Fodder Resources Development Plan for Karnataka

भा.च.चा.अ.सं.
IGFRI

ICAR- Indian Grassland and Fodder Research Institute
Jhansi-284 003 (UP) India

An ISO 9001:2015 Certified Institute

Sardar Patel Award for Outstanding ICAR Institute (Large) for 2015

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...a policy paper

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Director General (ICAR)

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Message

It gives me immense pleasure to learn that the State specific, "Fodder Resources Development Plan", has been developed by the ICAR-Indian Grassland and Fodder Research Institute, Jhansi for Karnataka, in consultation with all the stakeholders from the state, under the program 'National Initiatives on Accelerating Fodder Technology Adoption (NIAFTA)'.

Agriculture plays an important role in the overall growth of Karnataka's economy despite a fall in its share in the state domestic product. It is also well known for floriculture production and is a major silk-producing state in the country. The per capita availability of milk is lesser than the national average. This may be attributed to low milk yielding indigenous breeds, poor feeding and lesser availability of quality fodder. In spite of having a large livestock population the proportion of fodder availability to meet the fodder demand in the state is low. I hope, the state fodder development plan for Karnataka will be able to address these issues in an effective manner.

I appreciate the efforts made by ICAR-IGFRI, Jhansi in bringing out this much needed document for the State of Karnataka.

(Himanshu Pathak)

7th June, 2023
New Delhi

Fodder Resources Development Plan for Karnataka state prepared as a part of

National Initiative for Accelerating Fodder Technology Adoption (NIAFTA)

ICAR-Indian Grassland and Fodder Research Institute, Jhansi

Themes of NIAFTA

- Developing state fodder resources development plan.
- Disseminating fodder production technologies for enhanced productivity and improved management.
- Promoting alternate land usage.
- Focusing fodder based rationing.
- Utilizing fodder processing technologies for value addition.

NIAFTA Coordination Team

Dr. Amaresh Chandra, Director	Chairman
Dr. Purushottam Sharma, PS & Head	Nodal Officer
Dr. V.K. Yadav, PS & Head	Member
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Dr. B.G. Shivkumar	Chairman
Dr. N. Biradar	Member
Dr. K. Sridhar	Member
Dr. N.S. Kulkarni	Member

Acknowledgement

The fodder resource development plan provides technological options available for enhancing production, conservation and value addition of fodder resources of the state of Karnataka. It is prepared with an objective to provide executable plan for the state government and other agencies involved in livestock and fodder related sector. It deals with area specific strategy which can be adopted to enhance the forage resource for better livestock output and increasing the livelihood options of the rural community.

Looking into the shortage of green and dry fodder in the country, the idea and vision of the development of state-wise fodder plans for different states of the country were visualized by Prof. Trilochan Mohapatra, Ex Secretary DARE, and Director General, ICAR. He advised to develop a state-wise fodder resource development plan which covers the broad areas as per the requirement of the state. We are highly grateful to him for his insight, guidance, encouragement, continuous support and suggestions in preparing this document. We extend our sincere thanks to Prof. Himanshu Pathak, Hon'ble Secretary DARE, and Director General, ICAR for motivating us for continuation of this important activity. We are also thankful to the Deputy Director General (Crop Science), ADG (FFC) and other officers of the ICAR who extended their support during the development of the fodder plan of Karnataka. ICAR-IGFRI greatly acknowledge the august presence and the support of Dr. M.B. Chetti, Vice Chancellor, UAS, Dharwad, Dr. Rajendra Prasad, Vice Chancellor, UAS, Bengaluru, Dr. H.D. Narayanaswamy, Vice Chancellor, Karnataka Veterinary, Animal and Fisheries Sciences, Bidar.

The efforts made by our team from ICAR-IGFRI, Jhansi in preparation of fodder plan for the state of Karnataka and organizing interactive workshop are praise worthy. This fodder plan is prepared as a part of the activities of our programme 'National Initiatives on Accelerating Fodder Technology Adoption (NIAFTA)', whole team of the programme and Nodal Officer, Dr Purushottam Sharma, Principal Scientist, deserves special appreciation.

(Amaresh Chandra)
Director
ICAR-IGFRI, Jhansi

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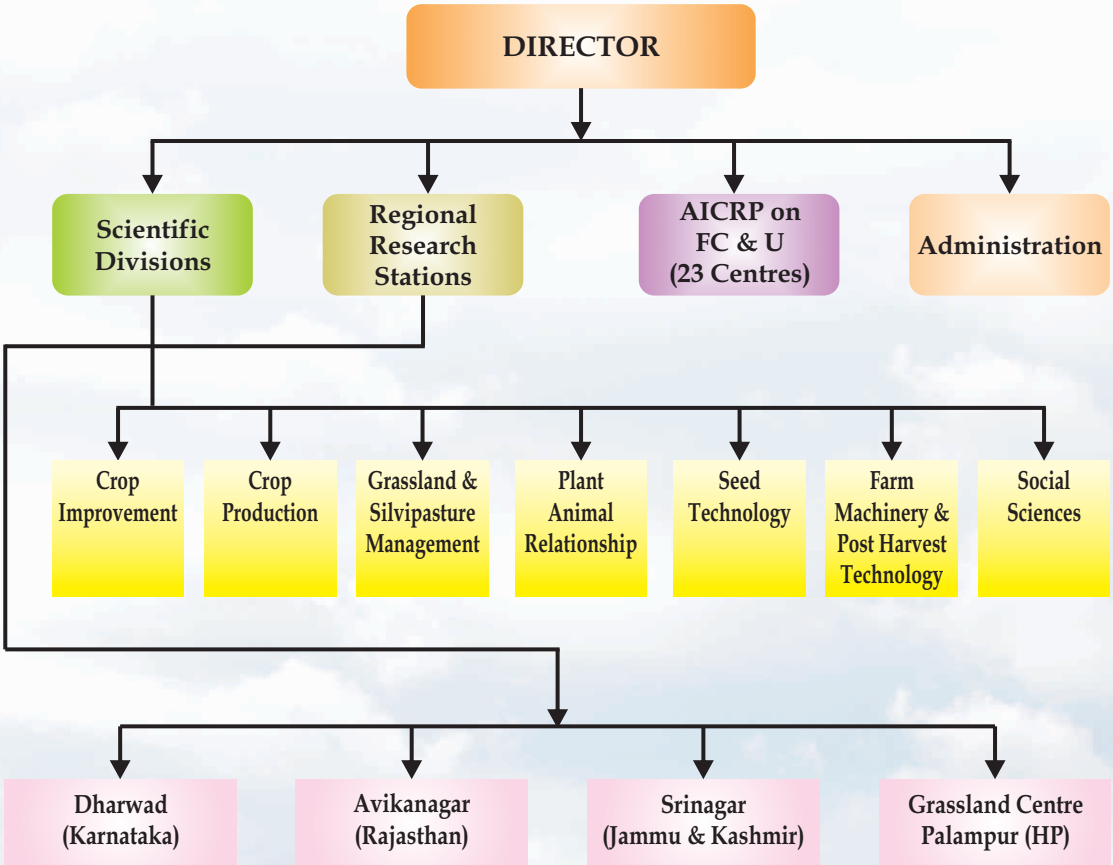
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IGFRI
Grassland

ICAR-IGFRI - A Profile

ICAR-Indian Grassland and Fodder Research Institute, Jhansi (U.P.) India

The ICAR-Indian Grassland and Fodder Research Institute (ICAR-IGFRI), Jhansi, was established in 1962 to conduct scientific research on grasslands and fodder production, conservation and their utilization. On 1 April, 1966, it became part of the Indian Council of Agricultural Research (ICAR). Subsequently All India Coordinated Research Project on Forage Crops and Utilization was started in 1972 with ICAR-IGFRI, Jhansi as head quarter for multi-location testing of forage varieties and technologies in different agro climatic zones of the country through 23 coordinating centers and 15 as volunteer centers at various State Agricultural Universities/NGO/ICAR under the National Agricultural Research System. The institute consists of seven multi-disciplinary division *viz.*, Crop Improvement, Crop Production, Farm Machinery and Post-Harvest Technology, Seed Technology, Social Science, Grassland and Silvipasture Management and Plant Animal Relationship. It also has five units *viz.*, PME, HRD, ATIC, ITMU and AKMU and facilities like Library, Central Research Farm, Dairy and Central Instrumentation Lab. The institute has three regional stations located in Avikanagar (Rajasthan), Dharwad (Karnataka) and Srinagar (Jammu & Kashmir) to conduct focused forage research on arid, semi-arid and temperate climatic conditions, respectively and a grassland center at Palampur (Himachal Pradesh). Recently, ABIC has been established to develop and provide entrepreneurship skills in technologies generated by the institute as well as incubation center to train and skill upliftment.

Mandate

- Basic strategic and adaptive research on improvement, production and utilization of fodder crops and grasslands.
- Coordination of research on forages and grasslands for enhancing productivity and quality for enhancing livestock productivity.
- Technology dissemination and human resource development.

The institute has successfully served the country for 60 years achieving several milestones in generation of fodder technologies. Institute was conferred with "Sardar Patel Outstanding ICAR Institution Award in the year 2015" for its outstanding progress and contributions in the field of forage research, capacity building and infrastructure development. ICAR-IGFRI is an ISO 9001:2015 certified institute. The institute is endeavoring in basic and applied research in both cultivated as well as range species in the fields of intensive fodder production systems, alternative fodder sources,

grasslands, silvi and horti-pasture systems, seed production technology, farm mechanization, post-harvest conservation and utilization, livestock feeding and management, *etc.* Institute is striving through numerous research projects at various levels like institute, inter-institute, externally funded national and international collaborative projects to address the persistent problems of fodder shortage and lack of quality forages. The institute is undertaking several new initiatives in forage research in new frontier areas.

Proven Technologies of Institute

- No. of forage varieties released: >300
- Climate resilient forage production systems under rainfed situation
- Round the year fodder production systems (Irrigated situation)
- Round the year fodder production systems (Rainfed situation)
- Fodder on Field boundary/Bunds/Channels
- Alternate land use systems
- Silvi-pasture models for highly degraded/ waste lands
- Horti-pastoral models for higher income in rainfed ecosystem
- Azolla as supplement feed for livestock
- Silage for sustenance of livestock production
- Community pastureland development
- Fodder production in mango orchards
- Improved varieties of grasses and cultivated fodder
- Seed production technology for all important forages
- Seed quality and field standards of forage crops
- DUS guidelines for forage crops.

Accelerating Fodder Technology adoption

Transferring knowledge and skills are the essential component required for execution and implementation of resource conservation based projects in the country. The institute is organizing training and skill development programmes regularly of varying duration for farmers, students, state government officials, field functionaries in the field of soil and water conservation. The ICAR-IGFRI has signed MoUs with more than 20 Gaushalas for transfer of fodder production technologies. The MoU of ICAR-IGFRI are for collaboration on education, technology dissemination and providing consultancy on different proven technologies. Field demonstration on validated technologies for resource conservation and productivity enhancement in red soils of Bundelkhand region are operating at full fledge. Several outreach programmes such as Adarsh Chara Gram (a cluster of three villages), Mera Gaon Mera Gaurav (MGMG),

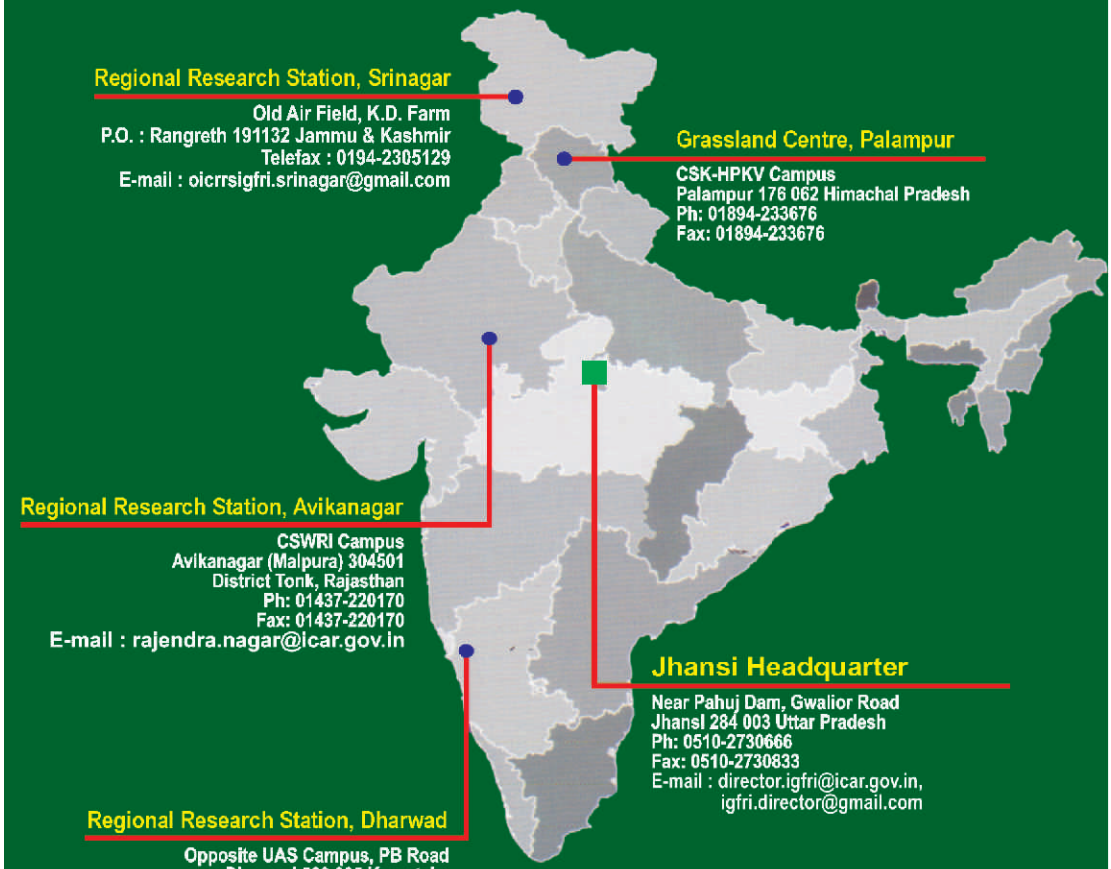
National Initiative on Fodder Technology Demonstration (NIFTD), Network Project on Bhadawari Buffaloes, Participatory Fodder Production in Mango Orchards, Farmers FIRST Programme, NICRA, TSP, SCSP, NEH, DFI-Kisan Mitra and NIAFTA have been initiated and implemented.

NIAFTA: New Initiative

Institute has initiated "National Initiative for Fodder Technologies Adoption (NIAFTA)" to formulate an implementable fodder resource development plan for each state/UT of the country suitable to specific niches which can utilize the potential of available resources to achieve self-sufficiency in fodder production and utilization. NIAFTA also aims for extension of latest research findings/technologies with the policy planners, management personnel and field level functionaries for enhancing country's fodder productivity, capacity building and skill enhancement of the fodder producers and livestock keepers on emerging technologies and also provide opportunity to interact with scientists and managers and impact assessment on fodder supply and farmers livelihood.

ICAR-Indian Grassland and Fodder Research Institute

https://igfri.icar.gov.in



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Part-I : Agriculture, Livestock and Fodder Scenario

A. Introduction

Karnataka state is located in the south western region of India between 11°30' North and 18°30' North latitudes and 74°00' East and 78°30' East longitudes. It was formed on 1st November 1956, with the passage of the States Reorganization Act. Originally known as the State of Mysore, it was renamed *Karnataka* in 1973. The state corresponds to the Carnatic region. The capital and the largest city is Bengaluru.

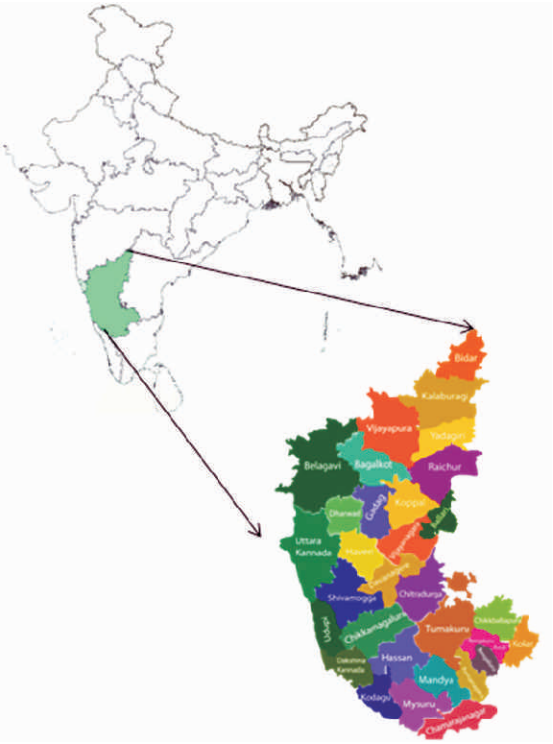

Figure 1: Geographical location of Karnataka

Karnataka is bordered by the Arabian Sea to the west, Goa to the northwest, Maharashtra to the north, Telangana to the northeast, Andhra Pradesh to the east, Tamil Nadu to the southeast, and Kerala to the south (Figure 1). It is the only southern state to have land borders with the other entire 4 south Indian sister states. The state covers an area of 1,91,976 square kilometers (74,122 sq miles), or 5.83 per cent of the total geographical area of India. It is the sixth largest Indian state by area. With 6,11,30,704 inhabitants as per the 2011 census, Karnataka is the eighth largest state by population, comprising 31 districts. Kannada, one of the classical languages of India, is the most widely spoken and official language of the state. The two main river systems of the state are the Krishna and its tributaries, the Bhima, Ghataprabha, Vedavathi, Malaprabha and Tungabhadra in north Karnataka and the Kaveri and its tributaries, the Hemavati, Shimsa, Arkavati, Lakshmana Thirtha and Kabini, in south Karnataka. Most of these rivers flow out of Karnataka eastward, reaching the sea at the Bay of Bengal. Other prominent rivers such as the Sharavati in Shivamogga district and Netravati in Dakshin Kannada district flow westward, reaching the Arabian sea.

Climate

The state of Karnataka experiences four seasons. The winter in January and February is followed by summer between March and May, the monsoon season between June and September and the post-monsoon season from October till December.

Meteorologically, Karnataka is divided into three zones – coastal, north interior and south interior. Of these, the coastal zone receives the heaviest rainfall with an average rainfall of about 3,638.5 mm (143 inches) per annum, far in excess of the state average of 1,139 mm (45 inches). Amagaon in Khanapura taluka of Belagavi district received 10,068 mm (396 inches) of rainfall in the year 2010. In the year 2014, Kokalli in Sirsi taluka of Uttara Kannada district received 8,746 mm (344 in) of rainfall. Agumbe in Thirthahalli taluka and Hulikal of Hosanagara taluka in Shivamogga district were the rainiest places in Karnataka, forming one of the wettest regions in the world. The highest recorded temperature was 45.6 °C (114 °F) in Raichuru district. The lowest recorded temperature was 2.8 °C (37 °F) at Bidar district.

Land use scenario

The state of Karnataka is predominantly an agricultural state with a net sown area of 10.81 million ha accounting for 56.76% of the total geographical area. Forest is spread over an area of 3.07 million ha (16.13%). There is a sizeable land (11.9%) under non-cultivable area having scope for introduction of fodder crops in one or other way. Permanent pastures (8.71 lakh ha), trees and groves (2.37 lakh ha) and fallow land (14.12 lakh ha) constitute remaining land use pattern. With more than 39.2% area irrigated to new sown area and remaining under rainfed condition agriculture is quite vibrant with variety of food and horticultural crops besides commercial and plantation crops (Table 1 and Figure 2).

Table 1. Land use pattern in Karnataka

Sl.No.	Land utilization	Area (ha)	Percent
1	Total reported geographical area	19050068	100
2	Forest	3073376	16.13
3	Land not available for cultivation	2262532	11.88
	Non-agricultural uses	1511022	7.93
	Barren and uncultivable land	751510	3.94
4	Cultivable waste land	389840	2.05
5	Permanent pastures	871469	4.57
6	Trees and groves	237913	1.25
7	Fallow land	1412548	7.41
	Current fallow	927053	4.87
	Other fallow	485435	2.55
8	Area sown	13829027	72.59
	Net sown	10812391	56.76
	More than once	3026636	15.89
9	Gross irrigated area	5034344	26.43
	Net irrigated area	4234798	22.23
	Area irrigated to net sown area	-	39.20

Source: GOK, 2022

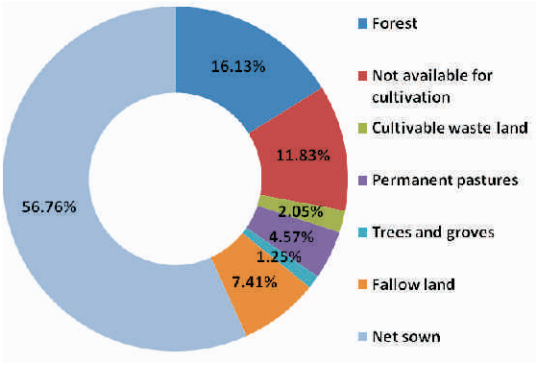

Figure 2: Land use pattern in Karnataka

More than half of the land holders fall under the category of marginal (54.92%) with an average land holding of 0.44 ha followed by small (25.50%) and semi-medium (13.74%) with an average land holding of 1.40 and 2.67, respectively. The medium and large land holders together constitute <6 per cent of the total land holder in the state with an average land holding of 5.6 and 15.45 ha, respectively. The medium and large holdings are primarily observed in dry and rainfed areas of the state (Table 2 and Figure 3).

Table 2. Land holding pattern in Karnataka

Size group	No. of Holdings	% to Total	Area (Lakh ha)	% to Total	Average size of holdings (ha)
Marginal (<1 ha)	4767132	54.92	2080094.86	17.62	0.44
Small (1-2 ha)	2213732	25.50	3107118.51	26.32	1.40
Semi medium (2-4 ha)	1192724	13.74	3188190.63	27.01	2.67
Medium (4-10 ha)	451445	5.20	2568761.96	21.76	5.69
Large (>10 ha)	55706	0.64	860931.49	7.29	15.45
Total	8680739	100.00	11805097.15	100.00	1.36

Source: GOK, 2022

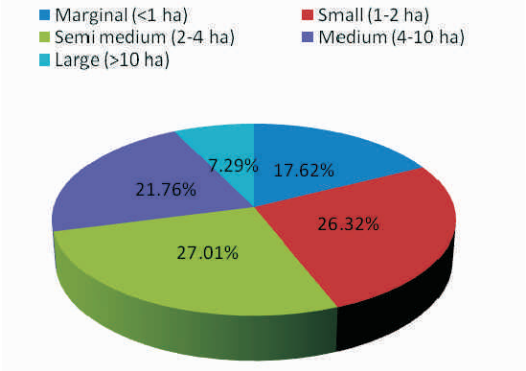

Figure 3: Land holding pattern in Karntaka

General Agricultural Scenario

In Karnataka, agriculture is the major occupation for a majority of the rural population. Agriculture contributes about 13.15% to states GSDP. As per the population Census 2011, agriculture supports 13.74 million workers, of which 23.61% are cultivators and 25.67% agricultural workers. A total of 1,38,29,027 ha of land is cultivated in Karnataka constituting 72.59% of the total geographical area of the state. The agricultural sector of Karnataka is characterized by vast steppes of drought prone region and sporadic patches of irrigated area. Thus, a large portion of agricultural land in the state is exposed to the vagaries of monsoon with severe agro-climatic and resource constraints. Agriculture employs >60% of Karnataka's workforce. Agriculture in Karnataka is heavily dependent on the southwest monsoon. Only 26.43% of the sown area is under irrigation. Many cereal crops, pulses, oilseed crops besides commercial crops are grown in different parts of the state (Table 3). About ten crops occupy 80% gross cropped area. The state has a substantial area under horticulture. Many fruit, vegetable and plantation crops are grown in a big way (Table 4). It ranks among top five states in India in production of vegetable crops and fruit crop production. It is also one of the largest producers of spices, aromatic and medicinal crops and tropical fruits. Karnataka is the third largest producer of sugar and ranks fourth in sugarcane production. In floriculture, Karnataka occupies the second position in India. Agriculture plays an important role in the overall growth of Karnataka's economy despite a fall in its share in the state domestic product. It is also well known for floriculture and is a major silk-producing state in the country.

Table 3. Principal crops grown in Karnataka

Sl.No.	Name of crop	Area (ha)	Production (tonnes)	Productivity (kg/ha)
I	**Cereals**			
1	Rice	1248114	3947973	3330
2	Jowar	913988	1045642	1204
3	Bajra	338952	367056	1140
4	Maize	1500393	4745711	3329
5	Ragi	673713	1162531	1816
6	Wheat	158319	180114	1198
7	Other cereals and minor millets	52382	38089	765
8	Total	4885861	11487116	2475
II	**Pulses**			
1	Redgram	1626391	1125991	729
2	Horsegram	169911	121857	755

3	Blackgram	71611	33656	495
4	Greengram	403755	141003	368
5	Fieldbean	46869	40473	909
6	Cowpea	45740	15057	347
7	Bengalgram	908637	674750	782
8	Other pulses	4089	2594	641
9	Total pulses	3277003	2155381	592
10	Total cereals and pulses	8162864	13642497	1759
III	**Flowers**	**30975**	**-**	**-**
IV	**Oilseeds**			
1	Groundnut	530181	503425	1000
2	Sunflower	135592	103331	802
3	Safflower	26593	24556	972
4	Castor	4144	3818	970
5	Sesamum	30964	26306	894
6	Niger and Mustard	1229	299	248
7	Soybean	336854	378700	1183
8	Linseed	818	399	513
9	Oilpalm and Jatropha	1066	-	-
10	Total oilseeds	1067437	1040834	1027
V	**Commercial crops**			
1	**Cotton**	**817213**	**2329550 (Bales)**	**485**
2	**Sugarcane**	**430668**	**36034027**	**83670**
3	**Tobacco**	**94963**	**83000**	**874**
4	**Fibre crops**	**2937**	**-**	**-**

Source: GOK, 2022

Table 4. Principal horticultural crops grown in Karnataka

Sl.No.	Name of crop	Area (ha)	Production (tonnes)	Productivity (kg/ha)
I	**Fruit crops**			
	Banana	101676.90	2775069	27.293
	Mango	171111.74	1559728	9.115
	Lemon	15388.21	362035	23.527

	Pineapple	2356.38	133596	56.695
	Guava	6091.27	123143	20.216
	Grapes	28059.25	678949	24.197
	Sapota	9333.01	115533	12.379
	Pomegranate	28135.68	285161	10.135
	Papaya	4699.69	391221	83.244
	Orange	4543.48	-	-
	Watermelon	6390.13	-	-
	Others	25943.74	-	-
	Total	403729.48	-	-
II	**Vegetables**			
	Tomato	68703.08	2452402	35.696
	Brinjal	10623.70	269849	25.401
	Cucumber	7416.94	-	-
	Beans	11858.43	131220	11.066
	Clusterbean	1763.00	16127	9.147
	Cabbage	9403.40	-	-
	Ridgegourd	4475.57	-	-
	Bittergourd	2083.12	-	-
	Snakegourd	338.95	-	-
	Bottlegourd	1291.06	-	-
	Total gourds	-	345137	-
	Raddish	1884.97	-	-
	Onion	199767.56	353327	1.769
	Beetroot	2392.24	-	-
	Carrot	4081.03	-	-
	Knolkhol	661.17	-	-
	Ladies finger	5160.83	-	-
	Green chillies	39882.60	688381	17.260
	Potato	28644.69	437286	15.266
	Pumpkin	2620.78	-	-
	Cauliflower	3918.55	-	-

	Leafy vegetables	21619.25	95457	4.415
	Others	22550.70	-	-
	Total vegetables	451139.72	-	-
III	**Condiments and spices**	**511286**	**-**	**-**
IV	**Coconut**	**610323**	**5030774 (nuts)**	**8243 (nuts/ha)**
V	**Arecanut**	**500522**	**1081840 (Processed)**	**2.161**
VI	**Total plantation crops**	**340342**	**-**	**-**

Source: GOK, 2022

A standout feature of Karnataka's economy is the significant contribution of the services sectors. In financial year 2020, the services sector contributed 66.3% to gross state value added (GSVA), followed by 21.3% by the industry sector and 12.3% by the agriculture sector. In Karnataka, crops had the lowest compound annual growth rate (CAGR) among the major groups — at 7.6 per cent, compared to 9.8 per cent for fruits & vegetables, 23% for condiments & spices, 11% for livestock and 9.2 per cent for fishing & aquaculture (Table 5).

Table 5. Gross value output (GVO) of different crop groups at current prices in Karnataka (Rs. in crores)

Sector	2011-12	2013-14	2015-16	2017-18	2018-19	CAGR
Crop	36,990	48,976	50,316	57,221	61,748	7.6%
Fruits & vegetables	14,703	19,711	24,148	28,605	28,254	9.8%
Condiments & spices	6,297	9,495	14,508	20,373	26,648	22.9%
Drugs & narcotics	6,444	5,722	6,999	8,317	8,091	3.3%
Livestock	18,936	23,933	28,242	35,187	39,829	11.2%
Forestry and logging	7,083	7,894	10,054	10,408	12,315	8.2%
Fishing and Aquaculture	3,229	4,532	5,042	7,503	5,969	9.2%
Agriculture, forestry and fishing	93,682	1,20,263	1,39,308	1,67,614	1,82,854	10.0%

Source: ESK, 2022.

Agriculture remains the primary activity and main source of livelihood for the rural population in the state. It is characterized by wide crop diversification and remains highly dependent on the vagaries of the southwest monsoon.

B. Agro-climatic zones

There are 10 distinct agro climatic zones in Karnataka on the basis of rainfall pattern-quantum and distribution, soil types, texture, depth and physico-chemical properties, elevation, topography, major crops grown and type of vegetation (Table 6; Figure 4).

Table 6. Agro climatic zones of Karnataka

Zone number and Name	District (No. of Talukas)	Name of Talukas
1. North Eastern Transition Zone	Bidar (5) & Gulbarga (2).	Aland, Bhalki, Basvakalyan, Bidar, Chincholi, Humnabad, Aurad Afzalpur, Chitapur,
2. North Eastern Dry Zone	Gulbarga (5) Yadgir (3) & Raichur (3)	Gulbarga, Jewargi, Sedum, Shahapur, Yadgir, Shorapur, Raichur, Deodurga, Manvi Gangavathi, Koppal, Kushtagi, Lingasugur,
3. Northern Dry Zone	Koppal (4), Gadag (4), Dharwad (1), Belgaum (5), Bijapur (5), Bagalkot (6), Bellary (7), Davangere (1), Raichur (2)	Sindhanur, Yelburga, Badami, Bagalkote, Bagewadi, Bilgi, Bijapur, Hungund, Indi, Jamkhandi, Mudhol, Muddebihal, Sindhagi, Bellary, Hagaribommanahalli, Harapanahalli, Hadagali, Hospet, Kudligi, Sandur, Siruguppa, Ron, Navalgund, Naragund, Gadag, Mundargi, Ramdurga, Gokak, Raibag, Soundatti, Athani
4. Central Dry Zone	Chitradurga (6), Davangere (3), Tumkur (6), Chickmagalur (1), Hassan (1)	Challakere, Chitradurga, Davanagere, Harihara, Hiriyur, Hosadurga, Holalkere, Jagalur, Molkalmuru, Arasikere, Kadur, Madhugiri, Pavagada, Koratagere, C.N. Halli, Sira, Tiptur
5. Eastern Dry Zone	Bangalore Rural (4), Ramanagar (4) Bangalore Urban (3), Kolar (5), Chikkaballpur (6) Tumkur (2).	Gubbi, Tumkur, Anekal, Bangalore South, Bangalore North, Channapatna, Devanahalli, Doddabalapur, Hosakote, Kankapura, Magadi, Nelmangala, Ramanagar, Bagepalli, Bangarpet, Chikkabalapur, Chintamani, Gudibanda, Gowribidanur, Kolar, Malur, Mulbagal, Sidlaghatta, Srinivasapura
6. Southern Dry Zone	Mysore (4), Chamarajnagar (4), Mandya (7), Tumkur (2), Hassan (2).	K.R. Nagar, T. Narasipur, Mysore, Kollegal, Nanjangud, Turuvekere, Kunigal, Nagamangala, Maddur, Srirangapatna, Malavalli, Mandya, Pandavapura, K.R.Pet, Hassan, Channarayapatna, Chamarajanagar, Yelandur, Gundlupet
7. Southern Transition Zone	Hassan (4), Chickmagalur (1), Shimoga (3), Mysore (3), Davanagere (2).	H.D. Kote, Hunsur, Periyapatna, H.N.Pura, Alur, Arkalgud, Belur, Tarikere, Bhadravathi, Shimoga, Honnali, Shikaripura, Channagiri.
8. Northern Transition Zone	Belgaum (4), Dharwad (3), Haveri (6), Gadag (1).	Hukkeri, Chikodi, Bailhongal, Hubli, Belgaum, Shiggaon, Savanur, Haveri, Byadgi, Shirahatti, Kundagol, Dharwad, Hirekerur, Ranebennur.

9. Hilly Zone	Uttara Kannada (6), Belgaum (1), Dharwad (1), Haveri (1), Shimoga (4), Chickmagalur (5), Kodagu (3), Hassan (1)	Sirsi, Siddapura, Yellapura, Supa, Haliyal, Mundgod, Khanapur, Soraba, Hosanagar, Sagar, Koppa, Thirthahalli, Sringeri, Mudigere, Narasimharajapur, Chickmagalur, Kalaghatagi, Hangal, Sakleshpur, Virajpet, Somwarpet, Madikere.
10. Coastal Zone	Udupi (3), D. Kannada (5), U. Kannada (5)	Karwar, Kumta, Honnavar, Bhatkal, Ankola, Bantwal, Udupi, Karkala, Belthangadi, Kundapura, Mangalore, Puttur, Sulya.

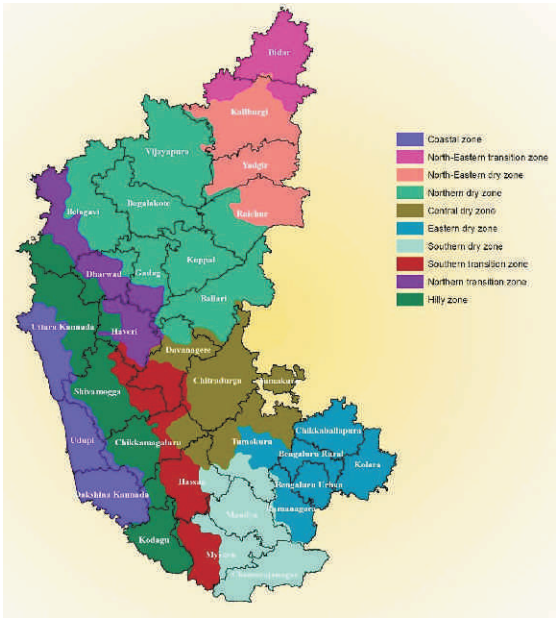

Figure 4: Agro-climatic zones of Karnataka

Soils, Seasons and Crops

There are varied types of soils in Karnataka. Six broad groups of soil orders are recognized, based on differences in soil formation processes, as reflected in the nature and sequence of soil horizons. Black soils are found in northern Karnataka whereas red and red loamy soils are prominent in southern Karnataka. Laterite soils are found in *malnad* and coastal areas of the state. Karnataka receives 3 distinct seasonal rains *viz.*, pre-monsoon also called early *kharif* from April to May in the districts of Mysuru, Chamarajnagar, Mandya, Chikkamagalur, Chitradurga, Tumakuru; south-west monsoon also called *kharif* from June to September in all the districts of the state and north-east monsoon also called as *rabi* in the districts of Bengaluru, Kolar, Chikkaballapur, Ballari, Koppal and Raichur. The State receives 80% of the annual rainfall in the southwest monsoon period, 12% in the post-monsoon period, 7 per cent

in the summer and only 1 per cent in winter. Droughts present a serious problem in the state with about two-thirds of the state having 750 mm or less annual rainfall. The severity and extent of drought not only depends on low rainfall but also on other hydro-meteorological factors like soil moisture, infiltration and moisture-retention capacity of the soil. The agro-climatic conditions of the state permit the cultivation of different types of crops. Some of the important crops grown are cereals like rice, jowar, bajra, maize, wheat, ragi and minor millets; pulses like redgram, bengal gram, horse gram, black gram, green gram, cowpea etc; oil seeds like groundnut, sesamum, sunflower, soybean and safflower; commercial crops like sugarcane, cotton and tobacco. Depending upon the soil type, rainfall, irrigation etc., a variety of field crops and plantation and horticultural crops are grown in the state of Karnataka. Agricultural crops like bajra, jowar, minor millets redgram, sesamum, castor and niger are purely *kharif* crops. Wheat, *rabi* jowar and safflower are cultivated in the *rabi* season. Cereal crops like paddy, jowar, ragi and maize can be grown in all the three seasons. Pulses too are grown in all seasons. Among oil seed crops, groundnut and sunflower are grown during all seasons. In Karnataka, the *kharif* crops are cultivated in all the agro climatic zones. The *rabi* crops are mostly cultivated in the northeastern dry and the northern dry zones. The salient features of each agro-climatic zone are presented below.

1 ***North Eastern Transition Zone:*** The annual rainfall in this region varies from 830-890 mm. About 63% of the rainfall is received during the *kharif* season. The elevation ranges between 800-900 m in major areas. The soils are shallow to medium black, clay in major areas and lateritic in the remaining areas. The important crops grown are pulses, jowar, oilseeds, bajra, cotton and sugarcane. The total geographical area of this zone is 0.871 million ha.

2 ***North Eastern Dry Zone:*** This zone covers an area of 1.762 million ha. The annual rainfall varies from 633.2 to 806.6 mm. About 55% of the rainfall is received during *rabi* season. The elevation ranges from 300-450 m in all taluks. The soils are deep to very deep black clay in major areas and shallow to medium black in minor pockets. The principal crops grown are *rabi* jowar, bajra, pulses, oilseeds and cotton.

3 ***Northern Dry Zone:*** This zone covers an area of 4.78 million ha. The annual rainfall ranges from 464.5-785.7 mm and about 52% of the annual rainfall is received during *rabi* season. The elevation is between 450-900 m. The soils are shallow to deep black clay in major areas. The important crops grown here are *rabi* jowar, maize, bajra, groundnut, cotton, wheat, sugarcane and tobacco.

4 ***Central Dry Zone:*** This zone covers an area of 1.943 million ha. The annual rainfall ranges from 453.5-717.7 mm of which more than 55 % is received in *kharif* season. The elevation ranges between 450-900 m and the soils are red sandy loams in major areas, shallow to deep black in the remaining areas. The principal crops grown are ragi, jowar, pulses and oilseeds.

5 ***Eastern Dry Zone:*** This zone consists of an area of 1.808 million ha. The annual rainfall ranges from 679.1-888.9 mm. More than 50% of it is received during the *kharif* season. The elevation is 800-900 m and the soils are red loamy in major areas, lateritic in the remaining areas. The main crops are ragi, rice, pulses, maize and oil seeds.

6 ***Southern Dry Zone:*** This zone extends over an area of 1.739 million ha. The annual rainfall ranges from 670.6-888.6 mm of which more than 50% rain is received in *kharif* season. The elevation is 450-900 m and the soils are red sandy loam in major areas and red loamy in the remaining areas. The principal crops grown are rice, ragi, pulses, jowar and tobacco.

7 ***Southern Transition Zone:*** This zone comprises an area of 1.218 million ha. The annual rainfall ranges from 611.7-1053.9 mm. More than 60% of the rain is received in *kharif* season. Soils are red sandy loam in major areas and red loamy in the remaining areas. The principal crops grown are rice, ragi, pulses, jowar and tobacco.

8 ***Northern Transition Zone:*** This zone comprises an area of 1.194 million ha. The annual rainfall ranges from 619.4-1303.2 mm. About 61% of rainfall is received in *kharif* season. The elevation is 450-900 m and the soils are shallow to medium black clay and red sandy loam in equal proportions. The main crops grown are rice, jowar, groundnut, pulses, sugarcane and tobacco.

9 ***Hilly Zone:*** This zone covers an area of 2.56 million ha. The annual rainfall received ranges from 904.4-3695.1 mm. About 75% of it is received in *kharif* season. The soils are red sandy loam in major areas. The principal crops are rice and pulses.

10 ***Coastal Zone:*** This zone comprises of an area of 1.167 million ha. The annual rainfall ranges from 3010.9-4694.4 mm of which 80% is received in *kharif* season. The elevation is less than 300-800 m and the soils are red lateritic and coastal alluvial. The crops grown are rice, pulses and sugarcane.

C. Interactive Workshop - IGFRI and State Departments

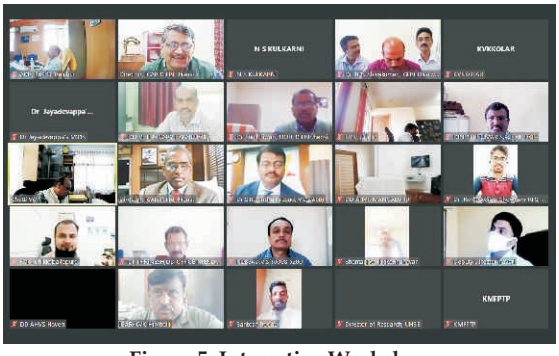

Figure 5: Interactive Workshop

An online interactive workshop was held on 16th February 2022 with all the stake holders to elicit their opinion on the fodder resources availability in the state of Karnataka and to get suggestions for improving the fodder availability. Dr. Amaresh Chandra, Director, Indian Grassland and Fodder Research Institute, Jhansi, Dr. M.B. Chetti, Vice Chancellor, UAS, Dharwad, Dr. Rajendra Prasad, Vice Chancellor, UAS, Bengaluru, Dr. H.D. Narayanaswamy, Vice Chancellor, Karnataka

Veterinary, Animal and Fisheries Sciences, Bidar, Dr. Manjunath Palegar, Director of Animal Husbandry and Veterinary Services, Govt. of Karnataka, Dr. C. Nandini Kumari, Director, Department of Agriculture, Govt. of Karnataka, Directors of Research, UAS, Raichur, UHS, Bagalkot, Karnataka State Rural Development and Panchayat Raj University, Gadag, Director of Extension, UAHS, Shivamoga, Scientists of Indian Grassland and Fodder Research Institute Jhansi, Heads of Krishi Vigyan Kendras, Joint Directors, Deputy Directors of Department of Animal Husbandry, Agriculture, Dr. Shashikant Kulkarni, Advanta Seeds, Hyderabad, fodder seed producing progressive farmers etc. participated in the workshop. Dr. Amaresh Chandra, in his welcome address, highlighted the fodder scenario in the country and achievements attained by the Indian Grassland and Fodder Research Institute, Jhansi. He appealed all the participants to highlight the fodder related issues and ways of overcoming the shortage of fodder through innovative programme. All the Vice Chancellors, Directors of Research, Director, AHVS, expressed their concern about the continued fodder shortage and its ramification on the animal husbandry and dairying in the State. They highlighted the ways and means of overcoming the shortages through increased fodder production by undertaking suitable programmes without affecting the existing agricultural and horticultural practices. Dr. B.G. Shivakumar presented the Karnataka Fodder Resource Development Plan. He highlighted the agricultural, animal husbandry and fodder scenario in the state. He further presented the various possible measures to augment the fodder production and brief outline of the proposed plan. Dr. K. Sridhar, Dr. Sultan Singh, Dr. Purushottam Sharma and Dr. P.K. Pathak spoke about the varieties, animal nutrition and farm machineries in the process of fodder plan implementation in the State. There was detailed discussion after the presentations and several suitable suggestions were made by the participants. Dr. M.B. Chetti in his Chairman address highlighted all the suggestions for taking care in the proposed fodder plan. Dr. Amaresh Chandra in his concluding remarks urged all stake holders to actively participate in the fodder plan implementation and make it successful. At the end, Dr. N.S. Kulkarni proposed vote of thanks. About 150 participant for across SAUs, ICAR Institutes, IGFRI, KVKs, Department of AHVS, Agriculture, Karnataka Milk Federation, Progressive Farmers, Fodder Seed producers, private industry *etc.*, took part in the workshop and contributed for the successful implementation of the proposed Karnataka Fodder Resources Development Plan (Annexure I)

D. Livestock Scenario

Karnataka is one of the bigger states in India having 31 districts, 227 tehsils comprising about 6019 Gram Panchayats. Animal husbandry and dairy farming are important sources of supplementary income to farmers. Livestock also helps in reducing the variability in income of farm families and insulate them from risks of crop failure owing

to vagaries of monsoon. Animal husbandry contributes about 3.53 per cent to the GSDP of Karnataka and roughly 22% to the state GSDP generated from agriculture as a whole. The livestock density in Karnataka stands at 151 per square kilometer with 77,914 livestock per lakh population. Karnataka is a leading state in milk production in the country and has a good network of milk co-operative societies, milk-chilling plants, veterinary hospitals, artificial insemination centers *etc.* With a production of 7.90 million tonnes of milk, 2.54 lakh tonnes of meat and 3.06 thousand tonnes of wool, Karnataka contributes for 4.21 per cent, 3.13 per cent and 7.57 per cent of the national production and stands 11th, 10th and 4th among all the states in milk, meat and wool, respectively in the country (Table 7). However, its contribution is much lower than the smaller states like Punjab, Haryana, Tamil Nadu, Bihar *etc.* owing to the fact that the productivity of milk is low in the State. Thus, the per capita availability of milk is lesser than the national average. This may be attributed to low milk yielding indigenous breeds, poor feeding and lesser availability of quality fodder.

Table 7. Milk, meat and wool production in Karnataka

Sl. No.	Particulars	India	Karnataka	% of India	Rank among states
1	Milk (million tonne)	187.75	7.90	4.21	11
2	Meat (Lakh tonnes)	81.14	2.54	3.13	10
3	Wool ('000 tonnes)	40.42	3.06	7.57	4

(Source: BAHS, 2019)

Karnataka is a leading animal husbandry state in the country with total livestock population of more than 29 million, comprising of cattle (8.46 million), buffaloes (2.98 million), sheep (11.05 million), goats (6.17 million), pigs (0.3 million) *etc.* Karnataka ranks 9th among the largest livestock population states in the country, accounting for 5.41 per cent of the total population as per the latest Livestock Census, 2019 (Table 8).

Table 8. Livestock population of Karnataka

Sl.No.	Particulars	Number (million)	% population of India	Rank among states
1	Cattle	8.46	4.39	13
2	Buffaloe	2.98	2.72	11
3	Sheep	11.05	14.88	3
4	Goat	6.17	4.14	10
5	Total	29.00	5.41	9

(Source: BAHS, 2019)

About half of the total bovine population is indigenous cattle and the rest is almost equally shared by crossbred cattle and buffalo population. The share of crossbreds to bovine population has been increasing over the years. Both indigenous cattle and

buffalo population registered an annual decline, while that of crossbred cattle increased. Farmers in the districts of Bangalore, Kolar, Chikkaballapura, Dakshina Kannada, Chamarajanagar, Mandya, Ramanagara *etc.*, have more crossbred animals in their herds, which have helped them generate substantial income through dairying. Karnataka ranks 13th in cattle (4.39%), 11th in buffaolo (2.72%), 3rd in sheep (14.88%) and 10th in goat (4.14%), population in the country. The distribution of livestock population in different districts of the state is presented in figure 6. The district wise livestock population, indigenous, crossbred/exotic and total cattle population, male, female, milking and total population of buffaloes, indigenous, crossbred/exotic and total sheep population and male, female and total goat population in the state of Karnataka have been presented in the following tables 9-13. About 68,05,780 household/household enterprises have maintained one or other kind of livestock. The cattle (43.72%), buffalo (19.36%), sheep (10.51%) and goat (7.84%) account for about 81.42% of the total households/household enterprises and remaining are occupied by pigs and poultry birds (Table 9-14).

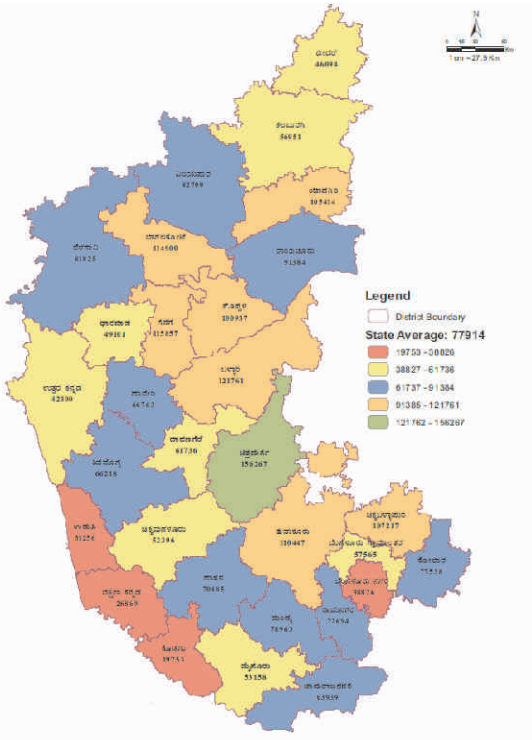

Figure 6: District wise number of livestock per lakh population in Karnataka

Table 9. District-wise livestock population in Karnataka

District	Cattle	Buffaloes	Sheep	Goat	Total
Bagalkot	222,823	234,340	622,856	383,926	1,463,945
Bengaluru Rural	170,722	16,924	118,788	95,156	401,590
Belagavi	549,540	844,171	7 57,679	701,741	2,095,452
Bellary	283,699	127,407	1,005,565	253,119	1,669,790
Bengaluru Urban	153,861	11,168	82,873	62,464	310,366
Bidar	173,634	125,510	85,948	182,854	567,946
Bijapur	202,111	177,079	347,070	569,098	1,295,358
Chamarajanagar	249,361	9,918	135,321	144,633	539,233
Chikballapur	213,815	26,397	613,193	188,392	1,041,797

Chikmagalur	290,007	34,362	97,962	41,040	463,371
Chitradurga	225,603	113,304	1,352,087	385,058	2,076,052
Dakshin Kannada	250,569	1,832	289	32,215	284,905
Davangere	297,377	123,596	505,630	124,542	1,051,145
Dharwad	172,219	61,245	7 9,869	74,069	307,533
Gadag	136,311	55,798	395,899	191,656	779,664
Kalaburagi	385,580	73,176	112,387	446,200	1,017,343
Hassan	548,185	107,971	199,387	129,058	984,601
Haveri	261,060	85,501	313,205	144,969	804,735
Kodagu	71,684	5,236	650	7,603	85,173
Kolar	209,642	26,520	483,892	93,713	813,767
Koppal	231,413	63,467	625,367	172,578	1,092,825
Mandya	369,986	109,443	347,133	346,430	1,172,992
Mysore	492,598	21,682	203,463	208,206	925,949
Raichur	245,374	112,420	657,633	282,718	1,298,145
Ramanagara	287,502	19,644	127,988	150,130	585,264
Shivamogga	518,653	120,563	42,526	59,719	741,461
Tumkur	431,251	142,047	1,290,008	427,926	2,291,232
Udupi	254,776	2,408	431	2,676	260,291
Uttar Kannada	336,312	73,993	8,537	10,655	429,497
Yadgir	233,336	57,438	437,092	256,848	984,714
Total	8,469,004	2,984,560	11,050,728	6,169,392	28,673,684

Table 10. District-wise indigenous, crossbred /exotic and total cattle population in Karnataka

District	Exotic /crossbred	Indigenous	Total
Bagalkot	63,837	158,986	222,823
Bengaluru Rural	151,981	18,741	170,722
Belagavi	243,984	305,556	549,540
Bellary	54,321	229,378	283,699
Bengaluru Urban	135,036	18,825	153,861
Bidar	20,155	153,479	173,634
Bijapur	14,466	187,645	202,111
Chamarajanagar	170,205	79,156	249,361
Chikballapur	170,420	43,395	213,815
Chikmagalur	112,654	177,353	290,007
Chitradurga	72,353	153,250	225,603

Dakshin Kannada	184,157	66,412	250,569
Davangere	181,691	115,686	297,377
Dharwad	75,394	96,825	172,219
Gadag	57,131	79,180	136,311
Kalaburagi	14,513	371,067	385,580
Hassan	356,245	191,940	548,185
Haveri	101,033	160,027	261,060
Kodagu	39,766	31,918	71,684
Kolar	185,783	23,859	209,642
Koppal	54,932	176,481	231,413
Mandya	293,905	76,081	369,986
Mysore	317,061	175,537	492,598
Raichur	18,544	226,830	245,374
Ramanagara	207,006	80,496	287,502
Shivamogga	138,013	380,640	518,653
Tumkur	271,468	159,783	431,251
Udupi	138,019	116,757	254,776
Uttar Kannada	62,515	273,797	336,312
Yadgir	1,574	231,762	233,336
Total	3,908,162	4,560,842	8,469,004

(Source: BAHS, 2019)

Table 11. District-wise male, female, milking and total population of buffaloes in Karnataka

District	Male	Female	Milking	Total
Bagalkot	11,265	223,075	76,462	234,340
Bengaluru Rural	566	16,358	7,716	16,924
Belagavi	25,653	818,518	359,958	844,171
Bellary	6,782	120,625	42,545	127,407
Bengaluru Urban	528	10,640	4,571	11,168
Bidar	7,569	117,941	50,912	125,510
Bijapur	5,434	171,645	73,109	177,079
Chamarajanagar	760	9,158	3,285	9,918
Chikballapur	902	25,495	11,752	26,397
Chikmagalur	3,743	30,619	11,723	34,362
Chitradurga	8,041	105,263	38,806	113,304
Dakshin Kannada	694	1,138	391	1,832
Davangere	11,634	111,962	44,468	123,596

Dharwad	4,088	57,157	24,691	61,245
Gadag	2,294	53,504	19,269	55,798
Kalaburagi	4,700	68,476	27,059	73,176
Hassan	5,639	102,332	45,083	107,971
Haveri	4,593	80,908	32,281	85,501
Kodagu	1,381	3,855	1,330	5,236
Kolar	568	25,952	11,567	26,520
Koppal	2,908	60,559	24,271	63,467
Mandya	2,069	107,374	49,880	109,443
Mysore	1,234	20,448	9,011	21,682
Raichur	4,851	107,569	36,429	112,420
Ramanagara	698	18,946	8,294	19,644
Shivamogga	19,329	101,234	33,430	120,563
Tumkur	5,761	136,286	56,535	142,047
Udupi	1,246	1,162	469	2,408
Uttar Kannada	12,855	61,138	23,743	73,993
Yadgir	4,307	53,131	17,201	57,438
Total	162,092	2,822,468	1,146,241	2,984,560

(Source: BAHS, 2019)

Table 12. District-wise indigenous, crossbred /exotic and total sheep population in Karnataka

District	Exotic /crossbred	Indigenous	Total
Bagalkot	3,025	619,831	622,856
Bengaluru Rural	3,367	115,421	118,788
Belagavi	3,161	754,518	757,679
Bellary	18,200	987,365	1,005,565
Bengaluru Urban	6,891	75,982	82,873
Bidar	80	85,868	85,948
Bijapur	1,107	345,963	347,070
Chamarajanagar	773	134,548	135,321
Chikballapur	16,302	596,891	613,193
Chikmagalur	126	97,836	97,962
Chitradurga	244	1,351,843	1,352,087
Dakshin Kannada	11	278	289
Davangere	761	504,869	505,630
Dharwad	378	79,491	79,869
Gadag	24,389	371,510	395,899

Kalaburagi	46	112,341	112,387
Hassan	184	199,203	199,387
Haveri	1,049	312,156	313,205
Kodagu	92	558	650
Kolar	3,534	480,358	483,892
Koppal	1,914	623,453	625,367
Mandya	1,400	345,733	347,133
Mysore	6,523	196,940	203,463
Raichur	543	657,090	657,633
Ramanagara	1,414	126,574	127,988
Shivamogga	793	41,733	42,526
Tumkur	3,167	1,286,841	1,290,008
Udupi	80	351	431
Uttar Kannada	40	8,497	8,537
Yadgir	669	436,423	437,092
Total	100,263	10,950,465	11,050,728

(Source: BAHS, 2019)

Table 13. District-wise male, female and total goat population in Karnataka

District	Male	Female	Total
Bagalkot	48,599	335,327	383,926
Bengaluru Rural	38,050	57,106	95,156
Belagavi	88,780	612,961	701,741
Bellary	37,258	215,861	253,119
Bengaluru Urban	22,890	39,574	62,464
Bidar	31,139	151,715	182,854
Bijapur	60,539	508,559	569,098
Chamarajanagar	35,715	108,918	144,633
Chikballapur	45,649	142,743	188,392
Chikmagalur	10,294	30,746	41,040
Chitradurga	79,494	305,564	385,058
Dakshin Kannada	10,658	21,557	32,215
Davangere	26,931	97,611	124,542
Dharwad	11,912	62,157	74,069
Gadag	22,633	169,023	191,656
Kalaburagi	87,499	358,701	446,200
Hassan	51,979	77,079	129,058
Haveri	22,871	122,098	144,969

Kodagu	2,519	5,084	7,603
Kolar	24,612	69,101	93,713
Koppal	26,400	146,178	172,578
Mandya	110,945	235,485	346,430
Mysore	71,728	136,478	208,206
Raichur	49,926	232,792	282,718
Ramanagara	46,643	103,487	150,130
Shivamogga	19,358	40,361	59,719
Tumkur	119,202	308,724	427,926
Udupi	760	1,916	2,676
Uttar Kannada	2,752	7,903	10,655
Yadgir	52,140	204,708	256,848
Total	1,259,875	4,909,517	6,169,392

(Source: BAHS, 2019)

Table 14. Number of households and household enterprises owning animals and poultry birds in Karnataka

Livestock	No. of households/household enterprises	% of Total
Cattle	2975805	43.72
Buffaloes	1317403	19.36
Goats	714979	10.51
Sheep	533266	7.84
Pigs	21304	0.31
Backyard poultry	1090311	16.02
Poultry farms & hatcheries	152712	2.24
Total	6805780	100

(BASH, 2012)

E. Fodder Scenario

In spite of having a large livestock population, the proportion of fodder availability to meet the fodder demand in the state is low. Karnataka has the second largest arid zone in the country. Out of a net cultivable area of 99 lakh ha in the state, about 34% has assured irrigation and the fodder cultivation is relegated to unproductive land which is dependent on rainfall. The total availability of feed resources in the state is lower than overall requirement. In case of green fodder, the area under crop is practically negligible in the districts of Bellary, Chikmagalur, Chitradurga, Gadag, Kodagu, Koppal, Raichur, Shivamogga. These districts face acute fodder shortage even in normal years. Dry matter availability from crop residues in the districts of Belgaum, Dakshina Kannada, Hassan, Mandya, Tumkur and Kolar is considerably lower than the requirement due to higher density of dairy animal population in these regions.

Karnataka had only 35,000 ha under fodder crops and 9,12,000 ha permanent pastures and other grazing land leading to acute scarcity of fodder for livestock impacting their productivity. The district-wise area und fodder crops *vis-à-vis* gross sown area in the state is present in table 15. In all the districts the ratio of fodder crops to gross sown area is very small clearly showing the disregard for fodder crops despite the fact that the livestock need a larger amount of fodder crops.

Table 15. District-wise area under fodder crops in Karnataka

District	Area under fodder crop (% of gross sown area)			Gross sown area ('000 ha)		
	2009-10	2010-11	2011-12	2009-10	2010-11	2011-12
Karnataka	0.30	0.27	0.27	12873	13062	12059
Bagalkot	0.05	0.07	0.05	600	609	616
Bengaluru Rural	2.52	2.82	2.52	131	131	131
Bengaluru Urban	1.09	1.15	1.30	55	52	54
Belagavi	0.35	0.33	0.39	1109	1100	1011
Ballari	<0.01	<0.01	<0.0 1	570	582	532
Bidar	0.02	<0.01	0.05	401	424	416
Bijapur	0.02	0.02	0.01	1041	1038	844
Chamrajnagar	<0.01	<0.01	<0.01	225	225	222
Chikkaballapur	1.32	0.60	0.60	174	215	215
Chikkamagalur	<0.01	<0.01	<0.01	330	330	324
Chitradurga	<0.01	<0.01	<0.01	460	524	453
D Kannada	0.32	0.32	0.32	157	157	158
Davangere	<0.01	<0.01	<0.01	478	494	487
Dharwad	0.14	0.16	0.17	553	512	477
Gadag	<0.01	<0.01	<0.01	575	553	495
Kalaburagi	<0.01	0.02	0.01	1435	1062	973
Hassan	0.13	0.12	0.20	454	505	449
Haveri	<0.01	0.02	<0.01	433	422	411
Kodagu	<0.01	<0.01	<0.01	179	185	186
Kolar	1.04	0.99	0.72	173	203	194
Koppala	<0.01	<0.01	<0.01	508	500	433
Mandya	0.69	0.83	0.77	289	300	273
Mysore	<0.01	<0.01	0.07	557	549	536
Raichur	<0.01	<0.01	<0.01	680	663	541
Ramanagar	1.15	2.27	2.60	174	176	169
Shivamogga	0.04	0.04	<0.01	263	267	268

Tumkur	3.27	2.31	2.14	624	632	576
Udupi	<0.01	<0.01	<0.01	119	118	118
U. Kannada	0.08	0.08	0.08	126	124	124
Yadgir		<0.01	<0.01	-	411	374

(**Source**: DES 2016. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Govt. of Indian, New Delhi)

The gravity of the problem of fodder scarcity becomes clearer when we observe the dry matter availability, requirement and balance in different districts of the state over the year. Virtually, all districts in the state have net deficit with regard to the availability of dry matter requirement (Table 16; Figures 7-8). In absolute terms there was a net deficit of 10 million tonnes of feed resources in Karnataka (NIANP, 2012) (Table 16).

Table 16. District-wise dry matter availability, requirement and balance in Karnataka

Districts	Fodder Production status (tonnes)			Gap	Major Crops
	Production	Requirement	Status	(%)	
North Interior Karnataka					
Belgaum	2803640	3062893	-259254	-8.50	Maize, sorghum, paddy
Bellary	1962601	1231948	730652.6	59.30	Maize, sorghum, paddy
Bidar	178925.7	752208.1	-573282	-76.20	Sorghum
Yadgir	677863.1	970444.5	-292581	-30.10	Paddy and sorghum
Kalaburagi	1179185	1202626	-23441	-1.90	Sorghum
Bijapur	1274018	995087.1	278931.3	28.00	Sorghum and maize
Dharwad	581250.2	548446.1	32804.13	6.00	Sorghum and maize
Raichur	1448980	1244339	204640.4	16.40	Paddy and sorghum
Bagalkote	1283013	1324740	-41727.3	-3.10	Sorghum and maize
Gadag	801955.1	505021.3	296933.8	58.80	Sorghum and maize
Haveri	1684348	838715.3	845633.1	100.80	Maize, paddy & chilli
Koppal	1321891	874142.2	447748.5	51.20	sorghum
South Interior Karnataka					
Bengaluru Urban	285810	309228.7	-23418.8	-7.60	Ragi
Bengaluru Rural	509652.7	409389.5	100263.2	24.50	Ragi and maize
Ramanagara	621947	629900.9	-7953.95	-1.30	Ragi
Kolar	314790	695661.9	-380872	-54.70	Ragi
Chickballapur	703201.6	743554.6	-40353	-5.40	Ragi and maize
Tumkur	1670112	1799138	-129026	-7.20	Ragi
Chitradurga	1368084	1209983	158101	13.10	Ragi, groundnut, maize
Davanagere	2937361	1089970	1847390	169.50	Paddy and maize

Chamarajnagar	682076.6	601655.8	80420.8	13.40	Maize
Mysore	1452989	1226960	226029.2	18.40	Paddy, Ragi, Maize
Mandya	993458.3	1154989	-161531	-14.00	Paddy and Ragi
Malnad					
Hassan	1890084	1459529	430554.7	29.50	Ragi and Maize
Shivamogga	1358038	1344945	13092.92	1.00	Paddy and maize
Chickmagalur	655019.1	795557.7	-140539	-17.70	Maize, Ragi & paddy
Kodagu	222176.3	191152.7	31023.61	16.20	Paddy
Coastal					
D. Kannada	257859.5	478868.3	-221009	46.20	Paddy
Udupi	273751.1	478600.8	-204850	-42.80	Paddy
U. Kannada	376147.8	780223.6	-404076	-51.80	Paddy

Source: Kamrdi *et al.,* 2017

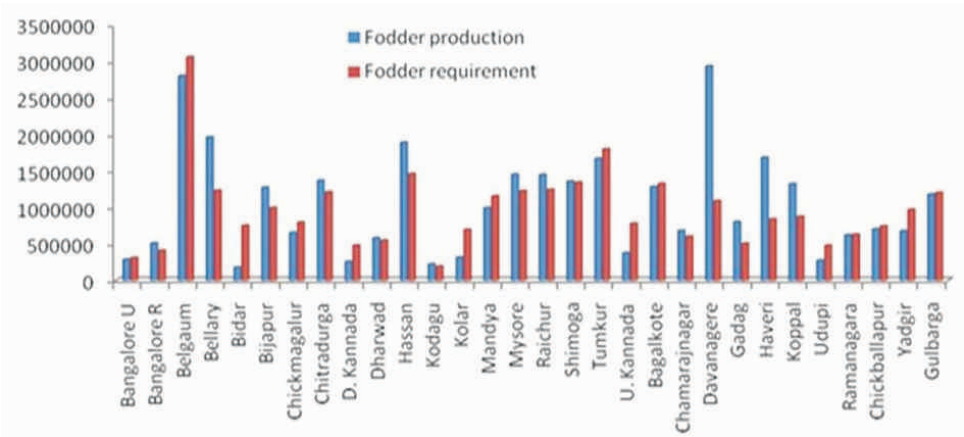

Figure 7: Availability, requirement and balance of fodder in terms of crop residues in Karnataka (Source: Kamrdi *et al.,* 2017)

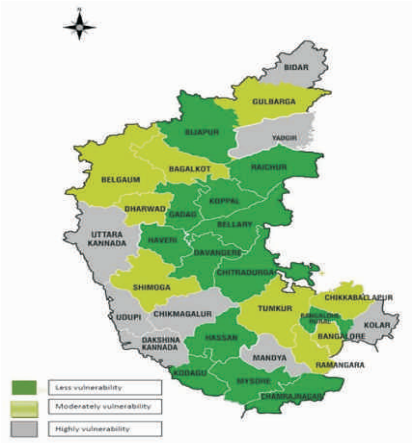

Figure 8: District-wise vulnerability of fodder shortages in Karnataka

Table 17. Availability, requirement and deficit of feed nutrient in Karnataka

Year	Dry Matter ('000 MT)		
	Availability	Requirement	Surplus/Deficit
1997	28,021	41,045	-13,024
2003	25,451	38,150	-12,699
2007	29,632	43,758	-14,126
2008	36,395	44,919	-8,524
2009	33,258	46,152	-12,894
2010	30,212	47,460	-17,249
2011	38,758	48,851	-10,093

Source: Feedback 2012, National Institute of Animal Nutrition and Physiology, Bangalore.

The major fodder resources include community grazing lands also called as *Gomalas,* trees having fodder values *viz.*, *prosopis/khejri*, subabul, sesbania, glyricidia, ficus *etc.*, cultivated fodder crops *viz.*, fodder jowar, fodder maize, *stylosanthes*, bajra napier hybrid grass, para grass, horsegram, fodder oats, cowpea *etc*. In recent years, bajra napier hybrid, guinea grass, lucerne, perennial fodder sorghum *etc.* are becoming popular in assured irrigation areas. Non-conventional fodder crops like fodder cactus, chaya *etc*. The major sources of crop residues commonly used as dry fodder include rice straw, jower stover, bajra stover, maize stover, ragi straw, greengram straw, bengal gram straw, red gram straw, sugarcane top, groundnut straw, soybean straw and mulberry twigs.

The major problems associated with the shortage of fodder are:

- Decreasing size of agricultural land holdings and disproportionate allocation of land to fodder crop production
- Continued dependence on the monsoon and irregular monsoon affecting the productivity of crops
- Fodder production mostly under rainfed conditions and inadequate access to irrigation, imbalanced use of plant nutrients.
- Frequent droughts and cyclonic floods affecting the fodder crops
- Non availability of suitable fodder crops, quality seeds and planting material.
- Lack of fodder marketing facilities and confined to home consumption
- Over dependence on natural niches for green fodder supply, crop residues as fodder sources and lesser emphasis on cultivated fodder crops.
- Allocation of marginal and sub-marginal lands for fodder production and subsistence production systems
- Regional imbalances in fodder production and availability

SWOT Analysis

There is a need to assess the strengths and weakness of the present scenario to develop a viable strategy for sustainable fodder production in the state on long term basis. Understanding of the various positive features and negative outlooks prevailing in the state gives an idea for careful planning and implementation of the programmes for successfully addressing the fodder shortage without compromising on the progress of other sectors. The threadbare analysis of strengths, weakness, opportunity and threats (SWOT) for augmenting the production of fodder in the state of Karnataka is presented in table 18. The state has a very positive outlook for further growth of animal husbandry with a robust set up in terms of government infrastructure for veterinary services, milk federations and farmers' active participation. Further there is a great scope for exploiting the existing natural resources for enhancing the fodder production without adversely affecting complementary sectors *viz.,* agriculture, horticulture, forestry *etc*. There is an urgent need for proper and clear planning with a long term objective of making the state surplus in fodder availability to meet the need of livestock wealth in the state.

Table 18. SWOT analysis and factors concerning fodder development in Karnataka

	Success factor	Failure factor
Internal factor	**Strength**	**Weakness**
	• Diverse agro-climatic conditions suitable for fodder cultivation round the year • Availability of high yielding varieties of fodder crops • Large areas of cultivable wasteland and fallow promising fodder production. • Livestock sector is still a main occupation of livelihood of rural people in the state. • Permanent pastures and other grazing land to the tune of 9.59 lakh ha is available in the state. • State has around 21.24% irrigated area. • Wide Govt. network of Animal Husbandry and Veterinary services • Well organized dairy enterprises both in private and co-operative sectors.	• Lack of technical human resource in fodder development. • Land under fodder crops is static & little scope of expansion in area, as per capita land is very low. • Largely noncommercial status of fodder crop and un-organized small market. • Lack of promotional infrastructure facilities of production and marketing of quality fodder seeds. • Marketing of fodder crops is not being organized and transportation of bulky fodder is difficult with cost per unit weight becoming higher due to high volume. • Fodder industry does not have access to sustainable funding. • Uneven and unreliable seasons/ drought

	Success factor	Failure factor
Internal factor	**Strength** • Increasing demand for both milk and milk based products like curd, cheese, butter, ghee *etc.* • Expanding market for milk products through co-operative dairy enterprises like Karnataka Milk Federation *etc.* • Emergence of dairying as an attractive alternative for small and marginal land holders and land less agricultural labourers.	**Weakness** • Regional fodder imbalance and uneven fodder production and distribution. • Alternative uses for crop residues like bio-energy plants reducing the availability of dry fodder • Overemphasis on exotic breeds of livestock susceptible to pests and diseases pulling down their productivity.
External factor	**Opportunity** • Increased demand for livestock products *viz.*, milk and meat highlight raising need of feed and fodder. • Growing demand for organic livestock products have increased the importance of organic fodder. • Climate variability – resulting in more fodder production in same season. • Peri-urban dairy creating organized fodder market and need for post-harvest processing of fodder and crop residues and formulation of complete food. • Introduction of genetically potential high yielding varieties can increase production by 2-3 fold. • By optimum utilization of land resources can nullify the deficit of fodder in the state. • Increase in number of expert human resource can help in dissemination and transfer of technology at faster rate. • Importance to fodder industry is increasing as prices of livestock product are increasing. • Introduction of innovative methods of fodder production can increase availability of fodder at rainfed areas or for vulnerable group of animal keepers.	**Threats** • Rising input costs including fertilizer, irrigation water and transport costs. • Changing land use – competition between agricultural (*eg.* grain production) and nonagricultural uses • Weed contamination and weed spread • Less funding for R&D with failure to secure future requirement of fodder. • Climate change, water scarcity due to recurrent drought, and rise in weather uncertainty like floods affecting crop failure and productivity of forage crops. • Increase in global competition for markets under WTO regimes is real challenge to promote livestock production as per there standards. • Above all factors intensify the rate of migration of rural people towards city for employment and uplift living standards. • Peri-urban dairying is shrinking due to escalating fodder and land costs. • Shorter shelf-life of milk and milk products and lack of cold storage chains in drier areas.

Part-II : Fodder Resources Development Plan

Increasing the fodder availability to the livestock is of great significance to augment the productivity of livestock and making livestock keeping and dairying a remunerative activity to the farming community. It requires well planned multipronged efforts comprising various possible avenues of fodder production. The major aspects include:

- Introduction of fodder crops in existing cropping systems
- Introduction of fodder crops in horti-pastoral, silvi-pastoral systems
- Growing of fodder trees/shrubs in non-cropped areas, fallow lands and creating grazing lands
- Efficient use of crop residues as fodder for animals
- Value addition and conservation of fodder crops for realizing profits during lean periods
- Fodder security policy of government having various components to provide quality feed and fodder to the livestock
- Creating demand for green fodder and dry fodder markets
- Prospects for fodder related research creating high yielding fodder crops under diverse agro-climatic conditions

Crop residues are major source of fodder for animals since time immemorial. The residues of cereals like paddy, wheat, jowar, millets and legumes were collected and conserved as source of dry fodder after the harvest of crops. The green foliage available on the bunds and on the non-cropped areas like community land was used as source of green fodder. The recent changes in agricultural practices *viz*., emphasis on commercial crops, use of high yielding crop varieties and lesser emphasis on crop residues as fodder reduced the supply of these materials to be used as fodder. The low stature high yielding hybrids with no or little biomass, use of excessive chemicals, harvesting methods have dwindled the available crop residues and also have reduced their suitability for feeding the animals. In addition the change in the composition of livestock breeds from indigenous to exotic and cross breeds having high milk yielding capacity needed quality green and dry fodder mix for achieving higher productivity as compared to local breeds has forced us to look for qualitatively as well as quantitatively superior fodder crops for meeting the demand of these breeds. With hardly any increase in the conventional fodder cultivation area with the decreasing land holdings, there has been frantic search for high yielding and nutrient rich fodder crops in many areas. However the non availability of suitable fodder seeds and planting material has affected the attractiveness of the fodder cultivation in many areas. Hence, the following

aspects may be looked into for popularizing the fodder cultivation among the farming community.

i Identification of suitable crops for different agro-climatic zones and agricultural situations

ii Improving the availability of the seed and planting material of fodder crops

iii Supplying the quality fodder seeds and planting material at subsidized prices

iv Motivating farmers for growing fodder crops to meet their fodder demand

There are variety of fodder crops suitable variable agro-climatic conditions. The crops like bajra-napier hybrid, guinea grass, lucerne *etc.*, are suitable for irrigated conditions. The crops like perennial fodder sorghum, signal grass, brizanta grass, *stylosanthes* are suitable for rain fed conditions. All these are being perennial in nature, once planted will be able to provide fodder for 2-3 years and won't need frequent sowing and investment on seed cost and land preparation. On the other hand fodder maize, fodder sorghum, fodder bajra, fodder oat and fodder cowpea being annual in nature can be grown when there is an anticipated shortage of fodder at a short notice.

The quality fodder seed and planting material availability is a major handicap at many a times and places for taking up these crops. There is an uncertainty about the possible demand for these seeds. The farmers in general are not inclined to go for seed production of these crops in view of oscillating demand. Hence there is a need for concerted effort for enhanced seed and planting material production in different agro-climatic conditions. The type of crop and quantum of demand varies with the agro-climatic conditions. Therefore there is a need to tailor the programme according to anticipated needs in consultation with the clientele departments. A rough outline has been presented in the programme outlay.

A. Cultivated fodder resources

Keeping in view the constraints in fodder production and to overcome the gap between demand and supply, the emphasis needs to be laid on multi-pronged efforts for augmenting the fodder production. Existing resource utilization pattern needs to be studied in totality according to a system approach. Fodder production should be a component of the farming system and efforts need to be made for increasing the forage production in a farming system approach. The holistic approach of integrated resource management will be based on maintaining the fragile balance between productivity functions and conservation practices for ecological sustainability. Different types of fodder crops, varieties and seed/planting requirement in general are given in table 19. It is suggested to grow forage grasses and fodder trees along village roads and panchayat lands, and on terrace risers/bunds - a non-competitive land use system. In-depth studies on migratory grazers, forage based agroforestry systems and

participatory pasture management and controlled grazing to maintain the productivity of pasture (grazing should be allowed as per carrying capacity) are some other solutions to this problem. Coupled with production, proper conservation and utilization methods also need to be adopted and livestock keepers need to be sensitized and trained accordingly.

Table 19. Suitable fodder crops, varieties and seed/planting requirement

Sl. No.	Crop	Varieties	Seed or root slips or stem cuttings per ha	Average yield (t/ha/annum/season)
i. Perennial fodder crops				
1	Bajra napier hybrid	CO-5, CO-6, DHN 6, DHN-15	28,000 nos.	200-250
2	Guinea grass	Bundel Guinea - 2, Dharwad Guinea Grass 1	40,000 nos.	150-200
3	Perennial fodder sorghum	CoFS 29, CoFS 31	10 kg/ha	100-150
4	Signal grass	DBRS 1	40,000 nos.	40-50
5	Lucerne	Anand 1, Anand 2, RL 88	10 kg/ha	60-80
ii. Annual fodder crops				
1	Fodder maize	African Tall	40 kg/ha	35-40
2	Fodder bajra	Moti Bajra,	20-25 kg/ha	25-30
3	Fodder sorghum	SSV 74	15-20 kg/ha	25-30
4	Fodder cowpea	MFC 09-1, Swetha, BL 1	20-25 kg/ha	15-20
iii. Fodder trees				
1	*Caliandra* spp.	Local species	Varied spacing	10-20
2	*Moringa oleifera*	PKM 1, Bhagya	Varied spacing	15-20
3	*Sesbania sesban*	-	Varied spacing	15-20
4	*Glyricidia sepium*	-	Varied spacing	10-20
5	*Acacia* spp.	-	Varied spacing	10-15

There are a number of fodder crops suitable for different growing conditions of the state (Table 20-22). We have a large basket of perennial grasses, range legumes, cultivated forage cereals and legumes. The crops like bajra napier hybrid, guinea grass, bracharia, maize, cowpea and lucerne for irrigated areas and perennial fodder sorghum, *stylosanthes* for rainfed areas. Guinea grass and grazing guinea for mango, sapota, arecanut and other orchards. Bracharia and bajra napier hybrid for the high rainfall and coastal areas. Further integration of food and fodder crops helps in

harnessing the maximum benefits of both crop residue of food crops and fodder crops in mutually synergistic ways. The annual fodder crops *viz.*, maize, sorghum, cowpea *etc.*, are suitable for conservation in the form of silage and hay for the utilization during lean period.

Promising food/fodder based cropping systems:

Maize - cowpea - maize

Sorghum - cowpea - maize

Bajra napier hybrid - cowpea - cowpea

Bajra napier hybrid + cowpea - fodder maize

Sorghum + cowpea - maize + cowpea - maize + cowpea

Fodder maize + cowpea - sorghum

Fodder sorghum + pigeonpea - maize

Fodder cowpea - maize - pigeonpea

Fodder bajra + cowpea - sorghum

Fodder bajra + pigeonpea - maize

Ragi + fodder cowpea-chickpea

Table 20. Fodder crops and their productivity under rainfed and irrigated conditions

Fodder crops		Productivity	
		Rainfed	Irrigated
I. Annual fodders	Fodder maize	30-40 t/ha	40-50 t/ha
	Fodder sorghum	20-25 t/ha	25-30 t/ha
	Fodder cowpea	10-15 t/ha	25-30 t/ha
II. Perennial fodder	Signal grass	80-100 t/ha	180-200 t/ha
	Guinea grass	80-100 t/ha	-
	Bajra napier hybrid	60-80 t/ha	200-250 t/ha
	Stylosanthes spp.	35-40 t/ha	-
	Hedge lucerne	40-70 t/ha	-
	Setaria anceps	25-40 t/ha	80-100 t/ha
	Para grass	60-80 t/ha	-
	Congo signal grass	35-40 t/ha	90-100 t/ha
	Cenchrus ciliaris	60-70 t/ha	-
	Calapogonium	20-25 t/ha	-
	Centrosema	25-30 t/ha	-

Table 21. Fodder crops for non-arable lands

Fodder crop	Green fodder yield (t/ha/annum)
Fodder grasses	
Dinanath grass	25-30
Perennial fodder sorghum	30-40
Cenchrus spp	25-30
Grazing guinea	75-80
Stylosanthes spp	10-15
Clitoria spp	10-12
Hedge lucerne	15-20
Sehima grass	2-4
Fodder shrubs	
Caliandra spp	10-20
Moringa oleifera	15-20
Sesbania sesban	15-20
Glyricidia sepium	10-20
Acacia spp.	10-15

Table 22. Fodder crops for arable lands and their varieties

Fodder crop	Crop	Varieties
Annual fodder crops		
Kharif (Rainfed)	Fodder maize	African Tall, APFM 8
	Fodder sorghum	SSG 59-3, Pusa Chari 6, HC 136, Pusa Chari 9, Pusa Chari 23, SV-74, SSV-84,TSFB15-4 and TSFB-15-8
	Fodder bajra	Gaint Bajra, Raj Bajra Chari 2, CO-8, TNSC 1, AVKB 19, KHB 202, Moti Bajra
	Fodder cowpea	UPC 5286, Co 5, UPC 287, Bundel lobia 1, MFC 09-1, EC 4216
	Fodder horsegram	DFHG 1
	Rice bean	RBL 6
Rabi (Irrigated)	Fodder maize	African tall, APFM-8
	Fodder sorghum	SSG 59-3, Pusa Chari 6, HC 136, Pusa Chari 9, Pusa Chari 23, SV-74, SSV-84,TSFB15-4 and TSFB-15-8
	Fodder oat	Kent, HFO 212B, OS-6, OS-7, UPO 94, UPO 2012, No.2688, OL-9, IGFR-2688
	Fodder cowpea	UPC 5286, Bundel Lobia 1, Bundel Lobia 2, MFC 09-1, MFC-08-14, EC 4216, Vijaya

	Berseem	JB1, Vardan (S99-1), B.L.1,2,10, JB-2, UPB 110
	Fodder horsegram	VLG-19, VLG-15, A.K-21, A.K- 42
Summer (Irrigated)	Fodder maize	African Tall, APFM 8
	Fodder cowpea	UPC 5286, Bundel lobia 1, Bundel lobia 2, MFC 09-1, MFC-08-14, EC 4216, Vijaya
Perennial fodder crops		
Rainfed	Signal grass	Bassilisk
	Ruzi grass	
	(Congo signal grass)	DBRS 1
	Grazing guinea	-
	Perennial fodder sorghum	CoFS 29, CoFS 31
	Dinanath grass	Bundel 1, Bundel 2, IGFRI 4-2-1, IGFRI 43-1, Co 1, TNDN 1
	Rhodes grass	Rhodes 10, Callide
	Stylosanthes spp	-
	Clitoria spp.	-
	Hedge lucerne	CO-2,TSHL-1
	Setaria anceps	Nandi, Narok, Kazungula
	Anjan grass	CO-2, Bundel Anjan 3
Irrigated	Bajra napier hybrid	NB 21, DHN 6, APBN 1 KKM 1, Co BN 5, CoBN 6
	Guinea grass	PGG 13, PGG 14, Marathakam, Bundel Guinea 2, DDG 1
	Lucerne	RL 88, Anand 2, Co 1, Anand-11

The full yield potential of fodder crops may be realized only when they are grown under suitable agro-climatic conditions. The suitable fodder crops for cultivation under various agro-climatic zones in Karnataka are presented in table 23.

Table 23. Zone wise suitable fodder crops recommended for Karnataka

Zone number and Name	District (No. of Tehsils)	Name of Talukas	Fodder crops suggested
1. North Eastern Transition Zone	Bidar (5) & Gulbarga (2).	Aland, Bhalki, Basvakalyan, Bidar, Chincholi, Humnabad, Aurad.	Bajra napier hybrid, Guinea grass, Grazing guinea,
2. North Eastern Dry Zone	Gulbarga (5) Yadgir (3) & Raichur (3)	Afzalpur, Chitapur, Kalaburagi, Jewargi, Sedum, Shahapur, Yadgir, Shorapur, Raichur, Deodurga, Manvi.	*Stylosanthes* spp., Fodder sorghum, Fodder maize, Fodder bajra

3.	Northern Dry Zone	Koppal (4), Gadag (4), Dharwad (1), Belgaum (5), Bijapur (5), Bagalkot (6), Bellary (7), Davangere (1), Raichur (2)	Gangavathi, Koppal, Kushtagi, Lingasugur, Sindhanur, Yelburga, Badami, Bagalkote, Bagewadi, Bilgi, Bijapur, Hungund, Indi, Jamkhandi, Mudhol, Muddebihal, Sindhagi, Bellary, Hagaribommanahalli, Harapanahalli, Hadagali, Hospet, Kudligi, Sandur, Siruguppa, Ron, Navalgund, Naragund, Gadag, Mundargi, Ramdurga, Gokak, Raibag, Soundatti, Athani.	Perennial fodder sorghum, Fodder cowpea Lucerne, Hedge lucerne, Dinanath grass, Rhodes grass
4.	Central Dry Zone	Chitradurga (6), Davangere (3), Tumkur (6), Chickmagalur (1), Hassan (1)	Challakere, Chitradurga, Davanagere, Harihara, Hiriyur, Hosadurga, Holalkere, Jagalur, Molkalmuru, Arasikere, Kadur, Madhugiri, Pavagada, Koratagere, C.N.Halli, Sira, Tiptur.	
5.	Eastern Dry Zone	Bangalore Rural (4), Ramanagar (4) Bangalore Urban (3), Kolar (5), Chikkaballpur (6) Tumkur (2).	Gubbi, Tumkur, Anekal, Bangalore South, Bangalore North, Channapatna, Devanahalli, Doddabalapur, Hosakote, Kankapura, Magadi, Nelmangala, Ramanagar, Bagepalli, Bangarpet, Chikkabalapur, Chintamani, Gudibanda, Gowribidanur, Kolar, Malur, Mulbagal, Sidalaghatta, Srinivasapura.	
6.	Southern Dry Zone	Mysore (4), Hassan (2), Tumkur (2), Chamarajanagar (4), Mandya (7)	K.R.Nagar, T.Narasipur, Mysore, Kollegal, Nanjangud, Turuvekere, Kunigal, Nagamangala, Srirangapatna, Malavalli, Maddur, Mandya, Pandavapura, K.R.Pet, Channarayapatna, Hassan, Chamarajanagar, Yelandur, Gundlupet.	

7. Southern Transition Zone	Hassan (4), Chickmagalur (1), Shimoga (3), Mysore (3), Davanagere (2)	H.D.Kote, Hunsur, Periyapatna, H.N.Pura, Alur, Arkalgud, Belur, Tarikere, Bhadravathi, Shivamogga, Honnali, Shikaripura, Channagiri.	
8. Northern Transition Zone	Belgaum (4), Dharwad (3), Haveri (6), Gadag (1)	Hukkeri, Chikodi, Bailhongal, Belgaum, Haveri, Shiggaon, Shirahatti, Kundagol, Savanur, Hubli, Dharwad, Byadgi, Hirekerur, Raneebennur.	
9. Hilly Zone	Uttara Kannada (6), Belgaum (1), Dharwad (1), Haveri (1), Shimoga (4), Chikkamangalur (5), Kodagu (3), Hassan (1)	Sirsi, Siddapura, Yellapura, Supa, Haliyal, Mundgod, Khanapur, Soraba, Hosanagar, Sagar, Thirthahalli, Koppa, Sringeri, Mudigere, Narasimharajapur, Chickmagalur, Kalaghatagi, Hangal, Sakleshpur, Virajpet, Somwarpet, Madikere.	*Brachiaria ruziziensis, Stylosanthes guianensis , Centrocema, Clitoria,* Subabul, Velvet bean
10. Coastal Zone	Udupi (3), Dakshin Kannada (5), Uttar Kannada (5)	Karwar, Kumta, Honnavar, Bhatkal, Ankola, Bantwal, Udupi, Belthangadi, Karkala, Kundapura, Mangalore, Puttur, Sulya.	

Forage based crop intensification (Round the year forage production system)

Fodder is needed round the year for the livestock keepers. Although the fodder is available during the main seasons in the form of crop residues and natural vegetation, it is necessary to ensure fodder production through crop intensification. The concept of round the year fodder production system is gaining prominence in recent time. It is a way of crop planning in which the availability of green fodder is ensured through appropriate cropping systems both mixed cropping and sequential cropping systems. While up-scaling plan for ensuring round the year green fodder availability, appropriate combination of annual and perennial fodder crops gives assurance for round the year quality fodder supply. Besides developing suitable round the year fodder production systems ensure the availability of fodder at all

times of the year. Several appropriate systems have been identified for sustainable round the year fodder production in the state of Karnataka keeping in view the agro-climatic conditions, soils and suitable crops for a given region. Some of the annual cropping systems for rainfed ecosystems are presented below.

- Fodder maize-fodder cowpea-fodder sorghum
- Fodder sorghum-fodder cowpea-fodder maize
- Fodder bajra-fodder cowpea-fodder maize
- Fodder sorghum + fodder horse gram - fodder sorghum-fodder maize
- Fodder maize + fodder horse gram - fodder sorghum-fodder cowpea
- Fodder maize-lucerne (Annual)
- Fodder sorghum-lucerne (Annual)
- Fodder bajra- lucerne (Annual)
- Fodder maize-fodder cowpea-fodder oats
- Fodder sorghum-fodder cowpea-fodder oats

Besides these knitting of perennial fodder crops helps in ensuring fodder availability in irrigated conditions all around the year.

B. Fodder production through horti-pasture

Karnataka state has a vast area under fruit trees which can be utilized for production of large amount of quality fodder by introduction of either grasses or grass legume mixtures. Introduction of grasses under fruit trees have been proved beneficial as studies carried out by ICAR-IGFRI at its Southern Regional Research Station, Dharwad (Karnataka). Mango, sapota and guava based hortipasture systems (Figure 9) have revealed that introduction of grass/legume mixtures improved physico-chemical properties of soils due to synergistic effect as grass/legume mixtures increased soil organic carbon percentage, carbon sequestration, conserve moisture and increase population of beneficial microbes. The perennial fodder crops suitable for introduction in various horticultural/plantation crops are listed in table 24. The zone wise list of grasses that can be integrated with fruit trees have been provided in the table 25. The possibility of introduction of fodder crops in horti-pasture system in important crops has been presented in table 26. And district wise expected fodder production under horti-pasture in Karnataka, is presented in table 27.

a. Mango based hortipasture system

b. Sapota based hortipasture system

c. Coconut based hortipasture system

d. Curry leaf based hortipasture system

Figure 9: Fodder crops in hortipasture systems

Table 24. Suitable fodder crops for horti-pasture systems

Orchard/ Plantation	Perennial Fodder crops
Cashew nut, Coconut, Coffee, Papaya, Mango, Cocoa, Sapota, Tamarind, Lemon, Guava	**Grasses:** Guinea grass, Bajra Napier hybrid, *Brachiaria*, Nandi grass, Grazing guinea, Perennial fodder sorghum, Rhodes grass **Legumes:** *Clitoria ternatea, Stylosanthes hamata, S. guianensis*, Lucerne, Hedge lucerne

Table 25. Suitable fodder crops under different orchards/plantations in Karnataka

Zone number and Name	District (No. of Tehasils)	Horticulture trees/ plantations	Fodder crops suggested
1. North Eastern Transition Zone	Bidar (5) & Gulbarga (2).	Mango, Guava, Sapota	Bajra Napier hybrid, Guinea grass,
2. North Eastern Dry Zone	Gulbarga (5) Yadgir (3) & Raichur (3)	Mango, Guava, Sapota, Pomegranate	Grazing guinea, Stylosanthes, Fodder Sorghum,
3. Northern Dry Zone	Koppal (4), Gadag (4), Dharwad (1), Belgaum (5), Bijapur (5), Bagalkot (6), Bellary (7), Davangere (1), Raichur (2)		Fodder maize, Fodder bajra Perennial fodder sorghum, Fodder cowpea Lucerne, hegdge lucerne, Dinanath grass, Rhodes grass
4. Central Dry Zone	Chitradurga (6), Davangere (3), Tumkur (6), Chickmagalur (1), Hassan (1)	Mango, Guava, Sapota	
5. Eastern Dry Zone	Bangalore Rural (4), Ramanagar (4) Bangalore Urban (3), Kolar (5), Chikkaballpur (6) Tumkur (2).	Mango, Guava, Sapota, coconut	
6. Southern Dry Zone	Mysore (4), Chamarajnagar(4), Mandya (7), Tumkur (2), Hassan (2).	Mango, Guava, Sapota	
7. Southern Transition Zone	Hassan (4), Chickmagalur (1), Shivamogga (3), Mysore (3), Davanagere (2).	Mango, Coconut, Arecanut	Guinea Guinea, Grazing guinea, Bajra Napier hybrid, *Stylosanthes*
8. Northern Transition Zone	Belgaum (4), Dharwad (3), Haveri (6), Gadag (1).	Mango, Guava, Sapota	
9. Hilly Zone	U.Kannada (6), Belgaum (1), Dharwad (1), Haveri (1), Shimoga (4), Chickmangalur (5), Kodagu (3), Hassan (1)	Coconut, Arecanut, Cashew, Mango	Guinea Guinea, Grazing guinea, Bajra Napier hybrid, *Stylosanthes guanensis*, Brachiaria

10. Coastal Zone	Udupi (3), Dakshin Kannada (5), Uttar Kannada (5)

Table 26. Fodder production potential under horti-pasture systems in Karnataka

Crop	Area (lakh ha)	Targeting 50% area (ha)	Targeting 25% area of 50% area (ha)	Expected green fodder production (t)	Expected dry fodder production(t)
Mango	1.79	89500	22375	559375	111875
Banana	0.84	42000	10500	262500	52500
Citrus	0.22	11000	2750	68750	13750
Guava	0.06	3000	750	18750	3750
Sapota	0.14	7000	1750	43750	8750
Grapes	0.29	14500	3625	90625	18125
Pineapple	0.02	1000	250	6250	1250
Pomegranate	0.29	14500	3625	90625	18125
Jack	0.02	1000	250	6250	1250
Papaya	0.07	3500	875	21875	4375
Ber	0.008	400	100	2500	500
Fig	0.02	1000	250	6250	1250
Custard apple	0.006	300	75	1875	375
Others	0.01	500	125	3125	625
Total	3.79	189500	47375	1184375	236875

(Assumption: Average green fodder yield: 20-30 t/ha & dry fodder yield: 4-6 t/ha)

Table 27. District wise expected fodder production under hortipasture in Karnataka

District	Area under orchard/ plantation ('000ha)*	Expected area to be brought under hortipasture ('000ha)	Expected green fodder production (tonnes)
Bagalkot	33.94	8.48	42,400
Bengaluru Rural	10.28	2.57	12,850
Bengaluru Urban	26.62	6.65	33,250
Belagavi	73.26	18.31	91,550
Ballari	56.47	14.11	70,550
Bidar	21.27	5.31	26,550
Bijapur	46.06	11.51	57,550
Chamrajnagar	49.99	12.50	62,500
Chikkaballapur	47.07	11.76	58,800
Chikamagalur	1272.05	318.01	15,90,050

Chitradurga	124.90	31.22	1,56,100
Dakshin Kannada	110.33	27.58	1,37,900
Davangere	82.18	20.54	1,02,700
Dharwad	75.00	18.75	93,750
Gadag	56.08	14.02	70,100
Kalaburagi	21.78	5.44	27,200
Hassan	122.99	30.73	1,53,650
Haveri	701.19	175.29	8,76,450
Kodagu	33.56	8.39	41,950
Kolar	108.88	27.22	1,36,100
Koppala	24.20	6.05	30,250
Mandya	78.73	19.68	98,400
Mysore	58.81	14.70	73,700
Raichur	14.57	3.64	18,200
Ramnagar	59.65	14.91	74,500
Shivamogga	78.58	19.64	98,200
Tumkur	212.68	53.17	2,65,850
Udupi	51.96	12.99	64,950
Uttar Kannada	38.20	9.55	47,750
Yadagiri	6.73	1.68	8,400

(Source: Nabi and Bagalkoti, 2017)

C. Fodder production from permanent pastures/grazing land/silvipasture systems

There is a great scope for introduction of fodder crops in newer areas like forest, pasture and fallow lands. There is a sizeable area under these categories of land in every district in the state of Karnataka (Table 28). Introduction of fodder in these areas can increase the fodder area and production without adversely impacting the prevailing systems. The potential of fodder production through these newer niches been listed in table 29. This if planned and executed will provide about 30.68 lakh ha comprising 15% of the total geographical area of Karnataka yielding about 11.51 lakh metric tonnes of green fodder per annum with a conservative productivity of 2.5t/ha.

Table 28. District wise percentage of forest, permanent pasture and fallow land to total geographical area in Karnataka

District	Forest	Pasture	Fallow
Bagalkot	12.31	0.52	3.60
Bengaluru Rural	4.93	1.69	5.87
Belagavi	14.16	1.59	5.52
Bellary	12.47	0.72	5.33

Bengaluru Urban	2.33	3.13	8.38
Bidar	5.11	2.58	11.60
Bijapur	0.19	0.91	8.97
Chamarajanagar	48.36	3.99	7.27
Chikballapur	12.29	13.73	5.02
Chikmagalur	27.98	11.61	6.00
Chitradurga	9.57	11.51	12.18
Dakshin Kannada	26.91	1.62	5.74
Davangere	14.89	2.43	2.31
Dharwad	8.25	0.84	6.09
Gadag	7.00	0.56	5.70
Kalaburagi	3.23	2.36	2.95
Hassan	8.87	4.97	5.73
Haveri	9.78	2.52	1.18
Kodagu	32.77	2.92	2.51
Kolar	5.50	9.75	9.27
Koppal	5.33	3.23	2.13
Mandya	4.97	6.43	13.33
Mysore	9.29	6.92	9.01
Raichur	2.17	2.37	9.64
Ramanagara	19.65	6.93	3.66
Shivamogga	32.66	19.28	3.11
Tumkur	4.34	7.18	22.69
Udupi	28.08	2.98	9.82
Uttar Kannada	79.4	0.66	1.38
Yadgir	6.54	2.28	3.59
Karnataka	16.13	4.57	6.91

Source: GOK, 2022.

Table 29. Newer niches for introduction of fodder in Karnataka

Sl. No.	Category	Total Area (Lakh ha)	% area of total area	Fodder area (Lakh ha)	Expected fodder yield (Lakh MT)*
1	Forests	30.68	15	4.60	11.51
2	Not available for cultivation	21.06	50	10.53	26.33
3	Permanent pastures and other grazing lands	9.59	75	7.19	17.98
4	Land under misc. tree crops & groves	3.03	25	0.76	1.89

5	Cultivable waste lands	4.27	75	3.20	8.01
6	Fallow lands other than current fallows	4.09	80	3.27	8.18
7	Current fallows	13.67	80	10.94	27.34
8	Total	30.68	15	4.60	11.51

Fodder production from permanent pasture/grazing lands

Karnataka has about 9.59 lakh ha area under permanent pasture/grazing and wasteland respectively that can be utilized for pasture improvement, silvipasture establishment and planting of fodder trees.

Rejuvenation of pastures/grazing land

Permanent pastures and grazing lands are gradually becoming less productive due to indiscriminate exploitation through uncontrolled grazing and affliction with unwanted vegetation like obnoxious weeds, water and soil erosion. These need to be managed systematically to augment productivity and retain them as sustainable sources of fodder on long term basis. Some interventions are proposed to be taken in pastures include-

- Rotational grazing
- Removal of non-palatable weeds and shrubs
- Nutrient management based on profiling
- Maintenance of proper population through seed pallets sowing
- Management of soil erosion
- Management to ensure flowering and seed production in nutritious species

Establishment of silvipastures for round the year quality fodder supply

Silvipasture can enhance average dry fodder biomass production from 1.25– 4.50 tonnes per hectare per year on natural grassland to 4.50–8.70 t/ha per year (Chinnaondi *et al*., 2014). The average animal carrying capacity can be increased up to 50% in comparison to natural grazing land during rainfed season by adopting silvipastural models. Trees in silvipastures supply fodder during lean period thereby reduce feeding cost and ensure round the year fodder supply. The important fodder shrubs for introduction in different agro-climatic zones have been listed in table 30. Zone wise list of important fodder crops for integration under trees species has been listed in table 31. These fodder trees can be integrated on farm bunds, agricultural border land area, and on grasslands owned by local people. Studies carried out by ICAR-IGFRI on silvi-pastures established in degraded land has shown significant improvement in soil nutrients, organic carbon, soil micro-flora and enzyme activities and carbon sequestration potential. Therefore, silvipastures can be established on wastelands of Karnataka which will be a win-win situation as on the one side it will reclaim the wasteland and on the other side it will provide round the year fodder for livestock. Moreover, tree leaf fodder quality does not get impacted significantly by seasons as in case of forage crops and grasses. The fodder trees vary with agro-climatic zone and preferences of people.

Table 30. Common fodder species in different agro-climatic zones of Karnataka

Zone number and Name	District (No. of Tehasils)	Fodder species
1. North Eastern Transition Zone	Bidar (5) & Gulbarga (2).	*Acacia albida, Albizia lebbek, Buddlea asiatica*
2. North Eastern Dry Zone	Gulbarga (5) Yadgir (3) & Raichur (3)	*A. albida, A. farnesiana, A. modesta, A.amara, A. lebbek, Ziziphus mauritiana*
3. Northern Dry Zone	Koppal (4), Gadag (4), Dharwad (1), Belgaum (5), Bijapur (5), Bagalkot (6), Bellary (7), Davangere (1), Raichur (2)	*A. albida, A. catechu, A. nilotica, A. Senegal, A. lebbek, Anogeissus latifolia, Dalbergia sissoo, Dendrocalamus strictus, Ficus spp., Erythria suberosa, Cordia dichotoma, Hardwickia binnata, Leucaena leucocephala, Meliaazedarach, P. cineraria, Syzygium cumini, Ziziphus mauritiana*
4. Central Dry Zone	Chitradurga (6), Davangere (3), Tumkur (6), Chickmagalur (1), Hassan (1)	*A. albida, A. catechu, A. nilotica, A. senegal, A. ebbek, A. latifolia*
5. Eastern Dry Zone	Bangalore Rural (4), Ramanagar (4) Bangalore Urban (3), Kolar (5), Chikkaballpur (6) Tumkur (2).	*D. sissoo, D.strictus, Ficus sp., E. suberosa, Cordia dichotoma*
6. Southern Dry Zone	Mysore (4), Chamarajnagar(4), Mandya (7), Tumkur (2), Hassan (2).	*H. binnata, L. leucocepha, M. azedarach, Ougeinia oojeinensis, Prosopis cineraria, S.cumini, Z. mauritiana*
7. Southern Transition Zone	Hassan (4), Chickmagalur (1), Shivamogga (3), Mysore (3), Davanagere (2).	*A. catechu, A. nilotica, A. lebbek, A. latifolia, B. semla, D. sissoo, E. variegate, E.suberosa, Artocarpus heterophyllus, L. leucocephala, Kydia calycina, M. alba, M. azedarach, Moringa oleifera, O.oojeinensis, T. chebula and Z. mauritiana*
8. Northern Transition Zone	Belgaum (4), Dharwad (3), Haveri (6), Gadag (1).	*A. nilotica, A. chinensis, A. lebbek, A. heterophyllus, A. indica, B. purpurea, D. sissoo, M. azedarach, M. alba, S. cumini, T. belerica, Pueraria montana*
9. Hilly Zone	U.Kannada (6), Belgaum (1), Dharwad (1), Haveri (1), Shivamogga (4), Chickmangalur (5), Kodagu (3), Hassan (1)	*A. chinensis, A. lebbek, B. purpurea, B. racemose, B. variegata, Bombax ceiba, G. elastic, G.tilifolia, M. azedarach, M. alba, M. serrata*

Source: Kartik and Durai, 2022

Table 31. Suitable trees and grasses for silvipasture establishment under various climatic zones of Karnataka

Zone number and Name	District (No of Talukas)	Trees	Fodder crops
1. North Eastern Transition Zone	Bidar (5) & Gulbarga (2).	Sandal wood - *Santalum album,* Teak - *Tectona grandis,* Mahogany - *Swietenia mahagoni*	Bajra napier hybrid, Guinea grass, Grazing guinea, *Stylosanthes*,
2. North Eastern Dry Zone	Gulbarga (5) Yadgir (3) & Raichur (3)	Raktachandana (Red sandal wood - *Pterocarpus santalinus,* Malabar neem - *Melia dubia,* Earleaf	Perennial fodder sorghum, Dinanath grass Rhodes grass
3. Northern Dry Zone	Koppal (4), Gadag (4), Dharwad (1), Belgaum (5), Bijapur (5), Bagalkot (6), Bellary (7), Davangere (1), Raichur (2)	Acacia - *Acacia auriculiformis*	
4. Central Dry Zone	Chitradurga (6), Davangere (3), Tumkur (6), Chickmagalur (1), Hassan (1)		
5. Eastern Dry Zone	Bangalore Rural (4), Ramanagar (4) Bangalore Urban (3), Kolar (5), Chikkaballpur (6) Tumkur (2).		
6. Southern Dry Zone	Mysore (4), Chamarajnagar(4), Mandya (7), Tumkur (2), Hassan (2).		
7. Southern Transition Zone	Hassan (4), Chickmagalur (1), Shivamogga (3), Mysore (3), Davanagere (2).		
8. Northern Transition Zone	Belgaum (4), Dharwad (3), Haveri (6), Gadag (1).		

9.	Hilly Zone	U.Kannada (6), Belgaum (1), Dharwad (1), Haveri (1), Shivamogga (4), Chickmangalur (5), Kodagu (3), Hassan (1)	Sandal wood-*Santalum album,* Teak - *Tectona grandis,* Red sandal wood - *Pterocarpus santalinus,* Bamboo, *Sesbania grandiflora,* Silver oak - *Grevillea robusta*	Guinea Guinea, Grazing guinea, Bajra napier hybrid, *Stylosanthes guanensis, Brachiaria*
10.	Coastal Zone	Udupi (3), Dakshina Kannada (5), Uttara Kannada (5)		

Targeting forage production from non-arable lands (alternate land use systems, ALUs)

There are various alternate land use (ALU) systems which provide fodder such as silvi-pasture (tree + pasture+ animals), horti-pasture (fruit trees + pasture+animal) and agri-horti-silvipasture (crop + fruit trees + MPTS + pasture). Many multipurpose tree species (MPTS)/shrubs growing in ALU systems are useful as leaf fodder used for animal feed besides multifarious products. These activities contribute significantly to domestic livestock production, which in turn influences milk and meat supply and contributes to household income. There is an ample scope and many opportunities for introducing fodder crops in existing orchards. Horti-pasture systems integrate pasture (grass and/or legumes) and fruit trees to fulfill the gap between demand and supply of fruit, fodder and fuel wood through utilizing moderately degraded land.

D. Fodder production on non-competitive land use systems

Farm bunds are common features of improved agricultural practices for demarcation of farmers' lands, irrigation, soil and water conservation *etc*. They are often left unused and become host for unwanted vegetation and obnoxious weeds *etc*. They may be exploited for cultivation of fodder without adversely affecting the crop productivity in the field. A moderate utilization of these farm bunds with a conservative fodder yield per unit area can produce about 10.47 lakh metric tonnes of green fodder per season (Table 32; Figures 10-11).

Table 32. Fodder production potential on farm bunds

Type of holding	No. of holdings (in lakhs)	Average size of holdings (ha)	Total bund length (lakh km)*	Fodder production (lakh MT)**
Marginal (<1 ha)	47.67	0.44	6.32	4.43
Small (1-2 ha)	22.14	1.4	5.30	3.71
Semi Medium (2-4 ha)	11.93	2.67	3.93	2.75
Medium (4-10 ha)	4.51	5.69	2.10	1.47
Large (>10 ha)	0.56	15.45	0.54	0.38
Total	86.81	1.36	14.96	10.47

*** Computed value **10% bund length used @ 7 kg/m length**

Figure 10: Fodder on farm bunds

Figure 11: Fodder on water pond embankment

E. Alternative fodder resources

Alternative fodder resources supplement the efforts for supply of quality fodder at affordable cost. They also sometimes provide a viable medium for nutritious fodder particularly in times of scarcity and natural calamity. There is a need for exploring the alternative or non-conventional fodder resources viz., moringa, azolla, hydroponics, fodder beet, food processing industry wastes Although Azolla and hydroponics could be ideal sources of fodder in plain areas and occupy lesser land area, they are labour intensive activities. These could be better options when house-hold labour is involved in augmenting the fodder resources and those livestock keepers, who have lesser number of animals. However, these can be supplementary in nature and cannot substitute natural fodder production.

a. Non-conventional fodder crops

Moringa *(Moringa oleifera)* grows well and is a good alternative source for substituting commercial rations for livestock. The relative ease with which moringa can be propagated through both sexual and asexual means and its low demand of soil nutrients and water after being planted, make its production and management comparatively easy. Its high nutritional quality and better biomass production, especially in dry periods, support its significance as livestock fodder. Moringa planted at ICAR-IGFRI, Jhansi at 50x50 cm spacing gave 80-130 tonnes green forage/ha in 4 cuts at 45 days harvest intervals in 2nd year of planting. Moringa leaves contain 21.53% crude protein, 24.07% acid detergent fiber (ADF) and 17.55% neutral detergent fiber (ADF). Moring pods being a food delicacy in the state of Karnataka, it is already a well accepted crop. Moringa based silvi-pasture model can be developed by involving suitable grass species, where moringa leaves can be utilized for leaf meal production for substituting as source of protein in rations and grasses will provide cheaper and nutritious fodder. Simlarly, chaya (*Cnidiscolus acontifolius*) in high rainfall areas, fodder cactus (*Oputia* spp), mulbery (*Morus alba*) in drier areas could be successful non-conventional fodder crops in Karnataka (Figure 13).

nutrients and water after being planted, make its production and management comparatively easy. Its high nutritional quality and better biomass production, especially in dry periods, support its significance as livestock fodder. Moringa planted at ICAR-IGFRI, Jhansi at 50x50 cm spacing gave 80-130 tonnes green forage/ha in 4 cuts at 45 days harvest intervals in 2nd year of planting. Moringa leaves contain 21.53% crude protein, 24.07% acid detergent fiber (ADF) and 17.55% neutral detergent fiber (ADF). Moring pods being a food delicacy in the state of Karnataka, it is already a well accepted crop. Moringa based silvi-pasture model can be developed by involving suitable grass species, where moringa leaves can be utilized for leaf meal production for substituting as source of protein in rations and grasses will provide cheaper and nutritious fodder. Simlarly, chaya (*Cnidiscolus acontifolius*) in high rainfall areas, fodder cactus (*Oputia* spp), mulbery (*Morus alba*) in drier areas could be successful non-conventional fodder crops in Karnataka (Figure 12).

a. Chaya **(*Cnidiscolus acontifolius*)**

b. Moringa *(Moringa oleifera)*

c. **Mulbery (*Morus alba*)**

d. **Cactus (*Oputia* spp)- in intercropping**

Figure 12: Non-conventional fodder crops

b. Azolla as alternate fodder

Figure 13: Azolla production on HDPE structures (Photo courtesy: MIPA industries, Pune)

Azolla farming in general, is inexpensive and it can be multiplied in natural water bodies for production of biomass. Biomass productivity is dependent on time and relative growth rate and efficiency of the species. Azolla is very rich in proteins, essential amino acids, vitamins (vitamin A, vitamin B_{12}, Beta Carotene), and minerals including calcium, phosphorous, potassium, ferrous, copper, magnesium. On a dry weight basis, Azolla has 25-35% protein, 10-15% mineral content, and 7-10 per cent comprising a combination of amino acids, bio-active substances and biopolymers. During lean/drought period it provides sufficient quantity of nutrients and acts as a feed resource. Azolla is a highly productive plant. It doubles its biomass in 3–10 days, depending on conditions and it can yield up to 37.8 t fresh weight/ha (2.78 t DM/ha dry weight). It can be cultivated in many structures (Figure 13).

c. Sugar beet/Fodder beet:

Fodder beet is an important energy supplements for both small and large category of animal. Fodder beets contain about 16-22% dry matter and provide about 4000 kcal/ kg (dry matter) gross energy and digestibility in ruminants is about 85%. The crude prude content ranges between 7-8 per cent on dry matter basis. Fodder beet can be cultivated in many parts of the state except high hills and in duration 140-150 days.

d. Hydroponic fodder production

Hydroponics is a way of rapid quality fodder production. Hydroponic growing systems produce a greater yield over a shorter period of time in a smaller area than traditionally-grown crops. Hydroponic fodder systems are usually used to sprout cereal grains, such as barley, oats, wheat, sorghum, and corn, or legumes, such as alfalfa, clover, or cowpeas. Hydroponic system for fodder introduced in the past on some government animal husbandry farms was not successful due to high energy requirement. But now less expensive and sustainable technologies are available which can be used for hydroponic fodder production. Hydroponic structure consists of a framework of shelves on which metal or plastic trays are stacked. After soaking overnight, a layer of seeds is spread over the base of the trays. During the growing period, the seeds are kept moist, but not saturated. They are supplied with moisture and nutrients, usually via drip or spray irrigation. Seeds will usually sprout within 24 hours and in 5 to 8 days have produced a 6 to 8 inch high grass mat. Peri-urban small

farms, landless animal farms and steep hill farms having no agricultural land but possess small pig, poultry and/or cow units can benefit from either of the two or combining the hydroponic fodder-cum-sprouted grain technologies. Hydroponic fodder cannot substitute green fodder and hay completely, as it lacks in fibre content. But it is definitely a better substitute for packaged feeds (Figure 14).

Figure 14: Hydroponics unit maintained by the farmer Sh. Dhareppa Kittur of Terdal village in Bagalkot district in Karnataka (Photo courtesy: Kannada Prapha, 2016)

Hydroponically grown fodders are rich in vitamins, minerals, enzymes and about 85 to 90% digestible protein. Sprouting of grains increases the enzymatic activity, total protein and changes amino acid profile, increase in sugars, crude fibre, certain vitamins and minerals, but decrease starch and increases simple sugars (Naik *et al*., 2016). Hydroponic fodder is grown inside a greenhouse or in a shaded net within a short period of approximately eight to ten days, even upto 14 days in case of maize to get higher production (Ningoji *et al*., 2020).

F. Crop residues quality enhancement

Crop residues that have high lignin content are used as fuel, while the others as fodder. An exception to the latter are rice husks that contain silica and maize cobs, which are difficult for the cattle to consume. In Karnataka, the agriculture residues are used as fodder, fuel, thatch and manure. Ninety two percent of the stalk from cereal crops is used as fodder, 4 per cent as thatch, 2 per cent as manure and 2 per cent have other use. In all the regions of the state, crop residue is most important source of dry fodder. Plain region is dominated by rice, wheat, maize and sugarcane. Crop residue of these crops is extensively used for feeding animals and is backbone for the livestock production. Small millets straw contains upto 61% total digestible nutrients and good amount of protein and digestible fibre, thus are considered superior to rice and wheat straw. Similarly, in irrigated areas rice and sugarcane are the major crops. Besides, small millets like ragi (*Eleusine coracana*) is mainly grown in south Karnataka. Among the pulses, soybean, blackgram, greengram and cowpea are grown and among oilseeds ground nut and its residues are also utilized for fodder purposes. The potential of dry fodder from food crops is presented in table 33.

Quality enhancement of rice and wheat straw are required to use them as value added fodder. There are various methods of treating the crop residues before feeding, to improve its nutritional value. It has been reported that even chaffing of stalk before feeding, can reduce the emission of methane by 10 per cent while saving the wastage by 25-30%. Further treatment of crop residues by way of water sprinkling and treating with steam under pressure, can also improve the nutritive value and palatability. There

Table 33. Fodder potential of crop residues of food crops

Sl. No.	Crop	Area (Lakh ha)	Production (Lakh MT)	Fodder part	Fodder yield (Lakh MT)
I. Cereals					
1	Rice	12.7	35.63	Straw	35.63
2	Jowar	7.33	7.95	Straw	11.93
3	Ragi	7.45	12.74	Stover	19.11
4	Maize	15.75	56.54	Stover	84.81
5	Bajra	2.09	2.76	Stover	4.14
6	Wheat	1.5	1.57	Straw	2.36
7	Minor millets	0.27	0.19	Straw	0.29
	Total Cereals	47.09	117.38	Straw	158.26
II. Pulses					
8	Redgram	15.9	10.57	Stover	24.66
9	Bengal gram	9	5.56	Stover	12.97
10	Horse gram	1.25	0.76	Stover	1.77
11	Blackgram	0.82	0.43	Stover	1.00
12	Greengram	4.06	1.41	Stover	3.29
13	Field bean	0.4	0.34	Stover	0.79
14	Cowpea	0.61	0.2	Stover	0.47
15	Other pulses	0.01	0.003	Stover	0.01
	Total pulses	32.06	19.28		44.97
III. Oilseeds					
16	Ground nut	6.96	6.37	Stover	14.86
17	Sesamum	0.2	0.17	Stover	0.40
18	Sunflower	1.4	1.09	Stover	2.54
19	Niger	0.01	0.002	Stover	0.00
20	Mustard	0.01	0.002	Stover	0.00
21	Soybean	3.2	3.61	Stover	8.42
22	Safflower	0.25	0.18	Stover	0.42
23	Linseed	0.02	0.007	Stover	0.02
24	Total oil seeds	12.09	11.46	Stover	26.67
IV.	**Sugarcane**	4.5	410.4	Top	45.60
			Grand Total (I+II+III+IV)		275.50

are other methods like urea treatment in addition to molasses. Establishment of a complete feed production unit (Figure 15) can also enhance availability of balanced fodder and will also increase the supply of complete feed at an affordable price can motivate a large number of small farmers to expand their livestock development activities as a reliable source of livelihood. To operationalize such decentralized feed production units on an economically viable scale, the units can be operated by local livestock keeper groups who have a major stake in procurement, distribution and its viability.

Figure 15: Fodder feed block making (Photo courtesy: IGFRI, Jhansi)

G. Fodder conservation technologies - Hay, Bale, Silage and Feed block

As there is a great reliance on crop residues, the farmers often will be carried away by the anticipated successful crop production and subsequent crop residue availability. Hence the aspect of conservation of fodder has been overlooked for long. In recent times, the frequent droughts, failure of crops and non-availability of fodder has forced everybody into thinking of fodder conservation. Traditionally fodder conservation has been only with the dry fodder in the form of hay making and heaping in the form locally known as "*Banave*" in Kannada. However, the lack of scientific hay making has often limited keeping quality of hay making and heaping. In recent times, there is greater emphasis on conserving green fodder popularly known as "silage". While the hay making is possible with the dry fodders, green fodders are conserved through silage making.

i. Hay making and bale making

Although it is common practice, necessary training is needed to ensure long keeping quality of the hay material kept as *Banave*. Further the dry fodder being voluminous in nature often needs larger space and pose problems in transportation. Hence, pressing dry fodder in to bales to reduce keeping space and ease of transportation has been found to be more necessary in recent times. The basic principle of hay making is to reduce the moisture concentration in the green forages sufficiently as to permit their storage without spoilage or further nutrient losses. The moisture concentration

in hay must be less than 15% at storage time. Hence, crops with thin stems and many leaves are better suited for hay making as they dry faster than those having thick and pithy stems and small leaves. Many cost effective and portable bale making machines are now available. Educating the farmers about the use of such machinery will awaken them to go for bale making and efficient use of dry fodder (Figure 16).

Figure 16: Bale making of paddy straw at UAS, Dharwad

i. Silage making

The conservation of green fodder is very important to use it as substitute during the periods of non-availability of fresh green fodder like in summers. However the green fodder due to higher moisture content cannot be kept for long period as they are subjected to mould formation and decaying. Thus they are conserved through silage making. Silage making is a process of conserving the green fodders in airtight conditions and facilitating conversion of sucrose into lactic acid through anaerobic fermentation. This will help in conserving the fodder without being spoiled for long time. Several green crops and grasses may be used for silage making *viz.*, fodder maize, fodder sorghum, fodder oats, bajra napier grass, guinea grass, fruit residues *etc.*, having sufficient sucrose content and moisture of >60-70%. The process involves harvesting of

Figure 17: Stages in silage making (Picture courtesy: NDDB, Anand)

the crop, cutting in to small pieces, placing compactly in airtight structures and keeping for anaerobic condition for fermentation. It forms a highly palatable substitute for green fodder to livestock. This could be one of the ways of meeting green fodder shortage through conservation excess green fodder during surplus time.

H. Contingency fodder planning and fodder conservation technologies

The availability of fodder becomes very scare following failure of monsoon and subsequent drought like situations. This is observed in many parts of the state particularly in the rainfed and dry land areas. There is a need to take both pre-emptive and ameliorative measure to tide over such situations. The measures may be categorized into to 3 types *viz*., before the event, during the event and after the event.

The contingency measures before the event in anticipation comprises; i). Sowing of cereals fodder sorghum, fodder bajra *etc.,* and leguminous crops *viz*., fodder horse gram, cowpea, field bean *etc.* during monsoon under dry land system for fodder production; ii). Harvesting and collection of perennial vegetation particularly grasses which grow during monsoon; iii). Proper drying, baling and densification of harvested grass from previous season; iv). Proper conservation of available legume stover/groundnut haulms/bajra stover *etc*.; v). Creation of permanent fodder, feed and fodder seed banks in all drought prone villages; and vi). Encouraging silage making with available green fodder in the villages.

The contingency measure during the event consists of; i). Harvesting and using of dried up crops like sorghum, bajra, groundnut, maize, greengram, blackgram, soybean, horsegram, cowpea *etc*.; ii). Harvesting the fodder shrubs and tree like subabul, acacia, pipal etc and other non-conventional fodder resources available in the affected areas; iii). Harvesting fodder from Common Property Resources (CPRs) and stall feeding to reduce the energy requirement of the animals; iv). Use of kitchen wastes with dry fodder while feeding; v). Use of concentrate ingredients such as grains, brans, chunnies and oilseed cakes, low grade grains *etc*., unfit for human consumption may be procured from government godowns for feeding as supplement for high productive animals during drought; and vi). Supplementation of mineral mixtures to prevent livestock infertility.

The contingency measures after the event should comprise of; i). Training/educating farmers for feed and fodder storage; ii). Maintenance/repair of silo pits and feed/fodder stores; iii). Motivating farmers to grow fodder crops like fodder sorghum, bajra and maize on their lands and supporting them with inputs like seeds and manures; iv). Making available quality fodder seed and planting material before the onset of monsoon; and v). Replenishing the feed and fodder banks.

I. Seed requirement and availability for targeted area under forages

Karnataka is one of the most vibrant animal husbandry states in India with a contribution of 4.21 per cent milk, 3.13 per cent meat and 7.57 per cent wool to the national production. The state is striving hard to further improve the animal husbandry and dairying. The success of this further improvement depends greatly on the cheaper availability of fodder

and feed to the livestock. With lesser area under fodder crops, their inconsistent productivity and greater reliance on the crop residues, the economic viability of the animal husbandry and dairying are greatly hampered. For a population of 29 million livestock heads comprising of cattle, buffaloes, sheep and goat, the area under fodder crops is meager and insufficient. Fodder is cultivated in about 35,000 ha area. With the permanent pastures and grazing areas occupying an area of 9.12 lakh ha, the state is faced with shortage of fodder. In addition, the availability of fodder is also greatly influenced by the vagaries of monsoon. The cultivation of fodder crops is very scanty and area ranges between 0.01 per cent - 2.60 per cent with an average of 0.27 per cent of the total cropped area in Karnataka. Only 3 districts had an area of >2.00 per cent of the gross sown area. In absolute terms, only one district had an area >1000 ha in the entire state. The total dry fodder requirement in the state is computed to be 31.77 million tonnes *vis-à-vis* the available 28.94 million tonnes with a net deficit of 2.82 million tonnes (Kamrdi *et al.,* 2017) and more than 12 districts suffered net shortages of 1.30 per cent to 76.20%. Furthermore the fodder scenario becomes grimmer with sub-optimal monsoons and failure of other field which act as buffer for supply of dry fodder in the form of crop residues. Hence, it is of great importance to ensure the availability of fodder through enhancing area under fodder crops for sustainable fodder production and availability.

Requirement of fodder seeds and planting material and probable source

Unlike in food and commercial crops, the timely availability of quality fodder seeds and planting material is a big issue. This problem arises because of the fact that there is no assured market for fodder seeds and planting material. As fodder crops have no prime priority in terms of allocation of land for cultivation, they are often grown when there is a limitation for cultivation of other crops. With lesser preference for fodder crops themselves, the production of quality fodder seeds and planting material is a remote proposition for many farmers. Thus there is a widespread scarcity of quality fodder seeds and planting material. With the information available as of now the area allocated for fodder crops is around 0.3 per cent of the cropped area. The recent awareness about the advantages of animal husbandry and dairying and subsequent need for enhancing the fodder area to around 5 per cent of the total cropped area, there is a likelihood of increase in the area of fodder crops in due course. With about 13.8 million ha area under cultivation, assuming 5 per cent area under crops, the total area comes to 6.9 lakh ha. Again assuming one-third area under annual fodder crops, one-third area under perennial fodder crops propagated through seeds and one-third area under perennial fodder crops propagated through planting material, there will be huge demand for fodder seeds and planting material of all types of fodder crops. The exact quantity of fodder seeds of different fodder crops and planting material varies with the type of fodder crop and their combination under a given situation. Further a large area under horti-pasture systems and newer niches, the quantum will further swells up. Once there is a realization of importance of fodder seeds and planting material, obviously there will interest among farmers to diversify fodder cultivation towards their seed production and planting

material. Till a time it becomes viable as commercial proposition for interested farmers, the availability of fodder seeds and planting material may be ensured through a fine tuned network of Farmers' Cooperative Fodder Seed Producing Agencies, Krishi Vigyan Kendras (KVKs), State Seed Corporations, State Agricultural Universities (SAUs), Milk Production Cooperatives, Department of Agriculture, Department of Animal Husbandry and Veterinary Services, Department of Horticulture, Department of Forest etc. With concerted efforts and coordination among these agencies, the availability of quality fodder seeds and planting would not be a big issue anymore.

Measures to ensure fodder seed and planting material availability

The timely availability of quality fodder seeds and planting material may be ensured with the following pro-active measures among different agencies:

I. Identification of suitable and sufficient area for different fodder crops in different agro-climatic regions in different seasons for ensuring sufficient green and dry fodder availability

ii. Computing the quantum of fodder seeds and planting material required well in advance before the beginning of season for their production/multiplication for distribution in different regions

iii. Entrusting the fodder seeds and planting material production among the different agencies with assured buy back arrangement

iv. Developing a system involving different stake holders to ensure remunerative price for the fodder seeds and planting material producers on one hand and availability of quality seeds and material to interested growers at affordable price on the other hand

v. Involvement of Technology Developers and Users at various stages of this process to evolve suitable fodder crops and their production technology to keep abreast of the modern developments seen in other category of crops to make the fodder crops more competitive and remunerative.

vi. Institutional support for the fodder seed and planting material producers as well as fodder growers in terms of incentives for fodder seeds and other inputs in the initial years to grow it to a level where it can sustain on its own.

Fodder seeds and planting material availability is a major bottle neck in fodder production. It is difficult to estimate in advance the seed requirement of different fodder crops as farmers look fodder crops as alternative during failure of main crops owing to vagaries of monsoon or pests/diseases *etc.* The fodder seed of desired crop and variety may be ensured if prior planning is done. There are several public and private fodder seed producers and sellers identified in Karnataka *e.g.,* Sh. Santosh Pagad and Sh. Sharanappa Kuri are well known fodder seed producers and sellers in Gadag district; Sh. Goutam Bhupalam in Bellary district. Private sector seed giant Advanta Seeds are also involved in production and selling of fodder seeds with Dr. Shashikant Kulkarni showing pro-active role in popularizing fodder seeds in peninsular India including Karnataka.

Part-III : Brief Action Plan

i Identification of areas for propagating fodder production

Bench mark survey on the micro-climatic conditions, cropping systems and introduction of fodder crops may be initiated for identifying the suitable fodder crops and their varieties and production potential *vis-à-vis* the farmers' acceptance and their satisfaction.

ii. Selection of villages in different agro-climatic zones based on livestock resources

Among several agro-climatic zones of the state, one district from each agro-climatic zone can be selected. Bench mark survey may be initiated in 2 talukas in each of the selected districts which will fairly give an idea about the possible conditions for propagation of fodder crops under varied situations.

iii. Identifying fodder species/varieties suitable for different agro-climatic zones

An exercise was made during the workshop to elicit the opinion of the staff of the Animal husbandry of Karnataka state as to which fodder crops and their varieties would be more suitable for different agro-climatic conditions prevailing in the state and it has been outlined in the recommendations. The same may be used as guideline for identification of suitable fodder crops and varieties.

iv. Providing package of practices for fodder crops

There are already well established package of practices for different fodder crops under various agro-climatic conditions. The same will be adopted as package of practices *mutatis mutandis* for successful cultivation of fodder crops in the state of Karnataka.

v. Master trainers training at IGFRI/SAUs

The staff of Dept. of Animal Husbandry, Veterinary, Agriculture, Horticulture, Forestry *etc.* from the Govt. of Karnataka having aptitude to work for augmenting fodder resources will be identified through their superiors in the first stage as master trainers. And they will be offered intensive need based training program at IGFRI, Jhansi. The number of participants, the duration of the training program and the topics of training programme will be finalized after discussion with the Head of the line department, Govt. of Karnataka.

vi. Creating awareness among farmers and other stakeholders and promoting production of forage crops

The Krishi Vigyan Kendras (KVKs) operating in the state of Karnataka will be roped in to identify the needy farmers for training on fodder crops. Other stake

holders like milk co-operatives, non-governmental agencies (NGOs) and progressive farmers will also be made partners in the process of creating awareness about fodder production.

vii. Conduct of frontline demonstration and training

After bench mark survey and identification of suitable places for propagating awareness about the fodder crops, sufficient number of front line demonstrations in each of the selected tehsil will be conducted in the farmers' field to make them aware of the fodder production potential and motivate them to go for cultivation of fodder as per the needs. In addition, tailor made training programs will be organized through KVKs for the benefit of the interested farmers on the topics of their interest in fodder crop production, livestock production and dairying.

viii. Strengthening of forage seed production chain

As emerged out of the discussion during the workshop, the non-availability of quality seeds and planting material of suitable fodder crops is one of the major hindrances for the cultivation of fodder crops. Therefore efforts will be made to estimate the quantum of various fodder crops' seeds and planting material well in advance and an institutional mechanism will be put in place to ensure the availability of different category of fodder seeds and planting material so that the non-availability does not become an issue for fodder cultivation.

ix. Adoption of holistic approach- fodder production, conservation and utilization

In fact, there is a fodder scarcity in almost all places in Karnataka. The would-be fodder cultivating farmers will be doing so out of their dire requirement of fodder for their livestock. And hence the fodder production will be need based and there is no way of facing any problem thereafter. However, all efforts will be made to interlink the activities of fodder production, its conservation either in the farm of silage (for green fodder) or hay (for dry fodder), and its scientific utilization will be ensured through creating awareness on all these aspects and ensuring the compliance by the master trainers, trained farmers and other stake holder in the process.

x. Enhance acreage and productivity in non-conventional areas

Indeed there is a shortage of land for allocation to production of fodder crops in the state of Karnataka. Therefore efforts will be made to bring non-conventional areas for production of fodder crops. In the process all efforts will be made for:

a. Production of fodder in non-arable land, wasteland.
b. Production of fodder in problem soils.
c. Enhancing production through grassland, rangeland and grazing land management.

d. Enhancing production through alternate land use management such as horti-pasture- silvi-pasture *etc.*

xi. Conservation of forage resources to mitigate calamities and ease of transport

In many areas in spite of having a large chuck of crop wastes having fodder value, it cannot be used due to faulty agricultural practices or lack of foresight and or lack of machinery *etc*. Hence, conservation of fodder resources wherever possible for future use during lean periods and at times of natural calamities like famine, high rainfall *etc*., will be highlighted. Further as fodder is bulky in nature accounting for huge expenditure in transportation, bale making of dry fodders, silage in poly bags of convenient sizes for transportation will be promoted and popularized among the livestock holders.

xii. Establishment of fodder banks

At times livestock holder are faced with fodder scarcity owing to natural calamities, unforeseen failure of crops and it poses a great threat to sustainable animal husbandry and dairying. To tide over such situation of fodder scarcity, efforts will be made to educate the policy makers, heads of line departments to establish fodder banks at village clusters or tehsils for ensuring the supply of minimum quantity of fodder to livestock keeper so that the animals are not forced to go hungry. In addition, establishment of fodder ware houses with enriched dry fodder or silage bins will also be popularized.

xiii. Networking through ICAR-State Govt machinery -SAUs-Milk Federations

Any isolated efforts to augment fodder resources may not be sustainable in long run owing to some unforeseen situations in future. And hence, networking of fodder producers, fodder entrepreneurs, heads of line departments will be made for foreseeing at the grass root level. Likewise, networking of ICAR Institutions *viz*., IGFRI, NIANP, NDRI, IVRI, IIVR, IIPR, IISR, *etc*., Department of Animal Husbandry and Veterinary Services of the state and central govt., Milk Federations and Dairy owners etc., will be established to supervise and evolve a mechanism to attend to problems associated with technologies and forth coming issues in future.

xiv. Public-Private-Partnership (PPP) mode of operation

Although the initial stage of program is hovering around the government agencies involved in various aspects of fodder production, processing, conservation, utilization, rationing, policy making, etc. the ultimate end user will be common farmers. Further there are several private players viz. dairy owners, animal pharma industries, feed manufactures, NGOs involved in livestock production and dairying etc. They will all be brought together under Public-Private Partnership (PPP) mode in more transparent, efficient and economical way for all the partners.

xv. Impact analysis of technology adoption

The objectives of the program also aim at seeing the perceptible changes that are going to occur though the implementation of the proposed project. Hence, base line data on various parameters will be collected before the start of the project and after the project implementation at regular interval. The findings will be used for impact analysis of the technology demonstrated through this project. Midterm corrections needed if any will be identified through this impact analysis study.

Part-IV : Road Map

This project is conceived to be multi-task, multi-partner and multi-year activity. Hence, a proper road map is necessary for making it more practical and result oriented. The following road map has been proposed under this project. There are several action points to be carried out in the process of implementation by several agencies (table 34).

Table 34. Road map for the implementation of the proposed activities

Sl.No.	Action point	Agencies involved
1	Breeder seed production of the identified varieties	IGFRI, Jhansi/ SAUs
2	Foundation seed production	RFS/ DAHD /SAHD
3	Production of TFL/certified seeds	SAUs/Milk unions/ NSC / SSC
4	Demonstration, training of farmers, field trials at farmers field, package of practices	District KVKs /milk unions/SAHD/LDB
5	Extension activities and development of fodder warehouse	Milk Unions/State Animal Husbandry Department
6	Dry fodder processing, value addition and fodder management (chaff cutter, fodder block, baling, grinding)	District level milk union/Animal Husbandry Dept.
7	R & D activity (evaluation of fodder quality, food-feed crops, hydroponics *etc.*,)	ICAR Institutes/ SAUs / SVUs
8	Capacity building of stake holders	ICAR-IGFRI/SAUs

The detailed plan for implementation of pilot project is presented in the Table 35.

Table 35. Implementation level plan for pilot project

Sl. No.	Activity	Time Frame	Action points
1	Target area selection	March-May	Selection of 3 districts from each agro-climatic zone Selection of 2 talukas and 2 villages in from each taluka, 4 farmers from each village, total of 48 farmers fields from each cluster Selection of 1.0 acre in each cluster for technology demonstrations Bench mark survey

2	Training	April-May	Training of master trainers- 25 master trainers per batch and 1 batch from each district in 2 batches at IGFRI, Jhansi/Dharwad. Training of farmers; 30 from each zone and total of 270 farmers from 9 zones. Exposure visit of progressive farmers and master trainers at IGFRI, Jhansi / IGFRI-SRRS, Dharwad / UASs, UHS, , KVAFSU etc.
3	Technology Demonstrations	June-July	Selection of crop and varieties will be done after identifying suitable districts and village clusters both under annual and perennial crops for different seasons *viz. kharif, rabi* and summer. Silage should be encouraged. Since crop residue being a precious commodity, fodder banks using densification technologies can be developed
		June- January	Annual fodder crops Bajra :DRSB 2, Giant Bajra , Moti Bajra *etc.* Cowpea: MFC-09-01,MFC-08-14, Annual Lucerne: Anand 1, Anand 2
		June - July	Perennial fodder crops bajra napier hybrid: CoBN-5, CoBN 6, DHN6, DHN 15 Guinea grass: DGG1, Grazing guinea, Congo signal grass: DBRS1 (high rainfall areas), Perennial sorghum: COFS 29,COFS 31 *Stylosanthes* spp.
4	Suitable silvi-pasture/ horti-pasture system demonstrations	June-September	In existing orchard- 1 ha (Guinea, Grazing guinea) In new orchard- 1 ha (Guinea, Grazing guinea) Popular and potential fodder trees: Calliandra, erythrina, gliricidia, sesbania moringa can be a potential source of legume fodder in upland areas and may be explored

5	Need based Watershed/ micro irrigation facility development	March-April	Suitable fodder species *viz.* grazing guinea, signal grass, *etc.* to check soil and water erosion and enhancing water retention will be highlighted.
6	Rejuvenation of grasslands/ pasturelands/ CPRs	October-December	The related activities will be taken up during post rainy season /with first *rabi* rains
7	Tapping rice fallow and other fallow areas for fodder production	October-December	Suitable annual fodder crops *viz.* fodder cowpea, pillipesara, oats etc. will be grown on residual moisture to ensure fodder supply during the period
8	Input supply	April-May and September-October	Inputs *viz.* seeds/ rooted slips/, fertilizers, insecticides *etc.*, small machinery and tools - improved sickles *etc.* will be supplied to farmers
9	Custom hiring centre in each village cluster	October-November and March - April	Exploring and facilitating the farmers with chaff cutter, bhusa urea enriching machinery, baling of paddy straw, dry fodder *etc.*, complete feed block making machine, regular farm implements including tractors, harrow, seed drill *etc.*

Funding arrangements

Govt. of Karnataka, Govt. of India through various state and central schemes like RKVY *etc.* can meet the fund requirement. ICAR- IGFRI will provide technical support for formulation of such fodder development proposals for funding. The fund requirement for the implementation of the pilot project is given below (Table 36)

Table 36. Approximate budget requirement (Rs in Lakhs)

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Master trainer training	3.0	3.0	2.0	1.0	1.0	10.00
Farmers training	3.0	3.0	3.0	3.0	3.0	15.00
Exposure visit of farmers / stakeholders	5.0	4.0	3.0	1.5	1.5	15.00
Seed/ Planting material	20.0	20.0	20.0	10.0	5.0	75.00
Micro Irrigation facilities	10.0	10.0	5.0	5.0	5.0	35.00
Other farm inputs small equipments etc	5.0	3.0	3.0	3.0	1.0	15.00
Custom hiring center equipments	20.0	10.0	3.0	1.0	1.0	35.00
TA/DA/ staff (SRF/YP/RA) / Consultancy/ Miscellaneous etc.	10.0	10.0	10.0	10.0	10.0	50.00
Total	76	63	49	34.50	27.50	250.00

Part-V : Implementation of Pilot Programme

The Karnataka Fodder Resources Development Plan is a very comprehensive and inclusive programme structured to include various stake holders. It is a multi agency, multi level and multi activity programme. The execution of the programme will be made with the involvement, input and knowledge sharing by all the participants. The participating farmers are also expected to be knowledge repositories for the fellow farmers once the initial participants achieve a certain degree of expertise. The various stages and activities of the programme are depicted in the diagram below (Figure 18).

Figure 18: Thematic diagram showing the execution of fodder resources development plan in Karnataka

Part-VI : Modalities

This programme is undertaken to enhance the fodder production, conservation and utilization on more sustainable basis in different fodder deficit districts of Karnataka. The ICAR- IGFRI has taken a lead in technological support in collaborating with other public and private sector agencies in this regard. However the modalities of executing this programme are as follows:

- IGFRI, Jhansi will be knowledge partner and will help in providing all technical backup, technological support, seed procurement, sources *etc.*
- IGFRI-SRRS, Dharwad will provide all the technological and technical support in implementation of fodder action plan
- IGFRI-SRRS, Dharwad will also supply the seeds/planting material or else will facilitate for the same from reliable sources in case of non-availability locally.
- IGFRI-SRRS, Dharwad would help in seed procurement on buy back arrangement in cases where seed production activities are involved in the programme
- Line Departments *viz.*, Dept. of Agriculture, Dept. of AH & VS, Dept. of Horticulture,
- Dept. of Forestry *etc.*, Govt. of Karnataka along with KVKs, NGOs, Milk Federation *etc.*, will implement the program at field and farmers level.

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Annexure-I

Proceedings and recommendations of interactive fodder workshop

The meeting began with welcome address by Dr. Purushottam Sharma, Nodal Officer, NIAFTA, ICAR-Indian Grassland and Fodder Research Institute, Jhansi. Dr. Amaresh Chandra, Director in his introductory remarks welcomed all the participants, once again and highlighted the research achievements of Indian Grassland and Fodder Research Institute with special emphasis on fodder technologies. He informed that this proposed States' Fodder Resources Development Plans are being developed on the advice of Dr. T .Mohapatra, Director General, Indian Council of Agricultural Research (ICAR) & Secretary DARE, Govt. of India. He informed that there are >300 improved varieties of fodder crops available both for rainfed and irrigated conditions and suitable to different agro-climatic situations. Fodder seeds are produced on large scale and their availability is being ensured under National Livestock Mission (NLM) projects. He stressed that at least 5 per cent of cultivable area needs to be brought under fodder crops and it will mitigate the fodder scarcity in the country. He appealed to all the participants to contribute for the development of the Karnataka State fodder plan.

Dr. Rajendra Prasad, Vice Chancellor, University of Agricultural Sciences, Bengaluru opined that as per the vision of Hon'ble Prime Minister of India, the fodder crops should be a component of organic and natural farming. The quality seed production and enhancing their availability to the needy farmers should be ensured. The fodder production may be a big challenge in view of the fragmentation of land holdings and shrinking community property resources (CPR). He appreciated the role of Govt. of Karnataka in distribution of fodder seeds through mini-kit programme. The cultivation of perennial fodder crops on field bunds in irrigated eco-system like rice, sugarcane etc needs to be popularized. He opined that introduction of short duration fodder crops like cowpea in rice fallows may be explored. He felt that introduction of fodder crops in prevailing cropping pattern and dry lands having short moist period may also be looked into. Bringing the fodder crop varieties into the seed multiplication chain like in other field crops has to be considered. He stressed evolving fodder seed production programmes involving all stake holders' *viz.*, ICAR institutes, SAUs, Milk Federations, line Departments of the State Government. This may ensure availability of quality fodder seeds to the farming community.

Dr. H.D. Narayanaswamy, Vice Chancellor, Karnataka Veterinary, Animal and Fisheries Sciences, Bidar highlighted that there is a decline in availability of land for fodder crops. He felt that the non cultivable areas may be utilized for fodder production, creating awareness among farmers to grow fodder crops suitable for different agro-ecological situations. Fodder trees may also be considered along with fodder crops to ensure availability of fodder to the animals during lean period.

Dr. B.K. Desai, Director of Research, University of Agricultural Sciences, Raichur, proposed cultivation of fodder under hortipasture, silvipasture, field bunds and popularization of hydroponics. He informed that the UAS, Raichur has already developed integrated farming system (IFS) models involving fodder crops.

Dr. Abdul Aziz, Director, Karnataka State Rural Development and Panchayat Raj University, Gadag, wished to establish fodder research and development centre at the university level in collaboration with Indian Grassland and Fodder Research Institute. He proposed entering into MoU with Indian Grassland and Fodder Research Institute, Southern Regional Research Station, Dharwad for furthering the fodder developmental activity in that University. He also stressed need for establishment of fodder banks.

Dr. H.P. Maheswarappa, Director of Research, University of Horticultural Sciences, Bagalkot, desired for the introduction of fodder crops in plantation and horticultural crops and to study the synergies between fodder crops and horticultural crops in collaboration with Indian Grassland and Fodder Research Institute, Southern Regional Research Station, Dharwad.

Dr. M.S. Palegar, Director, Animal Husbandry and Veterinary Services, Govt. of Karnataka highlighted the acute dry fodder shortage in the state of Karnataka and felt that there is a need for nutrient fortification of crop residues for increasing the palatability of the dry fodders. He also suggested identification of fodder crops suitable for small ruminants and fodder shrubs as alternative to mulberry. Fodder crops may be introduced to some extent in high intensive cropping systems involving soybean and other pulses.

Dr. M.B. Chetti, Vice Chancellor of University of Agricultural Sciences, Dharwad in his Chairman's remarks stressed alternative land use systems for fodder production, ensuring availability of quality fodder seeds and planting material and other inputs, importance of fodder conservation aspects to tide over fodder scarcity during lean periods, utilization of fodder shrubs, improving the quality of roughages through urea spray, addition of mineral mixture etc., educating farmers on fodder seeds and planting material multiplication, introduction of fodder crops in long duration perennial crops like sugarcane, horticultural and plantation crops etc. He opined that providing technical knowhow along with other physical inputs are required for popularizing the fodder crops' production and conservation. In this connection, he highlighted that Govt. of Karnataka has already sanctioned Rs. 43 lakhs for joint project between UAS, and IGFRI covering Dharwad, Haveri and Gadag districts in Karnataka and he impressed upon speedy implementation and completion of the project.

Dr. B.G. Shivakumar presented "Karnataka State Fodder Resources Development Plan" comprising all aspects of livestock and fodder scenario along with brief action plan. Presentations were made on improved fodder varieties and newer niches for introduction of fodder crops; fodder conservation and fodder based economic ration;

and fodder densification, storage and fodder bank by Dr. K. Sridhar, Dr. Sultan Singh, Dr. Purushottam Sharma and Dr. P.K. Pathak. It was followed by in-depth discussion and suggestions for improvement of the fodder plan.

In the ensuing discussion, Dr. Shashikant Kulkarni, representing Advanta Seeds Ltd. informed that several fodder crops have been developed including sorghum varieties for silage making by their research wing and at present conducting demonstrations for popularization of fodder crops in sugarcane fields. The Deputy Director AH&VS, Belagavi suggested to have demonstrations of suitable fodder crops in Belagavi district.

In his concluding remarks, Dr. Amaresh Chandra, Director thanked all the participants for active involvement and interaction and urged to provide critical suggestions/inputs for improvement of the proposed Karnataka State Fodder Resources Development Plan before it is finalized.

The workshop was attended by more than 150 Officers of the State Department of Animal Husbandry and Veterinary Services, Department of Agriculture, Heads of Krishi Vigyan Kendra's, Scientists from IGFRI, Jhansi and other ICAR Institutes located in Karnataka, public and private fodder seed producers and progressive farmers. The workshop ended with vote of thanks by Dr. Narendra Kulkarni.

Annexure-II

List of participants in IGFRI – UASD Collaborative online workshop on "Karnataka Fodder Resources Development Plan" held on 16th February 2022.

The following were present in the workshop:

1. Dr. Amaresh Chandra, Director, Indian Grassland and Fodder Research Institute, Jhansi
2. Dr. M.B. Chetti, Vice Chancellor, University of Agricultural Sciences, Dharwad
3. Dr. Rajendra Prasad, Vice Chancellor, University of Agricultural Sciences, Bengaluru
4. Dr. H.H. Narayanaswamy, Vice Chancellor, Karnataka Veterinary, Animal and Fisheries Science University, Bidar
5. Dr. M.S. Palegar, Director, Department of Animal Husbandry and Veterinary Services, Govt. of Karnataka, Bengaluru
6. Dr. C. Nandini Kumari, Director, Department of Agriculture, Govt. of Karnataka, Bengaluru
7. Dr. B.K. Desai, Director of Research, University of Agricultural Sciences, Raichur
8. Dr. H.P. Maheswarappa, Director of Research, University of Horticultural Sciences, Bagalkot
9. Dr. B. Hemla Naik, Director of Extension, University of Agricultural and Horticultural Sciences, Shivamoga
10. Dr. Abdul Aziz Mulla, Director, Karnataka Rural Development and Panchayat Raj University, Gadag
11. Dr. Bukka Mallikarjun, Director (AH), Karnataka Milk Federation Head Office, Bengaluru
12. Dr. B.G. Shivakumar, Principal Scientist (Agronomy) and Chairman, Karnataka Fodder Resources Development Plan Committee, Indian Grassland and Fodder Research Institute, Southern Regional Research Station, Dharwad
13. Dr. V.S. Kubsad, Professor (Agronomy) & Head Forage Section, University of Agricultural Sciences, Dharwad
14. Dr. S.A. Biradar, Head, Krishi Vigyan Kendra, Dharwad
15. Dr. D.V. Kolekar, ICAR-Agricultural Technology Application Research Institute, Zone 11, Bengaluru
16. Dr. Shashikant Kulkarni, TD-Lead Special Projects-South Asia, UPL Limited, Hyderabad
17. Sh. Santosh Pagad,Fodder Seed Producer and Seller, Ron, Karnataka

18. Dr. Shantappa Tirakannavar, ADRE, Regional Horticultural Research and Extension Centre, University of Horticultural Sciences, Kumbapur, Dharwad
19. Dr. J.B. Gopali, Professor and Sr. Farm Superintendent, Regional Horticultural Research and Extension Centre, University of Horticultural Sciences, Kumbapur, Dharwad
20. Dr. Laxman Kukanoor, Head, Horticultural Extension Education Unit, Regional Horticultural Research and Extension Centre, University of Horticultural Sciences, Kumbapur, Dharwad
21. Dr. B.G. Shekara, Professor and Head, AICRP (FCU), Zonal Agricultural Research Station, UAS, Mandya
22. Dr. Nagesh Chikkarugi, AICRP (FCU), Zonal Agricultural Research Station, UAS, Mandya
23. Sh. B.V. Goutham, Surabhi Seeds, Bellary
24. Dr. Korla Aditya Chowdary, Central Fodder Seed Production Farm, Department of Animal Husbandry and Dairying, Govt. of India, Hesserghatta, Bengluru
25. Dr. Sunil Kumar, Head, Crop Production, Indian Grassland and Fodder Research Institute, Jhansi
26. Dr. P.K. Pathak, Head, Farm Machinery and Post Harvest Technology, Indian Grassland and Fodder Research Institute, Jhansi
27. Dr. R.V. Kumar, Head, Grassland and Silvi-pasture Management, Indian Grassland and Fodder Research Institute, Jhansi
28. Dr. Vijay Kumar Yadav, Head, Seed Technology, Indian Grassland and Fodder Research Institute, Jhansi
29. Dr. Shahid Ahmed, Head, Crop Improvement, Indian Grassland and Fodder Research Institute, Jhansi
30. Dr. Purushottam Sharma, Head, Social science, Indian Grassland and Fodder Research Institute, Jhansi
31. Dr. Sultan Singh, Principal Scientist (Animal Nutrition), Indian Grassland and Fodder Research Institute, Jhansi
32. Dr. K.K. Singh, Principal Scientist (Animal Nutrition), Indian Grassland and Fodder Research Institute, Jhansi
33. Dr. D.R. Palsaniya, Principal Scientist (Agronomy), Indian Grassland and Fodder Research Institute, Jhansi
34. Dr. B.S. Chandrashekar, Indian Wood Research Institute, ICFRE, Bengaluru
35. Dr. N. Biradar, Principal Scientist (Agricultural Extension) and Officer in Charge, Indian Grassland and Fodder Research Institute, Southern Regional Research Station, Dharwad

36. Dr. Vinod Kumar, Principal Scientist (Seed Technology) Indian Grassland and Fodder Research Institute, Southern Regional Research Station, Dharwad
37. Dr. Edna Antony, Senior Scientist (Crop Physiology) Indian Grassland and Fodder Research Institute, Southern Regional Research Station, Dharwad
38. Dr. N.S. Kulkarni, Principal Scientist (Entomology) Indian Grassland and Fodder Research Institute, Southern Regional Research Station, Dharwad
39. Dr. K. Sridhar, Principal Scientist (Genetics and Plant Breeding) Indian Grassland and Fodder Research Institute, Southern Regional Research Station, Dharwad
40. Dr. Gaurendra Gupta, Scientist (Agronomy), Indian Grassland and Fodder Research Institute, Jhansi
41. A.K. Saxena, CTO, Indian Grassland and Fodder Research Institute, Jhansi
42. Dr. Ingale
43. Dr. G.J. Ranganath
44. Ms. Sushma Sirbi Matt
45. Dr. Jayadevappa
46. Vedashree, M.S.
47. Dinesh Kumar, Krishi Vigyan Kendra
48. Navya
49. Faraz Ahmed Khan
50. DDASVS Haveri
51. Dr. Rakshit Raaj, U.M. JSS KVK
52. ADR MARS Raichur
53. Dr. Papireddy, KVK CBPURA
54. KVK Kolar
55. KVK Ramnagara
56. DD Haveri
57. KVK Shivamogga
58. KVK Udupi
59. Prabhushankar
60. Girsih C M
61. DD Veterinary Kalburgi
62. Balakrishna S M
63. Dr. Thrinesh DD Office Mandya
64. DD AHVS Manaluru
65. Dr. Praveen Kumar, Surapura

66. ICAR KVK Hirehalli
67. Praful
68. Dr. Aigali Bujabali
69. Director AHVS Karnataka
70. Deputy Director, Bengaluru Urban
71. Manasa Y
72. ICAR-KLE, KVK, Belagavi 2
73. Anand R G
74. Sai Swaroop Rao
75. KVK, Belagavi 1
76. Deputy Direcor, AHVS
77. ICAR-KVK, Kalburagi II
78. Manjunath N Kalaburagi II
79. ICAR-KVK, Kalaburagi 2
80. Dr. Vasant Kumar
81. KVK, Gadag
82. DD Veterinary, Koppala
83. Karibasavaraja
84. DD ASHVS, Dharwad
85. Nagaraj
86. Shikha
87. Dr. Venkanna Balaganur
88. R Asha Kumari
89. Dr. Vishwanth S
90. DD AHVS BIDAR
91. ICAR KVK Gadag
92. Deputy Director AHVS, Belagavi
93. ICAR-KVK, Gadag
94. Dr. Manjanagouda
95. Department of Animal Husbandry and Veterinary Services
96. Dr. Ramesh, Jagapur
97. Muniraju K.M. Kolar KMF
98. G.B. Vishwanath
99. Mayanna
100. Munirajue KOMUL, Kolar

101. Manjunathaiah T M Komul Kolar
102. Manasa N
103. Dr. Vishwanath S Gowda
104. Dinesh Kumar, KVK BGK
105. Kamal Bai
106. Dr. S. Kamala Bai
107. Dr. Parmaeshwara Naik B L
108. KMF AH
109. Jitendra KMF
110. Rundan Gowda
111. Dinesh Kumar, S.P. KVK BGK
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113. Sujit
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116. DD Vet., DVG
117. Dr. Raghavendra Prasad
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123. Mayanna JD BMF Unit of NSS Bangalore
124. ICAR-KVK, Gadag
125. Manasa Yerraguntla
126. S R Baloch
127. Ajith Kumar K
128. DD ASVS, Hassan
129. Dinesh M S

Annexure-III

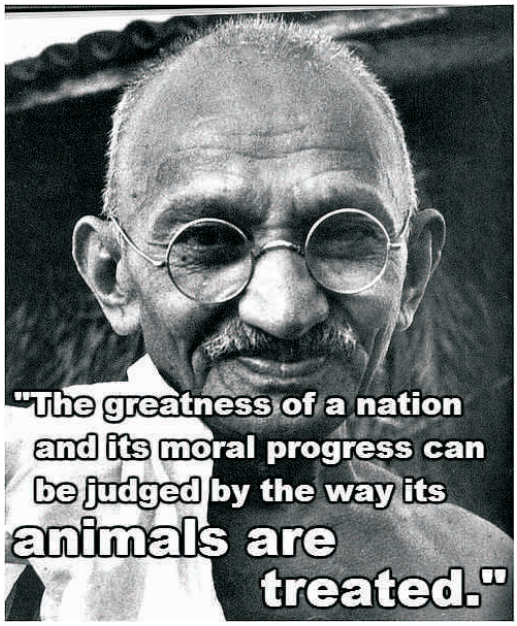
Fodder crop varieties developed by ICAR-IGFRI, Jhansi, in seed chain

Crop	Varieties	GFY (t/ha)	Recommendation for cultivation	Year of release
Berseem	Wardan	65-70	Whole country	1981
	Bundel Berseem 2	65-80	Centra1,NWzone	1997
	BundelBerseem 3	68-83	NE zone	2000
	JBSC-1	38-40	North west zone	2017
	JHB 17-1	40-45	North west and NE zone	2020
	JHB 17-2	40-85	North west and NE zone	2020
	JHB 18-1	30-80	North west and Central India	2021
	JHB 18-2	30-80	North west and Central India	2021
Lucerne	Chetak	140-150	North west central zone	1975
Oat	Bundel Jai 822	44-50	Central zone	1989
	Bundel Jai 851	40-50	Whole country	1997
	Bundel Jai 99-2	40-50	North West zone	2004
	Bundel Jai 2004	50	Northeast and northwest zone	2002
	Bundel Jai 2009-1	53-62	Central zone	2016
	Bundel Jai 99-1	35-40	Hill zone	2007
	Bundel Jai 2010-1	27-34	South zone	2015
	Bundel Jai 2012-2	33-37	South zone	2017
	Bundel Jai 2015-1	25-30	Hill zone	2018
Cowpea	Bundel Lobia 1	25-30	Whole country	1992
	Bundel Lobia 2	25-30	North zone	1992
	Bundel Lobia 4	23-26	North-eastern zone	2012
Guar	Bundel Guar 1	25-35	Whole country	1993
	Bundel Guar 2	30-40	Whole country	1994
	Bundel Guar 3	30-40	Whole country	1999
Field bean	Bundel Sem 1	25-35	Whole country	1993
Anjan grass	Bundel Anjan 1	30-35	Whole country	1989
Cenchrus	Bundel Anjan 3	30-35	Whole country	2006
ciliaris	Bundel Anjan 4	35-37	Whole zone	2019

Dhaman grass *Cenchrus setigerus*	Bundel Dhaman 1	13-15	Western part of country	2019
Dinanath grass	Bundel Dinanath 1	55-60	Whole country	1987
	Bundel Dinanath 2	60-65	Whole country	1990
BN hybrid	Swetika	100-120	Central, northern and north eastern areas	1983
	DHN-6 (Sammpoorna)	120-150	Irrigated areas of Karnataka state	2008
	DHN-15	200-250	Irrigated areas of Karnataka state	2020
Bajra-squamulatum hybrid	BBSH-I	30-33	Western and northern part of country	2019
Butterfly pea	Bundel Clitoria 1 (JGCT-2013-3)	25	All India	2017
Bajra	AVKB-19	50-60	Whole country	2007
	JHPM-05-2	70-80	Whole country except south zone	2008
	DRSB-1	35-40	North Transitional zone-8 (Karnataka)	2005-06
Guinea grass	Bundel Guinea 1	40-50	Punjab, HP, Central UP, Maharastra, Tamilnadu	2004
	Bundel Guinea 2	50-55	Fainted conditions in semi- arid, tropical, sub-tropical and humid tropics	2008
	Bundel Guinea 4	75-81	All guinea grass growing areas	2012
	DGG-1	85-125	Humid/arid tropical and sub-tropical regions	2016
Bracharia	DBRS-1	25-30	Whole country	2016
Sehima	Bundel Sen Ghas 1	18-20	Semi-arid, tropical and sub- tropical areas across the country	2007
Chrysopogon	Bundel Dhawalu Ghas-1	26-30	Rangelands under fainted condition across the country	2007
Heteropogon	Bundel Lampa Ghas-1, IGHC-03-4	25-30	Rangelands under rainfed condition across the country	2007
Dichanthium	Bundel Marvel Grass-2013-2 (JHD-2013-2)	35-45	NWZ particularly for Punjab and Rajasthan	2017
Congo Signal grass	DBRS-1	35-40	Rainfed conditions in Karnataka	2016
Lablab bean	Bundel Sem-1 (JLP-4)	22-25	Through out India	1993

Notes

Notes



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