need for Feed and Fodder Security

In India out of 55 micro-regions, 43 micro-regions are deficient on fodder availability. There are regional and seasonal disparity in fodder production and availability. Due to lack of sufficient post harvest and storage facility, surplus fodder is not properly utilized. Diversion of fodder from surplus to deficit areas is meager. Edible crop residues diversion to non-agricultural use is a current practice which needs to be checked. National Consultation on Conservation Agriculture has suggested promoting integrated crop-livestock conservation system and minimizing conflict of demands on crop residues. In India, the livestock production and agriculture are closely linked, each one being dependent on the other and both crucial for the overall food security of the people. In the current decade food security is being pursued at policy and intervention level through appropriate mechanism. But, feed and fodder security to huge livestock has been neglected so far. Policy and organizational set up has not been much productive and effective to deal the complexities of forage resource development in India. Feed and fodder security can be achieved through focused R&D on production, conservation and utilization of forages supported with policy on protection and promotion of livestock based farming across the regions. Approaches like forage production and management, post harvest management, fodder bank, linkages for harvesting

synergies, policy intervention will go long way in tapping the available potential to increase fodder and feed supplies to wealth of huge livestock population.

Planning Ahead: The Strategies

(i) Varietal development

Development and identification of novel planting material is an important issue for harnessing the full potential of both cultivated and non-cultivated lands. The strategies in this context would involve the approaches resolving the hurdles limiting the varietal development programme like complex nature of crops, strengthening the knowledge base on molecular genetics, breaking the barriers of low genetic variability and plant physiological issues associated with grasses. The non conventional approaches like interspecific hybridization, apomixis and other biotechnology tools can be of major saviour to deal with future challenges. Building up a strong genetic resource base of different forage crops will also require introduction, exploration and collection programmes from unexplored habitat. Nutrient fortification and tolerance to several biotic and abiotic stresses are other issue which needs to be addressed on priority. The competing land use, increased demand for food, forage and fiber has added new dimension to the crop ideotype. Now there is lot of discussion about dual type forage crops especially in Maize, Sorghum, Pearl millet, Barley, Oat etc.

(ii) Sustainable crop production

Integration of the forages and forage based cropping systems in existing farming systems of different agro-ecoregions needs immediate attention to meet out the multifaceted need of the farmers. Improved crop sequences and crop management practices for irrigated and rainfed conditions should be developed to ensure the maximum use efficiency of available resources. Emphasis should be given for augmentation of crop production through INM, conservation tillage, contingent crop planning, climate resilient cropping system, crop diversification, and soil carbon sequestration and its management, farming system research and micronutrient management in soil-plant-livestock continuum, weather-disease-pest modeling and crop modeling approaches.

Sustainable agriculture advocates integration of natural processes such as nutrient recycling, nitrogen fixation, increasing role of microbes in crop and livestock nutrition, bio-agents/pest predator relationships for crop protection into agricultural production systems, so ensuring profitable and efficient food production. In the changing scenario, it should be suggested to minimize the use of external and nonrenewable inputs having the potential to damage the environment or harm the health of farmers / consumers and a targeted use of the remaining inputs with a view to minimize costs. Majority of the soils at present are showing multi-nutrient deficiency due to continuous cropping. Now there is need to work on the balance sheet of nutrients depleted and nutrients supplemented for taking care of the soil health. A reliable system of quality control and efficient system of storage, transportation and management of bio-fertilizers is required for wider applicability of inoculums technology.

(iii) Integrated farming system approach

Forages are considered important component of integrated farming system. In present day of agriculture, one of the ways to make farming a viable proposition is to bring diversification. It has been found that share of income from crop activities declines over the period across the regions. However, the share of income from other enterprises particularly the animal husbandry is on increasing trend. Various agricultural production constraints such as labour scarcity, growing water scarcity coupled with ever-increasing demand for milk products motivates farm households to diversify their farms by including allied sectors like animal husbandry. In this context, the integrated farming system will play a crucial role in livelihood security.

(iv) Mission on forage seed production

Availability of quality seed in forage crops to enhance production and productivity is long felt need. Forage crops in general and range grasses and legumes in particular are shy seed producers. The quality seed production is an important area that needs to be strengthened for vertical growth in cultivated fodder and horizontal growth in grassland and silvipasture sector. Mission mode approach with a multi-pronged strategy policy and research interventions are required to take care of all aspects of seed production technology, quality, seed standards, certification, distribution and marketing. Projected requirement of fodder seed at current level of cultivated area of 8.47 million hectares has been worked out at replacement ratio of 20 per cent.

(v) Organic fodder- An emerging area

Global organic food demand is accelerating day by day so is the demand of organic milk, meat and poultry. As such the demand of livestock products is increasing by 2.8 to 3.3 per cent in developing nation. Peri-urban livestock production and commensurate increase in demand of fodder and changing scenario of small

unorganized fodder market into large organized fodder market need attention of R&D in forage crops. Corporate entering into milk and meat production and marketing need to view in totality developmental process of forage resource and livestock sector. In recent years, there is growing concern for healthier food, including organic milk and meat. Such products will fetch premium prices both in the domestic and international market. The demand for fodder that is organically produced will rise and a strategy to make available such fodder is to be worked out. Also, there will be opportunities to brand the livestock products coming out of natural grassland areas with appropriate geographical indications after certification.

(vi) Extending fodder production activities

In view of competing land use due to demographic pressures on land, the allocation of cultivable land exclusively for forage production may not be easy option to meet out the ever increasing demand of livestock sector, developing the forage resource conservation, environment protection and profitability. Technologies like agri-silvi-horti-pasture that integrate woody perennials, either in spatial arrangement or in a tune sequence, with pasture crops and livestock can fit here to produce more biomass per unit area and time. CPR(s) and the forest areas will continue to be important resource for animal grazing. The focus should be on strengthening these niches as forage resource base suitable for grazing as well as cut and carry system through socially compatible, economically viable and ecologically stable and sustainable technologies. For optimum utilization of forage resources from these areas a strong local institutional mechanism needs to be developed.

(vii) Agro-ecoregion specific technologies

In mixed crop-livestock production system followed in different regions, dairy contributes 20 to 50 per cent of family income depending upon market condition, economic status of family, crop condition and type of animal. Under mixed farming, crop residues, green fodder grow under various cropping system form main diet of the livestock. The share of livestock income for under privileged family is as high as 70 to 80 per cent during drought. Improvement in livestock productivity is largely dependent on availability for forage resources and their efficient utilization by the livestock in a particular agro-region. To optimize the forage production and enhance the productivity of forage, agro-region specific varieties and cropping systems are required to economize milk production in the country. Technologies generated by AICRPFC and IGFRI have to be capitalized for overall productivity enhancement of forages in the respective zones to bridge the gap in demand and supply.

(viii) Post harvest management of forages

Post harvest management of surplus fodder is looked as a mitigation strategy for abating regular phenomenon of seasonal and regional deficit of forage and during natural calamities like drought and flood. Bailing and enrichment of crop residues particularly paddy straw and other leguminous crop residues for proper storage, balanced feeding with green fodder and minimizing wastage and storage loss. Use of leaf meals from leguminous fodder and crop residues from pulses will substitute costly concentrate (lentil, gram, grass pea *(khesari)* etc. and subabool, *stylo, gliricidia* etc). Tremendous amount of different varieties of grasses and edible crop residues are available in India.

Forage resource availability round the year needs to be enhanced through promotion of fodder bank which will include feed block, leaf meal and mandatory region specific mineral mixture supplementation.

(ix) Ecological perspective

Natural resource management of water, air and biodiversity as a whole will require attention on holistic considerations. In fact carefully designed forage based feeding systems have great potential in reducing methane production in the ruminants. Current scenario in context of livestock production systems in India reveals that the rapidly increasing trend towards commercialization is leading to intensive livestock environment. The natural resources constituting vegetation, water, air and biodiversity as a whole are at risk due to increasing livestock population and changes in climate. The important aspects may be-

- High nutrient requirement of high biomass producing genotypes under low/no fertilizer input systems is adversely affecting the soil nutrient balance.
- Due to poor addition of bulky organic manures, soil organic carbon is declining leading to reduction in total factor productivity.
- Imbalanced fertilizer application and increased mining of soil nutrients without sufficient replacement has resulted in to multi-micronutrient deficiency which is affecting the fertility and health of livestock in milkshed areas in the country.
- Indiscriminate use of chemical fertilizers and pesticides for intensive cultivation increased the risk of poor soil health in the long run.
- Production of mineral nutrient deficient fodder is also affecting livestock health and productivity.

(x) Participatory approach

Participatory mode is a modern day accepted development approach. Participatory plant breeding and technology transfer through Participatory Rural Appraisal (PRA) approaches assume special significance. The entire forage technology transfer is to be viewed in a participatory mode in an increasingly manner for its better adoption by the various clientele groups and the farmers. For effective participatory network, the issues related to research and development in production of quality forage seeds and the mechanisms for its timely marketing will require a very careful attention and also investments. The social and gender issues are extremely important in adoption of forage production technologies as the benefits and costs involved in different technologies in various conditions and on farm types.

(xi) Economic feeding of livestock

Development of feeding system is also an extremely important area for sustainability of the livestock production. Ecologically and economically sustainable feeding systems should be developed keeping in mind the type of animals, species, breeds, level and stages of physiological production. The strategies envisaged on these aspects range from forage conservation, densification, baling to feeding trials and development of low cost biological feed substitute to replace costly feeds and concentrates. Designing the area specific mineral mixtures to supplement the deficient minerals in the feeding systems to overcome the problem of mineral deficiency is another issue requiring attention. Volume reduction and value addition through post harvest management and establishment of fodder bank will provide required edge for addressing forage crisis during lean periods, drought, flood and other natural calamities. Utilizing the leaf meal of the leguminous species (both woody perennials and herbaceous) such as lucerne, stylosanthes, Leucaena hold promise to overcome the lean period fodder deficits.

(xii) Human resource development

Fast changing socio-economic scenario of the country has lead to increased demand for livestock products. The needed support from agriculture sector in projected growth of GDP in 12th plan period can be attained by accelerated growth in livestock sector. This will create demand for efficient human resource capable of handling the issues related to forage based livestock production coupled with aided environmental protection. Human resource development in the area of grassland and fodder development will require greater thrusts and support. Revival of diploma course in Forage Production and utilization at IGFRI and HRD of various stakeholders such as forestry, animal husbandry, community developers, orchard maintainers, KVKs, pastoralists, nomadic and semi nomadic tribes need to be considered.

(xiii) Developing linkages in forge based livestock production with other sectors

There is need of strengthening and enabling the forage for better livestock productivity and livelihood activities in prevailing mixed farming situations. The rural entrepreneurial capacity should be build up to enable them to earn at least four-five times the present income to overcome their poverty. This can be achieved through capacity building of communities and facilitating service provider institutions of the locality. There is need to enable the communities and households to have access to the markets and other service providing institutions. They need to be educated for getting benefit of their rightful entitlements from other government schemes. The forage resource development related activities should be tailored in harmony with the policies of central government for poverty reduction and livelihood promotion being done through various developmental and livelihood supporting projects such as Horti-Mission. MGNREGA, and the National Rural Livelihoods Mission *etc.* Credit and market linkages to forage based livestock production needs support from central and state governments to enable livestock keepers for improving their income from animal husbandry.

(xiv) Technology transfer

The technologies of forage based livestock production are percolating at very slower pace to the end users. Now strategies should be changed from simple minikit programme on cultivated fodder of DAHDF to focused technology demonstration. In the 12th plan more emphasis should be given on FLD in major forage crops with active participation of KVK network. The advancement in the information technology should be harnessed utilizing suitable ICTs.

Policy issues

Lack of momentum in feed and fodder development in the country owes much to poor organizational structure. Agriculture has come a long way through green revolution but livestock sector could not grow beyond AI and veterinary services. Livestock continues to be a subsidiary activity. Major dependence of livestock on crop residues calls for its effective post harvest processing, value

addition, densification, storage and transport.

The forage resource development is a more complex issue than food and commercial crops. Due to multiplicity of forage crops grown in different season and region, surplus and deficit in different regions, non commercial nature of crops and production of forage with minimal inputs from degraded and marginal lands has led to huge gap in fodder availability and requirement. Some of the prominent aspects related to policy are required to provide favourable environment for accelerated forage development in India are

- Collection of database of fodder production and utilization,
- investment in forage resource development,
- credit facility to forage production,
- support price for forage, marketing of seed,
- non-diversion of edible crop residues to other use like packaging,
- policy on grazing and common property resources, legal protection of grasslands, *etc.*

Forage Research and Development in Mission Mode

There are a number of technological and policy options to address the issue of fodder deficiency. The deficit is largely due to huge number of low-producing animals. This suggests a need to optimize livestock population compatible with available feed resources or improve feed resources. Replacing the low-producing animals with high-producing animals is one option. This strategy, however, is feasible only in the long run. In short run, farmers should be encouraged to allocate more area to green fodder crops. Better management of common grazing lands would add to improved fodder supplies. Further, feed deficit is localized and seasonal. In such a situation there is a need to promote commodity fodder banks where surplus fodder can be stored as hay/silage/fodder blocks for use during scarcity. Besides there are a number of technologies (urea-ammoniation of straws, total mixed ration, feed blocks) available that help better use of feed and fodder and contribute to increasing animal productivity. Their adoption, however, has remained limited. Some of the interventions for improving fodder availability are:

- Production of high yielding varieties of fodder and fodder seeds making it more remunerative. States should take up fodder seed production programme in earnest manner.
- Rehabilitation of degraded lands, management of permanent pasture/silvi-pasture cover, exploitation of forest resources, forest marginal lands and village common property lands, silvi pastoral systems *etc.*
- Establishment of fodder banks near forest covers and bringing crop residues from surplus zones to meet the fodder requirement during natural calamities and scarcity.
- Use of intensive forage production system in achieving maximum sustainable harvest of nutritive herbage per unit area and time by using multiple cropping, over lapping cropping, parallel cropping, mixed intercropping systems for quality herbage production.
- Promoting peri-urban fodder markets by increasing infrastructure facility and price regulation like food crops.
- Controlled grazing practices by regulating grazing in tune with capacity will ensure sustainability of traditional pasture.
- The grazing resources should be developed as per the grazing habits and pasture requirements of particular animal species.
- For the browser species like goats, grazing land can be predominated with nutritionally superior shrubs and tree species.
- For grazing livestock like sheep and cattle proper balance of superior quality grasses and legumes may be the major component of the pasture.
- Village common lands/ CPRs including those on forest sides are to be used for development of tree crops and fodder resources.
- Legume fodder crops like Sesbania, Subabul, Desmenthus *etc.* can be grown on wasteland, canal banks, hill slopes and field boundaries, bunds.
- Inventory of degraded lands by use of GIS in all the agro-ecological regions of India should get a priority.
- Development of forage seed production chain from nucleus seed, breeder seed to certified seed as existing in cereal and other important crops.
- NSC/SSCs to be mandated for fodder seed production targets and seed reserves should be developed for fodder crop security.
- Perennial grass as well as range legume seeds should be incorporated to improve rangeland productivity.

Some of these issues if tackled in an integrated manner and mission mode approach will help in overcoming the fodder shortage at regional and national level.