CHAPTER 6

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AGRICULTURE AND ALLIED SECTORS

AGRICULTURE

Introduction
6.1. Karnataka state is located in the southwestern region of India. It is bordered by the Arabian Sea and the Laccadive Sea on the west, Goa on the northwest, Maharashtra on the north, Telangana on the northeast, Andhra Pradesh on the east, Tamil Nadu on the southeast, and Kerala on the southwest. The state is situated between 11°30' North and 18°30' North latitudes and 74° East and 78°30' East longitudes. The state covers an area of 1,90,500 square kilometers constituting 5.83 per cent of the total geographical area of India. It is the seventh largest and the eighth most populous state in the country. It comprises 30 districts, each of which is sub-divided into Taluks, Hoblis and Gram Panchayats for administrative purposes. It is endowed with two major river systems, the Krishna and its tributaries (Bhima, Ghataprabha, Vedavathi, Malaprabha and Tungabhadra) in the north and the Kaveri and its tributaries (Hemavati, Shimsha, Arkavati, Lakshmana Thirtha and Kabini) in the south. Both these rivers originate in the Western Ghats and flow out of Karnataka eastward to debouch into the Bay of Bengal. Major and minor reservoirs have been constructed in these watersheds making utmost use of the river waters by the riparian states. There are a number of west-flowing rivers which originate in the Western Ghats and drain into the Arabian Sea. These include Kalinadi, Sharavathi, Aghanashini, Gangavali, Venkatapur, Chakranadi, Souparnika (Kollurnadi), Varahi (Haladinadi), Swethanadi, Seethanadi, Phalguni (Gurupurnadi) and Netravathi. Among these rivers, Sharavathi, Kalinadi, Chakranadi and Varahi have been harnessed for generation of electricity.

Land use pattern
6.2. The total cultivated area of the state is 99.23 lakh hectares of which 35.55 lakh hectares are under irrigation and the remaining 63.68 lakh hectares are under rain fed agriculture. In 2013-14 the net sown area was 52.09%, 16.13% was under forest, 8.92% was under fallows, 7.58% was under non-agricultural uses, and 4.13% area constituted barren and uncultivable lands (Table-1).

Table-1: Land use pattern of Karnataka (in lakh hectares)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tr>
<td>Geographical Area</td>
<td>190.5</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Forest</td>
<td>30.33</td>
<td>30.74</td>
<td>30.68</td>
<td>30.72</td>
<td>30.72</td>
<td>30.73</td>
<td>30.73</td>
</tr>
<tr>
<td>Barren &amp; uncultivable</td>
<td>8.44</td>
<td>7.99</td>
<td>7.94</td>
<td>7.87</td>
<td>7.87</td>
<td>7.87</td>
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<tr>
<td>Cultivable waste</td>
<td>5.02</td>
<td>4.46</td>
<td>4.27</td>
<td>4.14</td>
<td>4.13</td>
<td>4.13</td>
<td>4.11</td>
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<tr>
<td>Permanent pastures &amp; other grazing land</td>
<td>13.46</td>
<td>10.98</td>
<td>9.59</td>
<td>9.12</td>
<td>9.08</td>
<td>9.08</td>
<td>9.06</td>
</tr>
<tr>
<td>Misc. Trees, Groves</td>
<td>3.42</td>
<td>3.16</td>
<td>3.03</td>
<td>2.86</td>
<td>2.85</td>
<td>2.83</td>
<td>2.81</td>
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<tr>
<td>Current fallow</td>
<td>14.59</td>
<td>12.9</td>
<td>13.67</td>
<td>11.99</td>
<td>16.72</td>
<td>18.22</td>
<td>17.00</td>
</tr>
<tr>
<td>Other fallow land</td>
<td>5.58</td>
<td>4.57</td>
<td>4.08</td>
<td>4.26</td>
<td>5.39</td>
<td>5.35</td>
<td>5.25</td>
</tr>
<tr>
<td>Net Area Sown</td>
<td>98.99</td>
<td>103.81</td>
<td>104.1</td>
<td>105.23</td>
<td>99.41</td>
<td>97.93</td>
<td>99.23</td>
</tr>
</tbody>
</table>

(Source: Dept. of Agriculture, GOK)
Soils

6.3. Soils of Karnataka have been classified into six major groups as shown in Table-2.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Soil Classification</th>
<th>Zones covered</th>
<th>Area covered in the state (Lakh Ha)</th>
<th>Percentage with respect to the area of the state</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Red soils</td>
<td>All zones except zone 2</td>
<td>71.08</td>
<td>37.3</td>
</tr>
<tr>
<td>2</td>
<td>Lateritic and Laterite soils</td>
<td>1, 2, 5, 7, 8, 9 and 10.</td>
<td>11.64</td>
<td>6.16</td>
</tr>
<tr>
<td>3</td>
<td>Black soils</td>
<td>1, 2, 3, 4, 6, 7 and 8</td>
<td>52.93</td>
<td>27.77</td>
</tr>
<tr>
<td>4</td>
<td>Alluvial soils</td>
<td>Isolated location in all the zones</td>
<td>29.98</td>
<td>15.74</td>
</tr>
<tr>
<td>5</td>
<td>Brown forest soils</td>
<td>9 and 10</td>
<td>11.47</td>
<td>6.0</td>
</tr>
<tr>
<td>6</td>
<td>Coastal soils</td>
<td>10</td>
<td>7.42</td>
<td>3.9</td>
</tr>
</tbody>
</table>

(Source: NBSS & LUP, Bangalore)

Surface soil texture

6.4. Surface soil texture has been grouped into three main classes as clayey (fine), loamy (medium) and sandy (coarse). The surface soil texture map is given in Fig.1.

Soil depth and drainage

6.5. Depth of the soil determines the effective rooting depth for plants and, in accordance with texture, mineralogy and gravel content, the capacity of the soil column to hold water and supply plant nutrients is determined. Karnataka Soil has been classified into six depths as Extremely shallow (0 to 10 cm), Very Shallow (10 to 25 cm), Shallow (25 to 50 cm),
Moderately shallow (50 to 75 cm), Moderately deep (75 to 100 cm) and Deep (more than 100 cm). Deep soil occupies more than 57% of the area in the state.

**Available water capacity (AWC) of soil**

6.6. Available-water capacity (AWC) of soil is an indicator of the soil’s ability to retain water and make it sufficiently available for plant use. AWC is dependent upon the texture and structure of soil which determine the infiltration and permeability. The extent of soils with different AWC is mapped in Fig.2. Forty four per cent areas of the state have soils with low and very low AWC suggesting short duration crops with water conservation techniques and are suitable for forestry, horticulture and pasture.

![Available Soil Water Capacity (mm) of Karnataka](image)

**Fig.2:** Available Soil Water Capacity (mm) of Karnataka (Source: NBSS& LUP, Bangalore)

**Degraded and Wastelands**

6.7. Degraded and wastelands in the state cover 80,93,000 ha (about 42% of the TGA). Districts with highly degraded areas are Belagavi (8,05,000 ha), followed by Gulbarga (5,73,000 ha), Vijayapura (5,08,000 ha), Koppal (4,87,000 ha) and Bagalkot (4,53,000 ha). About 41% of the total area is affected by water erosion. Different levels of soil erosion in Karnataka are shown in Fig.3.
Climate in general

6.8. Karnataka is a predominantly semi-arid state. The tropical monsoon climate covers the entire coastal belt and adjoining areas. The climate in this region is hot with heavy rainfall during monsoon season. The southern half of the state and small portions of extreme north and north-west Karnataka experience hot, seasonally dry tropical Savanna climate, while the remaining northern half experiences hot, semi-arid, tropical steppe type climate. The climate of the state varies with the seasons. Both day and night temperatures are more or less uniform over the state, except in the high elevated plateau. They generally decrease south-westwards over the state due to higher elevation and attain lower values at higher altitudes. The state by and large experiences the winter season (January to February), the summer season (March to May), the monsoon season (June to September) and the post-monsoon season (October to December). Based on rainfall and altitude, the state is divided into four meteorological zones, namely, North Interior Karnataka, South Interior Karnataka, Hilly region and Coastal Karnataka.

Agroclimatic zones

6.9. Based on soil, climate, suitability of crops and altitude, the State of Karnataka is divided into 10 Agro-climatic zones as shown in Fig. 4.
Fig. 4: Agro-climatic zones of Karnataka (Source: UAS, Bangalore)

Rainfall

6.10. Annual rainfall in the state varies roughly from 45 cm to 480 cm. The average annual rainfall in Karnataka is 1191.6 mm. Most of the districts of North Interior Karnataka and Chitradurga of South interior Karnataka receive the lowest rainfall varying from 50 to 60 cm. The rainfall increases significantly in the western part of the state and reaches its maximum over the coastal belt.

Monthly Rainfall distribution

6.11. Information on the monthly rainfall distribution is helpful for crop planning, cultivar selection, run off estimation, determining crop water needs, and for designing watersheds and ultimately irrigation system. The annual rainfall in the state is shown in Fig. 6. The mean annual rainfall of 1196.1 mm of the State is received over 83 rainy days (more than 2.4 mm). Annual rainfall in different parts of the state is mapped in Fig. 5.

Fig. 5: Monthly distribution of rainfall (mm) over Karnataka state
Length of growing period (FAO method)
6.12. The length of the growing season (LGP) in any given region represents the climatically determined number of days during which a crop receives enough moisture from soil for its growth. This depends on the start and end of rainy season. The length of growing period based on soil type, water available capacity and rainfall is depicted in Fig.7.

Drought
Meteorological drought
6.13. Meteorological drought occurs in all climatic regions of Karnataka, but its intensity differs from region to region. Moderate and severe drought probabilities are mapped in Fig.8. Sixty-four (64) % of the area has less than 10% probability of moderate drought and
34% of the area has probability of 10-20% drought. Two percent of the area has probability of 20-30%. As regards severe drought (MAI<25%), 53% of the area has less than 5% probability, while 43% of the area has 5-10% probability. The remaining 4% of the area has 10-20% probability. In extremely dry category of drought, 81 percent of stations have probability of less than 5%, with the remaining stations having probability of 5-10%.

**Fig. 8:** Probability of occurrence of meteorological drought in Karnataka (Source: UAS, Bangalore)

**Agricultural drought**

6.14. Areas affected by agricultural drought for the period 2001-2016 and during 2016 have been mapped in Fig. 9.

**Fig. 9:** Agricultural drought affected areas (Source: KSNMDC, Bangalore)
Agricultural scenario of Karnataka

6.15. Karnataka’s economy is an agrarian economy and as such the overall development of the state is mainly dependent upon the growth and development of agriculture and allied sectors. There has been significant increase in productivity and quality in the food production in the state over the last decade. There has also been change in the cropping pattern from conventional food crops to that of high value crops such as fruits, vegetables, flowers and plantation crops. Though this has raised the income levels, employment opportunities and the scope for agro based industry, there are still considerable gaps in terms of infrastructure and technology which sometimes lead to situations of glut, scarcity, fluctuation in prices, wastage and poor remunerative prices. The Government of Karnataka considers high growth of agriculture and allied sectors as a means to accelerate the state’s growth in GDP and enable farmers to earn higher income and ensure food security. The state has rich biodiversity and ten agro-climatic zones suited for the cultivation of varieties of agriculture and horticulture crops and a long coastline that encourages the fisheries sector. “Agribusiness and Food Processing” is the thrust area to achieve the goal of accelerating the state’s GDP.

6.16. The vision of the Department of Agriculture is to Ensure Food Security and also to make Agriculture a sustainable and viable vocation for livelihood support by 2020. Its Mission is to achieve the targeted growth rate of 4.5% in the agriculture sector by enhancing agricultural production, to improve the income level of farmers by successful implementation of various state and central schemes, to offer outstanding educational opportunities, generate appropriate research output to address the contemporary challenges faced in the agriculture and allied areas, to develop excellent globally competitive human resource for sustainable agriculture development, to effectively conserve, develop natural resources and their sustainable use and to ensure proper disaster and risk management in Agriculture/Climate resilient agriculture. Its objectives are:

1. Promotion of sustainable agriculture;
2. Generation and transfer of technology;
3. Ensuring food and nutritional security by increasing production and productivity;
4. Input management;
5. Promoting investments in agriculture;
6. Risk management;
7. Monitoring and evaluation of schemes.

6.17. About 22 field crops are grown in the state. Area covered by important crops are cereals (51.93 lakh ha), pulses (23.93 lakh ha), oil seeds (16.31 lakh ha), cotton (5.73 lakh ha), sugarcane (5.92 lakh ha) and tobacco (1.09 lakh ha). Total area under agricultural crops is about 104.94 lakh ha against the total cropped area of 122.766 lakh ha. The average yearly production during the period from 2001-02 to 2014-15 in respect of food grains (cereals and pulses) was 107.16 lakh tons with the highest production of 137.91 lakh tons during 2010-11. In case of oil seeds, the average yearly production was 11.22 lakh tons, the highest being 15.45 lakh tons during 2001-02 (Source: Dept. of Agriculture, GOK).

Soil health

6.18. The components of soils are mineral, organic matter, water and air, the proportions of which vary and together form a system for plant growth. Soils are studied and classified according to their use. Soil Testing is a part of the discipline of Fertilizer Use and Management.
6.19. **Nutrient status of soils of Karnataka**: In 2012-13, Karnataka consumed about 891.69 thousand tonnes of Nitrogen, 389.64 thousand tonnes of P$_2$O$_5$ and 249.87 thousand tonnes K$_2$O fertilizers at per ha consumption rate of 68.27 kg/ha of N, 29.83 kg/ha of P$_2$O$_5$, and 19.13 kg/ha of K$_2$O fertilizers. Fertilizer consumption ratio has increased from 2.1:1.4:1 in 2009-10 to 3.6:1.6:1 in 2012-13. In Karnataka around 19.52% of soils are found to be acidic, and 11.21% of soils are alkaline in nature. Around 41.17%, 26.31% and 28.45% soils of the state are found to be deficient in N, P and S respectively, whereas only 7.96% of soils are deficient in potassium. Zinc is found deficient in around 52.24% of soils whereas Iron and Boron are found to be deficient in 24.76% and 35.3% of soils respectively. However, Manganese is deficient in 6.23% and copper is deficient in 2.24% of soils in Karnataka.

6.20. **Soil Testing Programme**: There are 29 static soil testing laboratories or soil health centers (SHC) functioning in the state with analyzing capacity of 2,00,000 soil samples per annum. The soil samples are analyzed for pH, EC, major nutrients like Available N, P, K, secondary nutrients like Sulphur and Magnesium and micronutrients such as Zn, Fe, Mn, Cu and Boron. Water samples are also analyzed for pH, EC, Sodium absorption ratio (SAR), Ca, Mg, Co$_3$, HCO$_3$ and Cl$_2$ to assess the quality of water for irrigation. At present, 29 SHCs are catering to the needs of state farmers in respect of soil testing. On an average 1.30 to 1.35 lakh soil samples are analyzed annually. The Department of Agriculture (KSDA) has prepared elaborate plan to issue soil health cards to all the farmers in the state by the end of 2016-17 in collaboration with Companies / NGO’s / Associations /organizations /Institutes /Charitable trust / group of companies in Public Private-Partnership (PPP) mode through outsourcing.

**Chemical Fertilizers**

6.21. The total N-P-K nutrient consumption increased from 2000-01 to 2011-12 by 43.8%. This was followed by a significant reduction by 23.26% in 2016-17 compared to the baseline in 2000. The NPK use ratio has been fluctuating as follows: 2.07:1.35:1.0 in 2009-10; 3.57:1.56:1.0 in 2012-13; 3.63:2.12:1.0 in 2016-17. Consumption of fertilizers increased from 95 kg/ha (2002-03) to 184 kg/ha in 2011-12. Again there is a decrease in consumption of fertilizer to 139 kg/ha during 2016-17. Districts consuming more than 250 kg of N-P-K fertilizers per ha in Karnataka are Davanagere (635 kg/ha), Koppal (392 kg/ha), Bengaluru urban (356 kg/ha), Tumakuru (339 kg/ha), Chickmagaluru (311 kg/ha), Mysuru (256 kg/ha), Yadagir (255 kg/ha.). Fertilizer consumption in Karnataka is given in Table-3.

**Table-3: Fertilizer consumption (lakh tons) in Karnataka**

<table>
<thead>
<tr>
<th>Year</th>
<th>Nitrogen</th>
<th>Phosphorous</th>
<th>Potash</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-10</td>
<td>9.63</td>
<td>6.3</td>
<td>4.66</td>
<td>20.59</td>
</tr>
<tr>
<td>2010-11</td>
<td>10.16</td>
<td>6.96</td>
<td>3.98</td>
<td>21.10</td>
</tr>
<tr>
<td>2011-12</td>
<td>11.04</td>
<td>7.87</td>
<td>3.33</td>
<td>22.23</td>
</tr>
<tr>
<td>2012-13</td>
<td>8.92</td>
<td>3.90</td>
<td>2.50</td>
<td>15.31</td>
</tr>
<tr>
<td>2013-14</td>
<td>9.64</td>
<td>4.91</td>
<td>3.02</td>
<td>17.57</td>
</tr>
<tr>
<td>2014-15</td>
<td>10.02</td>
<td>4.98</td>
<td>3.32</td>
<td>18.32</td>
</tr>
<tr>
<td>2015-16</td>
<td>9.82</td>
<td>5.31</td>
<td>2.67</td>
<td>17.80</td>
</tr>
<tr>
<td>2016-17</td>
<td>8.76</td>
<td>5.11</td>
<td>2.41</td>
<td>16.28</td>
</tr>
</tbody>
</table>

(Source: Dept. of Agriculture, GOK)

6.22. Although chemical fertilizers contribute in a very big way in augmenting production and productivity, these are not free from negative effects on the environment. The biggest
environmental problem arising from excessive use of chemical fertilizers is contamination of groundwater. Nitrogen fertilizers break into nitrates and travel easily through the soil. Since nitrates are soluble in water, they remain in ground water for years together. Addition of more and more nitrogen over the years has an accumulative effect and the degree of contamination increases. Nitrates which enter into water bodies create an influx of plant life which eats up the available oxygen thereby starving fish and other aquatic fauna. This not only impacts the aquatic ecosystem but also the people whose livelihood is dependent on food sourced from such water bodies. Ammonia gas emanating from urea contributes to acid rain, ground water contamination and ozone depletion due to release of nitrous dioxide. Excessive air and water borne nitrogen from fertilizers may cause respiratory, cardiac and other ailments.

**Pesticides**

6.23. Use of various pesticides like insecticides, weedicides, fungicides, rodenticides, etc. is a major input to agriculture. As the cropping pattern is becoming more and more intensive, use of pesticides is also increasing. Consumption of insecticide in agriculture has increased many-fold during last few decades. Pesticides are used to control or eliminate insects and diseases that destroy crops and reduce food supply.

6.24. However, pesticides also have social costs. They also have negative impact on the environment and human health if they are not used at their optimum levels. The major economic and environmental losses due to the application of pesticides are public health, pesticide resistance in pests, crop losses caused by pesticides, bird losses due to pesticides, and groundwater contamination. Chemical pesticides are linked to many serious illnesses including cancer, reproductive abnormalities, endocrine disorders and neurological problems. In the recent past, positive changes have been observed in trends of pesticides consumption. As a consequence of adoption of bio-intensive Integrated Pest Management Programme in various crops, the consumption of chemical pesticides has come down. The demand and consumption of pesticides in Karnataka are indicated in Table-4.

| Table-4: Demand and Consumption of Pesticides in Karnataka (Qty in MTs of Technical Grade) |
|---|---|---|
|  | Demand | Consumption |
| 1 | 2011-12 | 1750 | 1412 |
| 2 | 2012-13 | 1750 | 1615 |
| 3 | 2013-14 | 1800 | 1735 |
| 4 | 2014-15 | 1800 | 1793 |
| 5 | 2015-16 | 1900 | 1434 |
| 6 | 2016-17 | 1900 | 1288 |

Source: Dept. of Agriculture, GOK

**Irrigation**

6.25. Agriculture being the main occupation of the state, Irrigation plays a very significant role in increasing agricultural yields. The development of irrigation in the state was by and large slow and unsystematic during the pre-independence era. However, some notable Irrigation works were started during pre-independence, such as Krishnaraja Sagar (which was the only major project completed prior to independence), Vijayanagar canals, Cauvery anicut Channels, Gokak canal, Vanivilasa Sagar, Markonahalli and Anjanapura. Though major projects like Tungabhadra, Bhadra and Ghataprabha stage-I were commenced prior to the
plan period, their progress was slow and they got impetus only after their inclusion in the first five year plan.

6.26. There were more than 25,000 tanks scattered over erstwhile Mysore state. However, the number of such minor irrigation works in the Bombay Karnataka and Hyderabad Karnataka areas was meager. The total investment up-to the end of March 2016 on major and medium irrigation using surface waters in the state is Rs.51,957.58 crore. The total irrigation potential of the state up to the end of March 2016 is 28.68 lakh ha (Major and Medium Irrigation projects).

6.27. The average annual yield of the rivers of the Karnataka has been roughly estimated as 98,406 million cum (3,475 TMC). Basin-wise breakup of this yield is given in Table-5.

### Table-5: Basin-wise water yield of the rivers of Karnataka

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>River System</th>
<th>Estimated average yield in M.cum</th>
<th>TMC</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Krishna</td>
<td>27,451</td>
<td>969.44</td>
<td>27.90</td>
</tr>
<tr>
<td>2</td>
<td>Cauvery</td>
<td>12,034</td>
<td>425.00</td>
<td>12.23</td>
</tr>
<tr>
<td>3</td>
<td>Godavari</td>
<td>1,415</td>
<td>49.97</td>
<td>1.44</td>
</tr>
<tr>
<td>4</td>
<td>West Flowing rivers</td>
<td>56,600</td>
<td>1,998.83</td>
<td>57.51</td>
</tr>
<tr>
<td>5</td>
<td>North Pennar, South Pennar &amp; Palar</td>
<td>906</td>
<td>32.00</td>
<td>0.92</td>
</tr>
<tr>
<td>6</td>
<td>TOTAL</td>
<td>98,406</td>
<td>3,475.24</td>
<td>100</td>
</tr>
</tbody>
</table>

(Source: Dept. of Irrigation, GOK)

6.28. However, the economically utilizable water potential for Irrigation is about 48,000 Mcum (1695 TMC). The ultimate Irrigation Potential, from all sources in the state has been estimated as 61.00 lakh hectares, out of which 39.43 Lakhs hectares is under major and medium irrigation projects. Up to end of March 2016, cumulative irrigation potential of 28.68 lakh ha has been created. The total investment up-to the end of March 2016 on Irrigation in the state is Rs 51957.58 crore on major and medium irrigation (using surface waters). Up to the end of March 2016 a total irrigation potential is 28.68 lakh ha (Major & Medium Irrigation projects). Different source of Irrigated Area in Karnataka (Lakh Ha) are given in Table-6.

### Table-6: Source-wise Irrigated Area in Karnataka (Lakh ha)

<table>
<thead>
<tr>
<th>Source</th>
<th>2010-11 to 2014-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Net</td>
</tr>
<tr>
<td>1  Canals</td>
<td>11.91</td>
</tr>
<tr>
<td>2  Tanks</td>
<td>1.65</td>
</tr>
<tr>
<td>3  Wells</td>
<td>4.126</td>
</tr>
<tr>
<td>4  Tube/Bore Wells</td>
<td>13.224</td>
</tr>
<tr>
<td>5  Lift Irrigation</td>
<td>0.98</td>
</tr>
<tr>
<td>6  Other Sources</td>
<td>3.238</td>
</tr>
</tbody>
</table>
6.29. One of the environmental problems faced in irrigated lands is that of water logging. The introduction of irrigation in arid and semi-arid regions has resulted in the development of the problem of water logging, as a result of which considerable areas remain uncultivated or have poor yields. Water logging is often accompanied by soil salinity as soils of waterlogged areas do not allow leaching of the salts imported by the irrigation water. Management of waterlogged and saline soils is carried out through drainage interventions followed by soil and irrigation management measures. Soil management measures include tillage, green manuring and gypsum application. Irrigation management measures include land development, leaching, field irrigation channels (FIC), drip irrigation, etc. When such measures become prohibitive, there are safer options such as tree planting which is environment friendly also. There are a number of tree species such as karijali, holematti, honge, neral, muthuga, etc. besides dowga bamboo which thrive and grow fairly well in waterlogged and saline areas.

Climate change

6.30. Among all sectors confronting the global environmental challenge of climate change, agriculture sector is likely to be impacted the most. Long-range climate change has already been observed worldwide. In Karnataka also, changes in the food production and productivity of the individual crop have been observed. Average rainfall of the state has an increasing trend. However, gradual decline in the south-west monsoon rainfall is observed and decreased portion of rainfall is partly shared by pre-monsoon and north-east monsoon. In addition to this some part of the state is likely to receive the south-west monsoon rains required for agriculture beyond the month of July. District-wise rise in mean temperature and changes in annual rainfall under 2035 A1B situation are indicated in Figures 10 and 11.

**Fig.10:** District wise rise in mean monthly Temperature

**Fig.11:** Rainfall deviations (%) projection for 2035

Impact of projected climate changes on weather parameters

6.31. As per the projection for rise in mean annual temperature for the year 2035, increase up to 2.2°C will be observed in almost all the districts except DK, Udupi and Kodagu districts where the increase will be up to 1.8°C. Uttara Kannada, Mysore, Shvaimogga, Hassan and Chikmagalur districts are expected to be warmer up to 1.9°C. Bijapur is expected to have the highest increased temperature up to 2.4°C. Belgaum, Bagalkot, Bidar, Gulbarga and Koppal
districts are likely to have increased temperature by up to 2°C. This overall increase in temperature leads to increase potential evapo-transpiration. Higher increase in temperature in the districts with low rainfall causes quick loss of soil moisture and reduces the growing period. This also increases the duration of drought causing low productivity. Winter and pre-monsoon months will experience higher increase in mean temperature than the south-west monsoon months. This leads to increased local convectional rains and thunder storms causing natural disasters.

**Impact of climate change on agriculture**

6.32. Based on the changes expected to take place in almost all the mean monthly weather parameters, it is anticipated that the agricultural cropping system and crop productions will be affected. Climate change has greater impact on future agriculture. Based on the current projections of climate change, productivity of different crops has been estimated and vulnerable districts with low productivity have been identified. Based on the major crops raised in each of the districts and their current production and productivity, the anticipated deviations in the productivity with respect to the anticipated climate change are depicted in Table-7.

**Table-7: Vulnerable districts under climate change for various crops**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Vulnerable districts with productivity loss from 5% to 45%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice (Rain fed)</td>
<td>DK, Hassan, Kodagu and majority of Northern districts</td>
</tr>
<tr>
<td>Rice (Irrigated)</td>
<td>Belgaum, Bellary, Raichur, Kodagu, Dharwad, Chamarajanagar, DK &amp; Hassan,</td>
</tr>
<tr>
<td>Maize</td>
<td>Bijapur, Chikmagalure, DK, UK, Udupi, Kodagu, Shimoga and partly Tumkur</td>
</tr>
<tr>
<td>Sorgam</td>
<td>Chikmagalure, DK, UK, Udupi, Davanagere, Hassan, Kolar, Shimoga and Tumkur,</td>
</tr>
<tr>
<td>Redgram</td>
<td>Bagalakote, Bellary, DK, Udupi, UK, Kodagu, Raichur,</td>
</tr>
<tr>
<td>Cotton</td>
<td>Bellary, Chikmagalure, Chitradurga, DK, UK, Shimoga, Kolar, Kodagu, Dharwad and Gadag,</td>
</tr>
<tr>
<td>Potato</td>
<td>Bangalore, Chikmagalure, Davanagere, Hassan,</td>
</tr>
<tr>
<td>Soybean</td>
<td>Bangalore, Tumkur and Chitradurga</td>
</tr>
<tr>
<td>Ragi</td>
<td>UK, DK, Udupi, Shimoga, Gulbarga and Bidar</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>Hassan, Mandya, DK, UK and Udupi</td>
</tr>
</tbody>
</table>

(Source: UAS, Bangalore)

**Adaptation Strategies**

6.33. Adaptation to climate can substantially reduce many of the adverse impacts of climate change and enhance beneficial impacts. Although total food production is likely to decrease by about 12.3% in the state, due to the benefit of the rise in temperature and CO₂ level, few districts will gain in productivity up to 35% in certain crops. Such districts have been identified. By changing over to such crops in those districts, the loss in the food production can be compensated and the advantages of the climate change effects can be absorbed positively. Suitable crops and the technologies have to be adopted for crop improvement and realization of potential higher productivity under the climate change scenario. Changes in the net productivity (for the entire state) and expected increased yield levels (rain-fed situation) in different crops in different districts in the changed climate scenario are tabulated in Table-8.
Table-8: Changes in the net productivity and expected increased yield levels (rain-fed situation) in different crops in different districts in the changed climate scenario

<table>
<thead>
<tr>
<th>Crops</th>
<th>Net Change in the Yield (%)</th>
<th>Increase in Productivity up to 10 % and identified to increase the growing area</th>
<th>Increase in productivity from 10 % to 25 % and identified to increase the growing area for enhanced food production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>-0.3 (Irri. Rice) -0.9 (rain-fed)</td>
<td>Bagalkot, Bangalore, Chitradurga, Davanagere, Haveri, Kolar and Tumkur</td>
<td>Bangalore, DK, Udupi, UK , Raichur and Kodagu</td>
</tr>
<tr>
<td>Maize</td>
<td>1.2</td>
<td>Bidar, Chitradurga, Davanagere, Gadag, Gulbarga, Haveri, Kolar and Mandya</td>
<td>Bangalore, Belgaum, Chamarajanagar, Mysore,</td>
</tr>
<tr>
<td>Sorgam</td>
<td>2.6</td>
<td>Bagalkote, Belgaum, Haveri, Raichur,</td>
<td>Bangalore, Bellary, Bidar, Chamarajanagar, Chitradurga, Gadag, Gulbarga, Kodagu, Mandya,</td>
</tr>
<tr>
<td>Redgram</td>
<td>1.3</td>
<td>Chamarajanagara and Hassan,</td>
<td>Bangalore, Chikmagalure, Chitradurga (upto 35%), Davanagere, Dharwad, Gadag, haveri, Kolar, Mandya, Mysore and Shimoga</td>
</tr>
<tr>
<td>Cotton</td>
<td>1.3</td>
<td>Bidar, Davanagere and Haveri,</td>
<td>Bangalore, Belgaum, Bijapur, Mandya, Raichur and Tumkur.</td>
</tr>
<tr>
<td>Potato</td>
<td>-14.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>-2.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ragi</td>
<td>-5.8</td>
<td>Mysore, Hassan, Kolar, Chitradurga, Davanagere, Haveri and Gadag</td>
<td>Chikmagalure,</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>2.6</td>
<td>Mandya, Shimoga and Belgaum</td>
<td></td>
</tr>
</tbody>
</table>

(Source: UAS, Bangalore)

**Dry-land farming**

6.34. Five out of ten agro-climatic zones in Karnataka are dry zones. Nearly 55% of food grains and 75% of oil seeds are contributed by rain-fed areas. A close analysis of rainfall pattern of the state indicates that 3 to 4 years in every decade face severe drought; sometimes drought occurs in consecutive years also. A vast majority of dry land areas receive an annual average rainfall of 450 to 700 mm, which is highly erratic and unevenly distributed during the cropping seasons. Thirteen years out of the last 16 years have been declared drought-years in the state. The land resources of Karnataka, especially the dry drought prone areas, have been poorly managed by the resource-starved farmers of the state. Soil loss due to erosion coupled with reduced water resources has led to a situation of rapid deterioration of soil fertility, declining/stagnating crop yields, depletion of underground water sources, deforestation, denudation, destruction of natural pasture and diminishing biomass production. Various watershed schemes implemented in the state have been quite successful and considering their importance, the state has created a dedicated department from 2000-01, namely, the
Watershed Development Department exclusively for giving undivided attention to all projects of watershed development under various schemes. The cumulative progress achieved under watershed development programs at the end of the Tenth Five-Year Plan i.e., 2006-07 under various schemes was 47.04 lakh hectares. As per available data, 7.5 lakh hectares of additional area were covered under watershed activities during the XI plan period with a cumulative total of 54.59 lakh hectares in 2011-12. Area covered under watershed was 4.01 and 4.67 lakh hectares during 2012-13 and 2013-14 respectively. However, the pace of watershed activities slowed down in the following years. The area covered under watershed activities was 2.22 lakh hectares during 2014-15 with a cumulative total of 65.49 lakh hectares. (Source: UAS, Bangalore).

6.35. The major problem in dry-land that the farmers face very often is to keep the crop/plants alive and to get economic returns from the crop production. But this single problem is influenced by several factors:

- **Moisture stress and uncertain rainfall:** The rains are very erratic, uncertain and unevenly distributed. Therefore, agriculture in these areas has become a sort of gamble with the nature and very often the crops have to face climatic hazards. The farmers also take up farming half-heartedly as they are not sure of being able to harvest the crops. Thus, water scarcity has become a serious bottleneck in dry land agriculture.

- **Effective storage of rain water:** Dry-lands suffer from extreme vagaries of nature; sometime there is very severe drought and sometime there will be torrential rain with very high intensity. In the former case, crops dry and wilt and in the latter case, they get spoilt due to flood or water logging. In the case of very heavy downpour, the excess water could be stored for providing lifesaving or protective irrigation to the crops grown in dry land areas.

- **Marketing of dry farming products:** In dry farming all the farmers in a region grow similar crops which are drought resistant. These crops mature at the same time and the farmers like to dispose off their produce soon after the harvest. This results in a glut of produce in the market and the situation is badly exploited by the grain traders and middlemen.

- **Selection of limited crops:** Only drought tolerant crops namely oilseeds, pulses and coarse grains like jowar, bajra, ragi, millets, etc. can be grown in dry land areas. Thus, the farmers have to purchase other food grains and household commodities that imbalance their economic position.

- **Careful, judicious and timely application of manure:** In case of irrigated farming, the farmers are at a liberty to apply manures and fertilizers according to their availability and facility, but in the case of dry farming they have to be very careful in fertilizer application.

- **Utilization of preserved moisture:** Judicious and purposeful utilization of preserved moisture depends upon soil type, plant type and other factors. The amount of available water to the plants depends upon the depth of plant roots, their proliferation and density. In case of limited moisture condition, the yield directly depends upon the rooting depth. The rooting depth can be desirably increased by mechanical manipulation of the soil.

- **Quality of the produce:** The quality of the produce from dry farming areas is often found to be inferior as the grains are not fully ripened or they are not filled properly, often mixed with seeds of other crops owing to mixed cropping system prevalent in these areas; the fodder becomes more fibrous. All these factors reduce the market value of produce and the farmers do not get the profit commensurate with their labor and investment.
6.36. Karnataka formulated an ambitious “Karnataka Rain-fed Farming Policy 2014” to address the dry land issues with more focus. The new policy aims to harness small water sources, integrate with affordable technologies, information and to access markets to achieve significant improvement in rural livelihoods, based on the principle of production of crop for every drop of rain water. In addition to having more efficient markets and improved delivery channels from farmers to consumers, the policy has underlined the importance of concerted efforts to increase value addition and processing to agricultural produce.

6.37. Salient features of the Karnataka Rain-fed Farming Policy 2014 are as follows:

i. Focus on small and marginal farmers who account for 76% of the holdings and operate 40% of the area;
ii. Increasing public investment under rain-fed agriculture;
iii. Integration of existing programs of line departments;
iv. Discouraging imbalanced use of chemical fertilizers and pesticides, and critical input management;
v. Preservation of germplasm of dry land crops and developing resource conservation technologies;
vi. Strengthening of extension at RSK level;
vi. Agro-processing;
viii. Developing systems for efficient medium and long term prediction of weather;
ix. Market intelligence, price forecasting ahead of sowing season.

**Organic farming**

6.38. The basic principle of Organic Farming is “live and let live”. It is found to be one of the best suitable production systems. The status of organic farming in the state is given in Table-9. Important crops grown under organic farming are given in Table-10.

**Table-9: Status of organic farming in Karnataka**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total cultivated area under certification</td>
<td>93,963 ha</td>
</tr>
<tr>
<td>2</td>
<td>Total certified production</td>
<td>2,82,633 tons</td>
</tr>
<tr>
<td>3</td>
<td>Total under wild harvest collection</td>
<td>39,683 ha</td>
</tr>
<tr>
<td>4</td>
<td>No. of certified operators</td>
<td>246</td>
</tr>
<tr>
<td>5</td>
<td>Total no. of farmers</td>
<td>96,612</td>
</tr>
<tr>
<td>6</td>
<td>No. of organic farming research institutes</td>
<td>08</td>
</tr>
<tr>
<td>7</td>
<td>No. of model private farms</td>
<td>109</td>
</tr>
<tr>
<td>8</td>
<td>No. of NGOs invited in promotion of organic farming</td>
<td>129</td>
</tr>
<tr>
<td>9</td>
<td>No. of Marketers</td>
<td>19</td>
</tr>
<tr>
<td>10</td>
<td>No. of private outlets/retailers/stores</td>
<td>513</td>
</tr>
<tr>
<td>11</td>
<td>No. of mega stores with organic shelves</td>
<td>48</td>
</tr>
<tr>
<td>12</td>
<td>No. of exclusive organic restaurants/caterers in Bangalore</td>
<td>20</td>
</tr>
<tr>
<td>13</td>
<td>No. of operators/processors and exporters</td>
<td>124</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Agriculture holding</th>
<th>Area in Lakh ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal farmers(&lt;1ha)</td>
<td>38.49 lakhs</td>
</tr>
<tr>
<td>Area operated</td>
<td>18,51,000 ha</td>
</tr>
</tbody>
</table>
Small farmers (1-2 ha)  
Area operated  
21.38 lakhs  
30,20,000 ha  

Medium to large farmers (2-10ha)  
Area operated  
17.78 lakhs  
62,97,000 ha  
(Source: Dept. of Agriculture, GOK)

### Table-10: Important crops grown under organic farming

<table>
<thead>
<tr>
<th>Cereals and millets</th>
<th>Non-basumathi Paddy, Maize, Bajra and Ragi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits</td>
<td>Mango, Pineapple, Banana</td>
</tr>
<tr>
<td>Dry fruits</td>
<td>Cashew nuts</td>
</tr>
<tr>
<td>Spices and condiments</td>
<td>Arecanut, Black pepper, Chilli, Cinnamon, cloves, Ginger, Turmeric, Nutmeg, Parsley, Bay leaves</td>
</tr>
<tr>
<td>Sugar crops</td>
<td>Sugar cane</td>
</tr>
<tr>
<td>Plantation</td>
<td>Coffee, Coconut</td>
</tr>
<tr>
<td>Pulses</td>
<td>Black gram, Green gram, Bengal gram, Horse gram, Redgram</td>
</tr>
<tr>
<td>Oil seeds</td>
<td>Sesame, Groundnut, Soybean</td>
</tr>
<tr>
<td>Medicinal &amp; aromatic plants</td>
<td>Amla, Ashwagandha, Brahmi, Tulsi, Citronellia, Chia, Gymnena, Lemon grass, Moringa, Palmarosa</td>
</tr>
</tbody>
</table>

(Source: Dept. of Agriculture, GOK)

6.39. In order to keep the momentum of agricultural development, GOK formulated a state policy during 2004 with focused approach towards conservation of bio-diversity, mixed farming, soil and water conservation including rainwater harvesting, on-farm production of organic manures, land regeneration, assistance for certification processing, marketing, credit, export promotion, training and publicity, etc. With this policy, there has been steady growth in the organic sector with an increased certified area from a mere 2,500 ha during 2004-05 to 93,963 ha during March 2016. Since the promotion of organic farming is directly linked with the market development, the GOK has established 14 Regional Federations of Organic Farmers’ Associations which are provided financial assistance to take up organic produce collection, grading, value addition, processing, packing, brand development and marketing apart from consumer awareness program and related activities. This has created a huge market opportunity for the farmers to expand the area under organic farming.

6.40. Now the organic sector in Karnataka, which was “supply driven” at one point of time, has become ‘consumer driven’ due to increase in “consumer demand”. This has created more demand. Hence, it is required to bridge the gap between demand and the supply arrangement.

6.41. The state policy on organic farming has the following **Mission** objectives:

- To bring organic farmers to the mainstream agricultural production system with the objective of transforming at least 10% of the cultivable area of the state to organic farming.
- To enable organic and millet farmers of the state to realize 25% to 30% additional income by leveraging the demands of organic farming.
- To focus on commodity /crop specific clusters to generate bulk quantity of organic foods and millets to meet the growing demand of domestic as well as export market.
• To improve the quality of organic foods and millets by extending state support to investors for the establishment of necessary supply chain and infrastructure facilities to process and market

• To safeguard the interest of the consumers by putting in place suitable regulatory measures, which would facilitate in uploading the principles of traceability, accountability and transparency in production, handling and marketing of organic produce. This helps in ensuring higher level of confidence among the public about organic produce.

6.42. The state policy on organic farming has the following aims:
• To maximize the production and productivity of organic produce and millets;
• To enable farmers to mitigate and adapt to the climate change and drought situations effectively;
• To maximize crop and farm diversification thereby enhancing protection against crop losses due to adverse weather conditions;
• To increase farmer’s income by facilitating value additions to organic produce and millets thereby reducing post-harvest losses and other wastes;
• To create and strengthen local institutions for effective service delivery and sharing of knowledge and skills;
• To bring in more transparency in production, handling and marketing of organic produce and to safeguard the consumer’s interest.

6.43. The policy shall be implemented through convergence of all related schemes of different departments in an integrated approach. The state level empowered committees shall have the powers to allocate the funds to different schemes and agencies.

6.44. Organic farming aims at production of quality and safe agricultural products, which contain no chemical residues, following eco-friendly production methods and farming system that restore and maintain soil fertility. Organic farming differs in many ways from conventional farming. Main objectives of the policy are to reduce the debt burden of farmers and enable them to achieve sustenance and self-respect, to enhance soil fertility and productivity increasing life in soil, to reduce the cost of production, to improve farmers’ income through production of quality produce, to increase the food security by encouraging traditional crops, to increase rural employment opportunities, to facilitate farmers’ Self Help Groups for most of their requirements, to make the environment safe and pollution free and also to protect health of human beings and animals, to equip the farmers to effectively mitigate the drought prone situation in rain fed and drought prone areas.

6.45. Savayava Bhagya Yojane: This mega programme initiated during the later part of 2013-14 is an extension of an earlier Organic village/site programme to hobli level with few modifications in its implementation such as developing good marketing linkages and market development for the organic produce. The programme is being implemented in association with the NGOs selected for each taluk through a transparent process of e-tendering. The NGO selected for the taluka has been entrusted with the responsibility of bringing around 100 ha under organic farming in each hobli of the taluka. The programme has been implemented in 571 hobulis covering 53,829 farmers and 63,677 hectares of farm land in association with the NGOs. Several developmental works have been carried out in each of 100 ha blocks under Savayava Bhagya Yojane.

**Concepts and carbon sequestration**
One of the most important terrestrial pools for carbon (C) storage and exchange with atmospheric CO$_2$ is soil organic carbon (SOC). Following the advent of large-scale cultivation, this long-term balance was disrupted and increased amounts of SOC were exposed to oxidation and loss as atmospheric CO$_2$. This resulted in dramatic decrease in SOC. When the amount of Carbon entering the soil exceeds the amount given out to the atmosphere by oxidation, SOC increases. The principles of Organic Farming i.e. “live and let live” are applied here. SOC can be increased by tillage management and cropping systems, management to increase amount of land cover and efficient use of production inputs, e.g. nutrients and water. Among the most important contributors, incorporation of organic components is the prominent one. Biomass production is increased by efficient use of production inputs. Incorporation of organic components in to the soil definitely improves the SOC.

Agro-forestry

Agro-forestry is an old practice in a new form i.e., the presence of trees on external and internal boundaries, cropland and homestead plots or on any other available areas within or in the periphery of farmlands. It includes agri-siliculture, agri-pasture, horti-pasture, bund, block and peripheral plantations and orchards on agricultural fields. Agro-forestry, the inclusion of woody perennials within farming systems, has been practiced as a traditional land use and livelihood option since time immemorial. It was being practiced on agricultural lands and rural areas for variety of reasons like, bio-fertilizer trees to enrich soil and helping in land regeneration enabling food security, fuel-wood and fodder trees, fruit trees as cash crops, medicinal trees, trees providing non timber forest products (NTFP), trees providing timber, shelter, etc. It has been observed that farmers usually prefer multipurpose tree species. The trees grown in agro-forestry systems should meet the requirement of feed, fodder, fruits, timber, fuel wood, medicines, resins, gums and green manures, besides providing indirect benefits such as biological nitrogen fixation, reduction in soil erosion, increase in water percolation, improving the microclimate, etc.

Important projects/schemes on Agro-forestry are Krishi Aranya Prothsaha Yojanae (KAPY), Raising of Seedlings for Public Distribution (RSPD), Sub-Mission on Agro-forestry (SMAF), Mahatma Gandhi Rural Employment Guarantee Scheme (MGNREGS), Village Forest Committees (JFPM), Moguvigondu Mara Shalegondu Vana, etc. The schemes aim at increasing awareness of the people regarding the multidimensional benefits of forestry in their door steps and in helping achieve the national goal of 33% forest or tree cover.

Agro-forestry deserves to be given further push in the state. Considering that about forty four per cent areas of the state currently under agriculture have soils with low and very low available water capacity (AWC), growing of perennial agricultural crops in such areas is not sustainable and will lead to further land degradation. Such areas need to be brought under perennial tree crop under horticulture, sericulture or agro-forestry. At present, the Forest department is implementing a few agro-forestry programs mentioned above with limited success. The vast extension net-work of the Agriculture department is in a very advantageous position to carry forward the message of tree planting in marginal and unproductive agricultural lands. This is mutually beneficial to the farmers as well as to the environment, as the farmers will be assured of better returns and the overall environment of the land ecosystem will get rejuvenated.

Decline in agricultural biodiversity

The term agricultural biodiversity refers to all components of biodiversity relevant to food and agriculture. It encompasses all agricultural ecosystems with their resident flora,
fauna and various micro-organisms all of which play very important role in sustaining key functions of the ecosystem in terms of food production and food security. Agricultural biodiversity is the basic foundation of agriculture. It is the source of genetic material that is vital to future generations. There are many species of cultivated plants that are threatened. When a species or diversity within the species is lost, we also lose genes that could be important for improving crops, promoting their resistance to pests and diseases, or adapting to the effects of climate change. Agricultural biodiversity can provide a cost-effective way for farmers to manage pests and diseases. Knowledge about the diversity of species and their resistance to different types of pests and diseases enables the farmers to plant appropriate species and reduce the damage by pests and diseases considerably. Agricultural biodiversity gives farmers options to manage climate risks. All farmers, especially the small and marginal farmers are very vulnerable to the fluctuations of climate and weather. Agricultural biodiversity offers more crop options to the farmers to choose from a larger basket of species so that they can effectively confront the effects of extreme events such as droughts and floods. Agricultural biodiversity can contribute to health and nutrition. Agricultural biodiversity can play a role in sustaining soil health, food and habit for important pollinators and natural pest predators that are vital to agricultural production. Traditional knowledge and culture is often based on local species diversity and its use (https://www.cbd.int, https://biodiversityinternational.org).

6.51. In the bid to increase food production to satisfy an increasing population, the traditional agricultural systems with multiple indigenous species, which were intricately linked with the farmers’ traditional knowledge and wisdom about agricultural biodiversity, were replaced by mono crop plantations of high yielding varieties (HYV) having very narrow genetic base. Advent of irrigation and over doses of chemical fertilizers and pesticides have transformed the erstwhile agricultural lands with diverse microhabitats into expansive and homogenous landscapes which respond to a limited number of high yielding varieties under very exacting conditions of soil, water, fertilizers, pesticides, etc. Most of the high yielding varieties of agricultural crops have been developed from genetic material taken from traditional varieties and their wild relatives. HYV hybrids are very vulnerable to attacks by pests and diseases within a few years of their introduction. This requires infusion of fresh genetic material which is again sourced from traditional varieties. This underscores the need for conserving the traditional varieties at any cost. There are national and international gene banks which are used to store and conserve the plants genetic resources of major crop plants and their wild relatives in living conditions. However, the best way to conserve agricultural biodiversity is to continue with the growing of the indigenous crops through traditional methods, at least in some limited scale. Such methods also help in evolution of new varieties. It is a good sign that many progressive farmers in the state at individual level have been growing such traditional varieties in smaller plots within their farm lands in order to conserve the biodiversity available with them. A few examples are given below:

- A farmer named Syed Ghani Khan in the Kirugavulu village of Mandya district has maintained more than 850 indigenous rice varieties from all parts of the country (Rice Museum) and over 116 varieties of mangoes (Bada Bagh). Syed has transformed the farm into a bio-diverse ecosystem, which is host to over 60 species of birds. Maintaining this living museum and perpetuating the lost knowledge to the future generations is his only passion. The farmer hopes to reintroduce the lost traditional varieties and bring back the lost wisdom of our ancestors to this generation of farmers.
B.K. Deva Rao of Mittabagilu village, a farmer in Dakshina Kannada is proud to own 80 varieties of paddy, most of them being traditional ones. Now, he sows them on rotation basis on 42 plots spread over six acres on the foothills of the Western Ghats. He cultivates 40 varieties from April to October and the other 40 varieties from October to March. Hence, all were saved. According to him, he used only “hatti gobbara” (organic manure) to grow them. The paddy in his possession includes not just the ones cultivated in the coastal belt but also elsewhere. It includes some hybrid varieties as well. He indicated that some of the traditional varieties such as “Samunga” or “Kumkuma” were still not available. “Kolanjipille” and “Jeerigesale” varieties are also lost. Some of the varieties in his possession are “Meese Bhatta”, “Kalame”, “Atikaya”, “Raja Kayame”, “Suggi Kayame”, “Tonnur”, “Navara”, “Gandhasale”, “Aden Kelte”, “Gidda Bhatta” and “Shasthitka (a two-and-a-half month crop).

6.52. Some prominent varieties of rice in Karnataka are Mysore Mallige, NMS2, Chinnaponni, HMT, De Govinda and Sidda Sanna;

**Medicinal Rice:** Navara (originally from Kerala),

**Diabetic Rice:** Karigajavali, Kagisale, Doddabairnellu

**Scented Aromatic Rice:** Gadhsale, Jeerige Sanna, Sannakki, Ambemore, Burma Black

**Daily Rice:** Salem Sanna, Rajbhoga, Gowri Sanna, Rajkamal,

**Red Rice Varieties:** Karijaddu, Karidaddibudda, Jolaga, Munduga, Doddabairnellu

**Other varieties of Rice specific to Karnataka:** Rajamudi, Rathnachudi, Sannavalya, Mysore Sanna, Bangaragundu, BR-2655, IR-30864, Jaya, Kagga, Thanu and Tunga

6.53. In Ragi, the oldest verities are Kari kaddi Ragi (GE3321), Beli kaddi Ragi (GE1447), Giddaragi (GE609), Hullubele, Purna (GE4606), Hasma white (GE288). There are more than 60 varieties of Ragi prevailing in Karnataka. Agricultural Universities in the State are maintaining the gene bank of some of the oldest/traditional varieties crops.

6.54. Millets are considered as positive and neutral grains. Positive millet grains have dietary fiber and they are Foxtail (Navane), Barnyard (Oodalu), Araka (Kodo), Little (Samai) and Brown Top (Korale). Pearl (Sajje), Finger (Ragi), Proso (Baragu), Great Millet (White Jowar) and Corn are classified as neutral grains, having a little lesser fiber and other nutrients. The millet foods are considered as miracle grains and are collectively called as “Siri Dhanya” millets. The millet crops require minimum water and minimum inputs. They provide maximum nutrition. They can be grown even without chemical fertilizers and pesticides and hence they are less harmful to the environment. They are becoming more popular to the urban population due to the health benefits. These crops are grown even under moderate drought situations and yield normal yield. Under the climate change scenario, they turn out to be the best crops for aberrant climate situations. Horsegram, Blackgram, Greengram, Cowpea, Redgram, Gram in pulses and Castor, Sesamum and Niger oil seeds are some of the traditional crops that can be grown under low rainfall years. The organic farmers’ regional federations are promoting back-to-the-old-ways culture and methodology to deal with the drastic water shortage and popularize growing of millets and other traditional crops.

**Important programs aimed at sustainable agriculture**

6.55. The Agriculture department has been implementing a large number of programs for the development of the agriculture sector. Some of these programs or schemes aim at enabling the farmers to receive commensurate financial returns for their produce; some
schemes provide for insurance against crop loss due to various reasons including natural calamities. The Agricultural Price Commission has been established to ensure maximum share of consumer prices to the farmers. The system of e-marketing has also been extremely beneficial to the farmers who have been able to get quick returns for their produce in a very transparent manner. It is a universal phenomenon that the concern for environment protection becomes more pronounced after attainment of some measure of economic prosperity. It is in the above context that there is a growing awareness among the policy makers, government and private agencies, and farmers themselves, about the need for integrating safety, amelioration and improvement of the environment into the ongoing agricultural activities. There are now a number of schemes which while increasing the production and productivity of crops have also laid emphasis on the overall improvement of the basic capital, i.e. the land on which the crops grow. These schemes are very relevant from the environmental point of view as they advocate sustainable agriculture through interventions which help in arresting land degradation, soil loss and decrease in soil fertility and in improving soil health.

**Bhoochetana**

6.56. The Government of Karnataka in 2009-10 initiated a novel dry land farming project 'Bhoochetana' with the mission goal of increasing average productivity of selected rain-fed crops by 20%. The partners of the project are the Department of Agriculture, Watershed Development Department and the Agricultural Universities of Karnataka, with ICRISAT, Hyderabad as the technical consultants. The scheme aimed at increasing productivity through nutrient management based on soil testing. Project implementation started during Kharif 2009-10 in 6 districts covering 1,440 villages, 2 lakh farmers and 2.25 lakh hectares. The Rabi area coverage during 2009-10 was 0.59 lakh hectares. An enhancement of 33-45% in yield was observed in the treated areas. The project was extended to 16 districts during Kharif 2010-11 covering 5,030 villages, 8.50 lakh farmers and 12.00 lakh hectares. The Rabi area coverage during 2010-11 was 3.32 lakh hectares. An enhancement of 21-41% in yield was observed in the treated areas. During Kharif 2011-12, Bhoochetana programme was implemented in all 30 districts covering 13,800 villages, 20 lakh farmers and 25.4 lakh hectares. The Rabi area coverage during 2011-12 was 5.40 lakh hectares. An enhancement of 29-41% in yield was observed in the treated areas. During 2012-13, the programme was extended to 50 lakh hectares of dry land area and 5 lakh hectares of irrigated area. By the fourth year, the project covered 26,000 villages with 42 lakh farmers. There was considerable area coverage of 27 lakh hectares during Rabi 2012-13 also. An enhancement of 11-37% in yield was observed in the treated areas. With this background, Bhoochetana phase 2 has been approved for implementation for five years (2013-14 to 2017-18). The success of the scheme augurs well for rain-fed dry land agriculture in the state.

**National Mission for Sustainable Agriculture (NMSA)**

6.57. National Mission for Sustainable Agriculture (NMSA) has been formulated for enhancing agricultural productivity especially in rain-fed areas focusing on integrated farming, water use efficiency, soil health management and synergizing resource conservation. NMSA derives its mandate from Sustainable Agriculture Mission which is one of the eight Missions outlined under National Action Plan on Climate Change (NAPCC). NMSA architecture has been designed by converging, consolidating and subsuming all ongoing as well as newly proposed activities/programs related to sustainable agriculture with a special emphasis on soil and water conservation, water use efficiency, soil health management and rain-fed area development.
Krishi Bhagya

6.58. The main objective of the scheme is to improve rain fed agriculture with efficient management of rain water with the aim of more crop-yield per drop of water, to enhance farm productivity. Thrust is given to conservation of rain water and utilization of the collected water to irrigate the crop at critical stages of crop growth. Krishi Bhagya scheme was implemented in the form of package (from the year 2014-15 to 2016-17), which includes various components such as construction of farm pond with polythene lining/alternate lining (Max-Rs. 50,000/-), distribution of diesel pump set, micro irrigation, field bund, cropping system, veterinary component and poly/shade net. For all the above components financial assistance of 80% and 90% was provided to general and SC/ST category famers respectively. Krishi Bhagya scheme was converged with other schemes such as Micro Irrigation scheme, National Food Security Mission (NFSM) and National Mission on Oilseeds and Oil Palm (NMOOP). During last 3 years, an amount of Rs.1536.51 crore has been spent under this program benefitting 1.76 lakh farmers. From 2017-18, it is targeted to construct around 70,000 farm ponds and an amount of Rs 600.00 crore has been earmarked for implementation of this scheme.

Karnataka Watershed Development Project II-(Sujala III)

6.59. Sujala III is a World Bank sponsored, multidisciplinary and multi-partnered watershed development project which is being implemented in 1931 micro watersheds across 11 districts of the State from year 2013 to 2018. The project has a budget of Rs.527.67 crore and aims to benefit 6.22 lakh rural households spread over treatment area of 9.66 lakh hectares. The project aims for effective and efficient watershed management through innovative and science based approaches, integration of programs related to rain-fed agriculture and strengthening the community based organizations (CBOs) and other institutional partners working for the project. The uniqueness of the project lies in the adoption of State of the Art technology for planning, implementation and monitoring. Tools like Satellite Remote Sensing, GIS, Management Information System, GPS and Satellite Communication are used in the project for providing farm specific advisory to the farmers.

Integrated Farming Systems (IFS)

6.60. Sustainable agriculture means an integrated approach to increasing farm yield and managing resources in order to address all three critical aspects of sustainability: economic, environmental and social. The IFS approach has multiple objectives of sustainability, food security, farmer security and poverty reduction. It involves use of outputs of one enterprise component as inputs for other related enterprises wherever feasible, for example, cattle dung mixed with crop residues and farm waste can be converted in to nutrient-rich vermi-compost. The salient features of IFS include – innovation in farming for maximizing production through optimal use of local resources, effective recycling of farm waste for productive purposes, community-led local systems for water conservation, organic farming, and developing a judicious mix of income-generating activities such as dairy, poultry, fishery, goat-rearing, vermi-composting and others. Benefits or advantages of Integrated Farming System are as follows:

1) Productivity: IFS provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises;

2) Profitability: It uses waste material of one component at the least cost. Thus it reduces cost of production, forms linkage of utilization of waste material and eliminates interference by middleman. Benefit cost ratio is increased.
3) Potentiality or Sustainability: Organic supplementation through effective utilization of byproducts of linked component is done thus providing an opportunity to sustain the potentiality of production base for much longer periods.

4) Balanced Food: IFS links components of varied nature enabling to produce different sources of nutrition.

5) Environmental Safety: In IFS waste materials are effectively recycled by linking appropriate components, thus minimize environment pollution.

6) Recycling: Effective recycling of waste material in IFS.

7) Income Round the year: Due to interaction of enterprises with crops, eggs, milk, mushroom, honey, cocoons silkworm, etc., it provides flow of money to the farmer throughout the year.

8) Adoption of New Technology: Resourceful farmers (big farmers) fully utilize the technologies. IFS farmers use the linkage of dairy/mushroom/sericulture/vegetable. Money flow round the year gives an inducement to the small/ original farmers to go for the adoption technologies.

9) Saving Energy: IFS helps in identifying an alternative source of energy to reduce dependence on fossil energy source. By using effective recycling technique, the organic wastes available in the system can be utilized to generate biogas. Energy crisis can be postponed to the later period.

10) Meeting Fodder crisis: Every piece of land area is effectively utilized. Plantation of perennial legume fodder trees on field borders helps in fixing the atmospheric nitrogen besides ensuring the availability of quality fodder for domestic animals.

11) Solving Fuel and Timber Crisis: By linking agro-forstery appropriately the production level of fuel and industrial wood can be enhanced without detrimental effect on crop. This will also greatly help in reducing deforestation and preserving our natural ecosystem.

12) Employment Generation: Combing crop with livestock enterprises would increase the labor requirement significantly and would help in reducing the problems of under employment to a great extent. IFS provides enough scope to employ family labor round the year.

13) Agro-industries: When one of the produces linked in IFS is increased to commercial level there is surplus value addition leading to development of allied agro-industries.

14) Increasing Input Efficiency: IFS provides good scope to use inputs in different components leading to greater efficiency and benefit cost ratio.

Action plans for Sustainable Agriculture

6.61. Adaptation to climate change has the potential to substantially reduce many of the adverse impacts of climate change and enhance beneficial impacts. Planned anticipatory adaptation has the potential to reduce vulnerability and realize opportunities associated with climate change. Implementation of adaptation policies, programs, and measures usually will
have immediate benefits, as well as future benefits. Adaptation measures are likely to be implemented only if they are consistent with or integrated with decisions or programs that address non-climatic stresses. The most vulnerable regions and crops are those that are highly sensitive to climate change effects having limited adaptive capacity. Enhancement of adaptive capacity is a necessary condition for reducing vulnerability, particularly for the most vulnerable regions and crops. Hence some of the comprehensive adaptation strategies are mentioned below, in addition to the changing over to potential crops in the vulnerable districts. This way, the loss in the food production can be compensated and the advantages of the climate change effects can be absorbed positively.

6.62. National Mission for Sustainable Agriculture is to make Indian agriculture more resilient to climate change by identifying new varieties of crops, especially thermal resistant ones and alternative cropping patterns. This is to be supported by integration of traditional knowledge and practical systems, information technology and biotechnology, as well as new credit and insurance mechanisms. In particular the Mission focuses on rain-fed agricultural zones and suggests:

- Development of drought and pest resistant crop varieties;
- Improving methods to conserve soil and water;
- Stakeholder consultations, training workshops and demonstration exercises for farming communities, for agro-climatic information sharing and dissemination;
- Financial support to enable farmers to invest in and adopt relevant technologies to overcome climatic related stresses.

6.63. Some of the mitigation strategies recommended for sustainable agriculture are:

1. Drought management strategies in rain-fed agriculture;
2. Rainwater management in rain-fed areas;
3. Long term measures for rain water management in rain-fed areas;
4. Strengthening Agro-met advisory services;
5. Controlling pest and diseases;
6. Agronomic Mitigation strategies for climate change;
7. Disease Control;
8. Bio-Technological approach to increase the food production under climate change scenario;
9. Extension strategy;
10. Strategies to protect soil health;
11. Development of resource conserving technologies;
12. Improved land use and natural resource management policies and institutions;
13. Improved risk management through early warning system and crop insurance.

SERICULTURE
Introduction

6.64. India is the second largest producer of raw silk after China and the biggest consumer of raw silk and silk fabrics. An analysis of trends in the international silk production suggests that sericulture has better prospects for growth in the developing countries rather than in the advanced countries. Silk production in temperate countries like Japan, South Korea, Russia, etc. is declining steadily not only because of the high cost of labor and heavy industrialization
in these countries, but also due to climatic restrictions imposed on mulberry leaf availability that allows only two cocoon crops per annum. India in general and Karnataka state in particular has a distinct advantage of practicing sericulture all through the year, yielding a stream of at least about 4 – 6 crops as a result of its tropical climate.

6.65. **Types of silks in India:** India is a home to a variety of silk secreting fauna which also includes an amazing diversity of silk moths. This has enabled India to achieve the unique distinction of being a producer of all the five commercially traded varieties of natural silks namely, Mulberry, Tropical Tasar, Oak Tasar, Eri and Muga. Silk obtained from the sources other than mulberry are generally termed as non-mulberry or Vanya silks. The bulk of the commercial silk produced in the world is mulberry silk that comes from the domesticated silkworm, *Bombyx mori* L. that feeds solely on the leaves of the mulberry plant (*Morus* sp.).

### Table-11: Production of non-mulberry silk vis-à-vis mulberry raw silk from 2007-08 to 2016-17 in India

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Year</th>
<th>Non mulberry raw silk (MTs)</th>
<th>Mulberry raw silk (MTs)</th>
<th>Total raw silk (MTs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2007-08</td>
<td>2075</td>
<td>16245</td>
<td>18320</td>
</tr>
<tr>
<td>2</td>
<td>2008-09</td>
<td>2760</td>
<td>15610</td>
<td>18370</td>
</tr>
<tr>
<td>3</td>
<td>2009-10</td>
<td>3368</td>
<td>16322</td>
<td>19690</td>
</tr>
<tr>
<td>4</td>
<td>2010-11</td>
<td>4050</td>
<td>16360</td>
<td>20410</td>
</tr>
<tr>
<td>5</td>
<td>2011-12</td>
<td>4788</td>
<td>18272</td>
<td>23060</td>
</tr>
<tr>
<td>6</td>
<td>2012-13</td>
<td>4964</td>
<td>18715</td>
<td>23679</td>
</tr>
<tr>
<td>7</td>
<td>2013-14</td>
<td>7004</td>
<td>19476</td>
<td>26480</td>
</tr>
<tr>
<td>8</td>
<td>2014-15</td>
<td>7318</td>
<td>21271</td>
<td>28708</td>
</tr>
<tr>
<td>9</td>
<td>2015-16</td>
<td>8045</td>
<td>20478</td>
<td>28516</td>
</tr>
<tr>
<td>10</td>
<td>2016-17</td>
<td>9075</td>
<td>21273</td>
<td>30348</td>
</tr>
</tbody>
</table>

**Sericulture in Karnataka**

6.66. In Karnataka, sericulture is not only a tradition but also a living culture. Karnataka is the premier state in the production of mulberry raw silk producing approximately 50% of the mulberry raw silk production of the country. The activities of silk industry like mulberry cultivation, silkworm seed production, silkworm rearing, silk reeling, twisting, dyeing, weaving (both handlooms and power looms), printing, finishing and trade activities, etc. are closely chain linked to one another. Apart from the above, the subsidiary activities like zari manufacturing and manufacturing units of silk machineries support the silk industry.

6.67. In the recent past silk industry in Karnataka has registered an impressive growth, both horizontally and vertically. Plans and schemes implemented by central and state governments and relentless efforts of thousands of dedicated persons in the fields of research and extension have helped in this context. For instance, the age old multivoltine hybrids have been replaced by multivoltine × bivoltine and bivoltine hybrids. The sericulture industry has witnessed a quantum jump in raw silk productivity. The average yield of 25 kg of cocoons/100 dfls in the recent past has increased and currently the average yields are in the range of 60 – 65 kg/100 dfls. The new technology, besides doubling yields has also led to qualitative improvements in
cocoon production with considerable reduction in renditta (No. of kg of cocoons required to produce one kg of raw silk) and has also helped to break the climate barrier.

6.68. Currently, the domestic demand for silk, considering all varieties, is about 34,000 MT, of which around 30,348 MT (2016-17) is produced in the country and the rest is imported mainly from China. Indian domestic silk market has been over the years driven by multivoltine mulberry silk. The quality of multivoltine silk is relatively inferior to that of bivoltine silk and does not meet the international quality standard. Though R&D efforts have been made to improve the quality of multivoltine silk, the best of multivoltine silk has not been able to match the bivoltine silk in quality. Therefore, it is essential to enlarge the production base and improve current productivity levels of bivoltine silk to meet the international standards and quality demands of the power loom sector.

Table-12: Growth of sericulture from 2010-11 to 2016-17 in Karnataka

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Year</th>
<th>Mulberry area (ha)</th>
<th>Production of cocoon (MTs)</th>
<th>Production of raw silk (MTs)</th>
<th>Renditta</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2010-11</td>
<td>62,697</td>
<td>52,709</td>
<td>7,027</td>
<td>7.18</td>
</tr>
<tr>
<td>2</td>
<td>2011-12</td>
<td>70,958</td>
<td>55,957</td>
<td>7,433</td>
<td>7.18</td>
</tr>
<tr>
<td>3</td>
<td>2012-13</td>
<td>74,128</td>
<td>49,441</td>
<td>6,491</td>
<td>7.00</td>
</tr>
<tr>
<td>4</td>
<td>2013-14</td>
<td>80,872</td>
<td>61,419</td>
<td>7,766</td>
<td>7.16</td>
</tr>
<tr>
<td>5</td>
<td>2014-15</td>
<td>88,489</td>
<td>68,758</td>
<td>8,442</td>
<td>7.13</td>
</tr>
<tr>
<td>6</td>
<td>2015-16</td>
<td>87,598</td>
<td>70,436</td>
<td>8,479</td>
<td>7.07</td>
</tr>
<tr>
<td>7</td>
<td>2016-17</td>
<td>91,492</td>
<td>68,381</td>
<td>8,083</td>
<td>7.05</td>
</tr>
<tr>
<td>Increase</td>
<td></td>
<td>28,795 (46%)</td>
<td>20,995 (43%)</td>
<td>1,988 (31%)</td>
<td>1,177 (378%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,827 (40%)</td>
</tr>
<tr>
<td>Increase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,827 (40%)</td>
</tr>
</tbody>
</table>

6.69. There has been an increase in the mulberry area by 28,795 ha from 62,697 ha to 91,492 ha registering 46% increase in the last seven years. The cocoon production has also increased by 20,995 MT from 49,441 MT to 70,436 MT registering an increase of 43% during the above period. While there has been an increase of only 31% in production of cross breed raw silk, production of bivoltine raw silk has increased four-fold during the same period indicating the importance given in the recent years to the production of bivoltine raw silk whose quality is comparable with that of China silk. The overall raw silk production during the above said period has increased by 40% in the last seven years.

Potential, strengths and challenges of sericulture industry

6.70. R&D achievements like development of indigenous mulberry varieties with highest leaf yields, new bivoltine silkworm hybrids eminently suited to the tropical regions, farmer-friendly technologies, cost-effective new package of practices for cultivation of food plants, rearing and reeling coupled with huge natural and man-made resources and trained manpower clearly indicate a very bright prospect for the sericulture industry to contribute to the economic development and uplifftment of the socially deprived and downtrodden sections of the society. The strengths, limitations, opportunities and challenges (SLOT analysis) of silk industry are given below:
Table-13: SLOT Analysis of Silk industry

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Limitations</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large production base, availability of skills, land and labour</td>
<td>Gaps in technology transfer and extension support besides continuous decline in underground water.</td>
<td>Generation of rural employment and reduction of migration to urban areas. Best tree mulberry species are available, require less water and labour as well as per unit area.</td>
<td>Falling international prices and heavy dumping from China at low prices</td>
</tr>
<tr>
<td>Established infrastructure, availability of silkworm breeds / hybrids</td>
<td>poor linkage among different stake holders</td>
<td>Liberalization policies of Govt. of India in line with WTO Agreements</td>
<td>Unpredictability of China’s silk policies</td>
</tr>
<tr>
<td>Low investment, short gestation period and higher returns</td>
<td>De-centralized nature of the industry inhibits financial institute from extending financial support to the sector</td>
<td>Reduction in production of silk even by traditional silk countries like Japan, USSR etc</td>
<td>Inability of the silk industry to react and adopt to the changing needs in terms of quality both for the domestic and export markets</td>
</tr>
<tr>
<td>Easily adoptable technologies and strong domestic demand-pull</td>
<td>Lack of quality based pricing system in the market, frequent price fluctuations and large scale imports from China at low prices</td>
<td>Garment exports are on a steady increase with huge employment opportunities</td>
<td>Lack of awareness in the domestic market to respond to the demand-driven milieu</td>
</tr>
</tbody>
</table>

Sericulture and rural development

6.71. Sericulture is a farm-based, labor intensive and commercially attractive economic activity falling under the cottage and small-scale sector. It particularly suits rural-based farmers, entrepreneurs and artisans, as it requires low investment but has potential for relatively higher returns. It provides income and employment to the rural poor especially farmers with small land-holdings and the marginalized and weaker sections of the society. The very nature of this industry with its rural based on-farm and off-farm activities and enormous employment generation potential has attracted the attention of many planners and policy makers to recognize sericulture industry as one of the most appropriate avenues for
socio-economic development of a largely agrarian economy like ours. In Karnataka, sericulture related activities ensure the livelihood security to over two million families spread over in some 10,500 villages across the state. Generally, the urban rich and middle-class consumers purchase silk goods and it is estimated that around 57% of the final value of silk fabrics flows back to the primary producers in rural areas. Sericulture can also play a very vital role in alleviating rural poverty due to its high work participation rate and thereby can check migration from rural to urban areas. It is estimated that sericulture can generate employment @ 11 man days per kg of mulberry raw silk production (in on-farm and off-farm activities) throughout the year.

Table-14: Activity-wise employment generation in Mulberry sericulture (per ha)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Employment generation (Mandays)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Mulberry cultivation and silkworm rearing</td>
<td></td>
</tr>
<tr>
<td>a. Mulberry cultivation</td>
<td>585</td>
</tr>
<tr>
<td>b. Leaf / shoot harvesting</td>
<td>320</td>
</tr>
<tr>
<td>c. Silkworm rearing</td>
<td>350</td>
</tr>
<tr>
<td>Sub-total</td>
<td>1,255</td>
</tr>
<tr>
<td>B. Reeling of silk cocoons</td>
<td></td>
</tr>
<tr>
<td>@ 300 mandays per 1000 kg of reeling cocoons (@ 8.0 renditta; 760 kg cocoon / ha; 95 kg raw silk / ha.)</td>
<td>2,250</td>
</tr>
<tr>
<td>Total (A + B)</td>
<td>3,535</td>
</tr>
<tr>
<td>C. Twisting</td>
<td></td>
</tr>
<tr>
<td>@ 220 g of silk per manday</td>
<td>432</td>
</tr>
<tr>
<td>D. Weaving</td>
<td></td>
</tr>
<tr>
<td>Handloom @ 0.13 kg per manday</td>
<td>438</td>
</tr>
<tr>
<td>Powerloom @ 0.3125 kg per manday</td>
<td>122</td>
</tr>
<tr>
<td>Sub-total (Weaving)</td>
<td>560</td>
</tr>
<tr>
<td>E. Printing and Dyeing</td>
<td></td>
</tr>
<tr>
<td>@ 40 mandays for 40 kg of raw silk</td>
<td>95</td>
</tr>
<tr>
<td>F. Finishing</td>
<td></td>
</tr>
<tr>
<td>@ 751 mandays for 40 kg of raw silk</td>
<td>1,784</td>
</tr>
<tr>
<td>G. Silk waste processing</td>
<td></td>
</tr>
<tr>
<td>@ 18.775 mandays per kg of raw silk</td>
<td>26</td>
</tr>
<tr>
<td>Total (C to G)</td>
<td>2,896</td>
</tr>
<tr>
<td>Grand Total</td>
<td>6,431</td>
</tr>
</tbody>
</table>

Sericulture and women empowerment

6.72. Women contribute to a little less than 50% of the state’s population and most of them are largely rural based, deriving their livelihood through agriculture and other land based activities, either as family members or wage earners. As a cottage industry, sericulture provides ample work for women in the rural areas particularly in silkworm rearing and reeling, while men, largely work in the field and in weaving. The involvement of women in different activities of sericulture is about 53% and their contribution in the on-farm activities is understandably lower than that in post-cocoon activities. Sericulture is an ideal avocation for women because of the following facts: (a) Being rural based, sericulture needs less specialized skill and hence, suits women well; (b) Involves mostly indoor activities, less physical energy and manual labor; (c) Work is evenly spread over during the day, with
intermittent gaps, offering leisure time and proximity to living place; (d) Minimum investment with long life and short gestation period; and (e) Continuous job with frequent income and scope for utilizing several by-products for value addition.

**Mechanization in sericulture**

6.73. Sericulture comprises four major activities, namely, mulberry cultivation, silkworm rearing, silk reeling and weaving. Of the four, one is land-based activity, one is household activity and the remaining two are industrial in nature. In mulberry cultivation, silkworm rearing and silkworm egg production are largely carried out manually. More than half of the cost of cocoon production accounts for production of mulberry leaves. The profitability in sericulture depends mainly on leaf and cocoon yield per unit area over a definite time and also price of cocoons. It is observed that profit margin in sericulture has come down due to sharp hike in input and operational cost. This has led to finding ways of reducing the cost of production of various intermediary outputs in the production chain of silk. The labor output/efficiency in Indian Sericulture is low compared to that in advanced countries. To overcome these problems, these activities are carried out by using machineries where cost of production can be reduced. Besides, with the introduction of tree mulberry, there is a vast scope for mechanization in sericulture because of wider spacing between the mulberry plants.

**Cocoon markets, silk exchanges, farmer produce organization (FPO) and Cocoon bank**

6.74. Karnataka has a well established marketing system for transaction of cocoons and raw silk. There are 34 commercial cocoon markets spread throughout the state. These are located in major reeling centers. Ramanagara, Channapatna, Siddlagatta, Kollegal, Vijayapura, Kanakapura and Kolar are the major cocoon markets. About 150-160 MT of cocoons are transacted daily with an average transaction value of Rs. 3.5 to 4.0 crore. E-bidding has been introduced in the major cocoon markets to ensure total transparency in cocoon transaction and competitive rates both to farmers and reelers. On a daily basis the silk reelers produce about 22-25 MTs of raw silk. The state has organized silk exchanges in major reeling centers to facilitate marketing of raw silk. However some of the reelers have direct linkages with their weaver / trader clients.

6.75. Farmer produce organizations (FPOs) have been formed to collectivize farmers, especially small and marginal farmers, at various levels across the state to foster technology penetration, improve productivity, enable improved access to inputs and services, minimize cost of production and increase farmers’ income, thereby strengthening their sustainable agriculture based livelihoods. The broad objective is to build, promote and nurture FPOs by way of extending the required financial and non-financial support during the formative stage and provide handholding support.

6.76. ‘Cocoon Bank’ is a storehouse wherein the sericulturists may stock their produce (silk cocoons) to avoid distress sale during price crash and adverse climatic conditions or during unfavorable circumstances until the price touches remunerative level.

**Environmental concerns and corrective/ameliorative measures**

**Concept of integrated nutrient management (INM) and integrated pest management (IPM)**

6.77. Luxuriant growth of mulberry attracts pests. It is estimated that about 20-30% loss in mulberry leaf is due to pests and diseases besides affecting leaf quality. Though chemical formulations are available for the control of these pests and diseases, they are not very
popular with sericulturists due to high cost, sometimes toxicity to silkworms, health hazards, etc. Instead, the use of plant extracts or microbial agents for the biological control of pests and diseases of mulberry is considered as a better and safe alternative to chemicals.

6.78. In this context, the concept of integrated nutrient management (INM) and integrated pest management (IPM) involving organic manures and inorganic fertilizers and bio-control agents to meet the growing need of the nutrient supplies for obtaining high leaf yields of mulberry on economic cost is very relevant and is the need of the day. The use of adequate doses of organic manures (bio-solids), coupled with chemical fertilizers and bio-control measures will ensure optimum growth and yield under intensive farming with high yielding varieties (HYV).

Integration of organic manures, crop residues and recycled agricultural wastes with fertilizers:

6.79. Organic manures like farm yard manure (FYM) and compost are traditionally important agronomic inputs in crop production systems. The FYM and composts when used along with fertilizers, besides supplying nutrients to the soil directly, play a role in augmenting crop productivity by improving physico-chemical and biological activities of the soil. The state has vast potential of crop residues of farm/industrial wastes such as rice or wheat straw, rice husk, sugarcane trash, non-edible cakes, cotton wastes, press-mud, sericulture waste, etc. Crop residues with wide C: N ratio (Carbon:Nitrogen) and those rich in resistant cellulose compounds should be supplemented with a part of N fertilizers recommended for succeeding crop. If huge quantities of such crop residues are to be recycled, their composting with efficient microbial inoculants could be adopted instead of direct application.

Integration of green manures with fertilizers

6.80. Green leaf manures are the cheapest sources of nutrients for the crops. Incorporation of leaf, stem and other plant parts into the soil when the plants are green is called as green leaf manuring management. There are two types of green manuring: (a) *in situ* cultivation of green manure crops and incorporating into the soil and (b) incorporating the leaves and other plant parts brought from outside. The advantages of green biomass of narrow C:N ratio when incorporated into the soil are: they decompose rapidly, it is easy to retain the moisture content and organic matter in the soil, improve both physical and chemical properties of the soil, provide energy to microbes, act as mulch and prevent soil erosion, control of weeds and reduction in the usage of nitrogenous fertilizers. Most of the green manure crops are legumes like Sunhemp (*Crotalaria juncia*), Dhaincha (*Sesbania aculeata*), Cowpea (*Vigna catjang*), green gram (*Phaseolus aureus*), black gram (*Phaseolus mungo*), Horse gram (*Dolichos biflorus*), etc.

6.81. In intercropping, two or more crops generally dissimilar in growth habits are grown simultaneously on the same field. Intercropping enhances the efficiency of resource-use (land, water, nutrients and light). The legume intercropping in mulberry cultivation can accrue benefits to the farmers.
Integration of bio-fertilizers

6.82. Bio-fertilizers are the products that contain living cells of different types of microorganisms that have an ability to mobilize nutrients from non-useable to usable form through biological processes. Bio-fertilizers are low cost supplements to chemical fertilizers without any negative impact on soil, plant, human and animal health. They help in increasing the biologically fixed atmospheric N (Nitrogen) and enhancing native P (Phosphorous) availability to the crops.

Integration of bio-control agents and bio-pesticides

6.83. The aim of this method is to change the ratio of pest to natural enemy leading to control of crop damage. Considerable progress has been made in reducing the negative effects of fungicides/pesticides on the environment (in view of crop yields, environment, energy use, pesticide residue, etc.). There is a greater emphasis on biological control and application on biotechnology. The potential yield of crop is determined by the characteristics of crops and prevailing atmospheric conditions. The attainable yields can be lower due to limiting factors like availability of water and plant nutrients. The actual yields are even lower because of growth reducing factors like diseases, pests and weeds. The traditional disease management, which includes preventive measures against plant pathogens like removal/destruction of crop residues to reduce contaminating potential, crop rotation including fallowing to reduce nematode/soil-borne pathogens and crop breeding for disease resistance, can be further augmented with biological and biotechnological interventions.

Concept of silk Reeling Park

6.84. Karnataka state is the largest producer of raw silk in the country. The share of Charaka and cottage/filature reeling is 25% and 65% respectively. Majority of silk production comes from traditional reeling areas situated in southern parts of the state namely Ramanagara,
Kolar, Chikkaballapura, and Chamarajanagara districts. Silk reeling in these traditional areas is developed as cottage industry. Presently, majority of the units are situated along with dwelling premises in the towns and cities. Because of socio economic status, most of the reelers have dwelling cum reeling units under the same roof. This is indicative of the fact that reeling activity largely developed as backyard home-cottage industry with least technological input. As a result, large numbers of scattered small reelers produce raw silk of varied quality standards in small quantities. On the other hand, the requirement of power-loom weaving industry is that of bulk quantity of raw silk of uniform quality. In addition, Bivoltine is fast catching up and India imports about 3500MT of raw silk annually. Hence, there is a need for automatic reeling units for producing high quality raw silk locally.

6.85. Reeling industry utilizes large quantities of water for production of raw silk (about 200 liters/kg of raw silk for cottage basin and multi-end reeling and about 450 liters/kg for Automatic reeling). The effluent from this industry contains protein matter, which decays within a short time. Most of these areas lack proper drainage system and therefore these units pose potential health threat. Further, most of the reelers use steam-stifling method to kill the pupae before silk reeling process. Because of this, pupa, which constitutes 80% of the cocoon weight, undergoes purification within hours after reeling in wet and humid conditions. This adds to pollution problems of the industry.

6.86. Production and quality in silk reeling are influenced by a combination of five factors, namely, raw material, process parameters, machinery, water and skill. Unsuitable water needs to be treated and for treatment of water, water treatment plant may be required. Large capacity treatment plant with a common water source will ensure uniform quality of water for silk reeling.

6.87. At present silk reelers use large quantity of firewood for heating water for reeling processes. Hence, there is a need to use alternative renewable energy sources such as solar energy for this purpose.

6.88. Silk Reeling Park is a conglomeration of reeling units offering benefits of common infrastructure facilities, and latest technologies. Under the scheme it is proposed to establish four reeling parks in four traditional areas namely, Ramanagara, Kolar, Chikkaballapura and Chamarajanagara districts with the following objectives:

1. To create infrastructure and reeling facilities to the reelers with necessary upgraded technology.
2. To produce bulk quantity of raw silk with uniform quality yarn and branding the product.
3. To minimize pollution through use of modern technology.
4. To improve socio-economic standards of the small and marginal reelers.
5. To decongest the present accumulation of reeling units inside the town area by providing facilities outside the town.

Mulberry cultivation in water sheds

6.89. Mulberry is a hardy plant belonging to family Moraceae. It can be grown in wide range of climatic conditions varying from temperate to tropical. The distribution of mulberry is found to be predominant in southern dry zone districts of Mysore, Mandya, Bangalore Rural and Urban, Ramanagar, Tumkur and Kolar. Mulberry is well distributed in red to black soils. The requirement of water to mulberry is less compared to other crops like paddy and sugarcane. In arable lands where treatment for soil and water conservation is undertaken, mulberry can be effectively grown as contours or trees on marginal lands. Where the farm
ponds are dug to impound runoff, farmers may be motivated to grow mulberry for silkworm rearing by utilizing the harvested water to get maximum returns. Mulberry can be grown along nala (dry stream) course as well as around water harvesting structures.

6.90. To introduce mulberry in watershed areas the following activities need emphasis.

- Identification of suitable varieties of mulberry particularly tree species
- Location for plantations
- System of plantation arable and non-arable lands

![Image](image_url)

Fig. 13: Krushi Honda-an effective measure for rain water retention and usage for protective irrigation.

**Organic farming in mulberry cultivation**

6.91. Mulberry is hardy perennial crop that needs 300-350 kg nitrogen, 120-140 kg phosphorous, 120-140 kg potash per hectare/year besides 20 MT of FYM for optimum yield. The quantity of chemical fertilizers recommended for mulberry cultivation is quite high as compared to other agriculture crops. This leads to increased cost of cultivation. In addition repeated application of chemical fertilizers leads to soil pollution and depletion in soil micro flora. In such situation, application of organic farming in mulberry cultivation has tremendous potential. It has been proved over the years that, it is possible to get sustainable mulberry leaf yield with better leaf quality by using bio fertilizers of bacterial as well as fungal origin, compost and vermicompost produced out of seri farm residue and green manure.

6.92. Microbes are major agents that transfer bio-products and play an important role in sustainable crop production. In this situation, farmers may opt to use bio-resources like sericulture farm wastes, which have maximum quantity of micro and macro nutrients. They can be largely benefitted by using Azotobacter bio-fertilizer for nitrogen supply, phosphorus solubilising microorganisms and Vesicular Arbuscular Mycorrhiza (VAM) for maximum uptake of phosphorous and green manure for improving soil fertility, productivity and moisture retaining capacity.
Table-15: Organic bio resources recommended for organic farming in mulberry leaf production and nutrients availability

<table>
<thead>
<tr>
<th>Bio-resources</th>
<th>Quantity (kg/ha/year)</th>
<th>Available nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nitrogen (kg)</td>
</tr>
<tr>
<td>Seri Azo</td>
<td>23</td>
<td>150-175</td>
</tr>
<tr>
<td>Seri-phos</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>FYM</td>
<td>10 MT</td>
<td>40-50</td>
</tr>
<tr>
<td>Vermi-compost</td>
<td>10 MT</td>
<td>180-200</td>
</tr>
<tr>
<td>Compost</td>
<td>10 MT</td>
<td>80-100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>450-525</strong></td>
<td><strong>175-235</strong></td>
</tr>
</tbody>
</table>

Drip irrigation in mulberry gardens

6.93. Water is becoming scarce commodity these days due to competitive demand and also due to the change in climatic behavior, particularly the erratic nature of rainfall. The available water sources or the new sources those are being created need to be used in best possible manner to fulfill the vision of “HarKhet KoPani” and “Per Drop More Crop” of PMKSY through efficient water conservation (Jal Sanchaya) and water management (Jal Sinchan) practices. In this context it is necessary to link most of the water sources with micro irrigation which facilitates extended coverage for longer duration. Micro-irrigation is well accepted by the farmers and about 70% mulberry gardens have been covered under micro-irrigation resulting in considerable reduction in the water utilization for crop production. Fertigation is also made mandatory to obtain maximum benefits from micro-irrigation.
Tree mulberry cultivation

6.94. Mulberry responds well to water and fertilizer application. However in recent years, due to acute shortage of rainfall and depletion of underground resources the yield has reduced and quality of leaf has deteriorated. Many sericulturists have reduced the area of mulberry garden to suit the water availability. To overcome this problem, some innovative sericulturists in Kolar and Chikkaballapura districts have taken up raising mulberry as small trees. A spacing of 8’ x 8’ or 10’ x 10’ and plant height of 4’ to 5’ is maintained, under both rain fed and irrigated conditions. This system is amenable to mechanization of cultural operations and drip irrigation. Thereby cost is reduced without compromising on leaf quality. It is a well-established fact that the quality of mulberry leaf from trees is superior to that of conventional gardens.

Advantages of tree mulberry

- Trees may be raised both under rain fed and irrigated conditions.
- Better quality leaf without reduction in yield per unit area.
- Mechanization could be easily adopted.
- Legumes/ Grains/ Commercial crops/ Green manure crops could be raised with additional monetary benefits and the residue could be used as manure/ mulch.
- The percolation pits between rows help to effectively harvest the rain water and also as composting pits for organic waste recycling all available organic waste resources.
A three year old garden with 8' x 8' spacing approximately yields 25 MTs of leaf/acre/year. On an average 1500 layings could be brushed per year to harvest 1000 kg of cocoons from one acre.

6.95. Mulberry is a perennial hardy plant and can tolerate varied range of agro-climatic conditions. Once established in the field, the plant continues to produce good quality leaves in full form for at least 20-25 years under bush cultivation practices and for more than 100 years in tree form. Though mulberry is arboreal in nature, it is trained as low bush or trees for commercial exploitation. However, the optimum temperature range of 20-30°C with sunshine of 9 to 13 hours per day is suitable for mulberry. On an average, mulberry requires 50 to 60 mm of water once in a week. Under such conditions (prevailing in southern tropics of India), 5-6 silkworm rearing crops can be harvested in a year, and farmer can earn Rs 1.5-2.0 lakh/acre/year by planting mulberry as trees with spacing of 10'x10' distance, apart from other agro-forestry crops. Integration of Mulberry tree in Agro-forestry system is suited for all climatic zones especially for hot arid zones of Karnataka and the income can be generated throughout the year.

Carbon sequestration in mulberry

6.96. Carbon is absorbed and assimilated by tree foliage and is stored as carbon rich organic compounds such as cellulose and hemicelluloses, lignin, starch, lipid and waxes mostly in the secondary of tissues and in large roots as well as foliage, branches and fine roots. A mulberry tree, of 2-3 years old, 10 feet tall with a trunk 3-4 inches in diameter can sequester 10-12 kg of CO₂ per year.

- In one hectare, 1,200 mulberry trees can be planted with 10'x10' spacing which can sequester 12,000 kg of CO₂ per year.

- In addition, farmer can utilize the mulberry leaf for silkworm rearing and produce 1680 kg of silkworm cocoons/ha/year and realize an income of Rs. 5-6 lakh/year.

Use of non-conventional energy

6.97. The reeling sector faces considerable impediments in the form of over dependence on firewood as resource of energy for cocoon cooking. With depleting forests, firewood has become a rare commodity and there is urgent requirement of finding alternative energy resources particularly non-conventional source like solar energy. Being a tropical country we have abundant and free solar energy that can be tapped for various
domestic/agriculture/industrial purposes. Solar energy based heating systems that are being developed will go a long way in conserving the natural resources and maintaining clean environment. The disposal of pupae has been a concern from the environment point of view causing health and environmental hazards. There are scientific methods developed now which not only assure of safe disposal of pupae but can generate additional income to the reellers.

**Silk Reeling Park**

6.98. Community reeling is another aspect that has been advocated in the recent past which will help uniform reeling condition and also minimize health and environmental hazards. Reeling parks are contemplated as a step towards achieving environment safety. Reeling of cocoons requires a lot of water which is a rare commodity and in the years to come it will be a scarce commodity. As of now used water after reeling is untreated and is a threat to both mankind and animals. Individual reellers cannot afford to install effluent treatment plant and the same is possible in community reeling park. Such recycled water can be used for agriculture purpose – a step towards clean environment and maintenance of environment safety.

6.99. Sericulture is a farm based cottage industry and is easily affected by the environment. Production of good quality leaf, organic farming, scientific silkworm rearing, effective disease and pest control methods and adopting new package for reeling are the prerequisites for harnessing additional income. The industry has potential and opportunities but is also vulnerable to many inherent weaknesses and threats. The strategy for overcoming the constraints should be environment-friendly. For sustainable sericulture, it is necessary to ensure that there is no adverse impact on the environment. It is the responsibility of every individual to preserve the environment and the natural resources not only for sustainable sericulture/agriculture but also for future generations.

**Integrated Farming systems:**

6.100. For sustainable agriculture integration of different activities like agriculture, horticulture, animal husbandry, sericulture, poultry is essential. This helps not only in labor saving but also in effective recycling of resources and by products from various activities besides risk minimization.

**Climate smart Sericulture:**

6.101. The Globe is witnessing fast change in the climate. Global warming has been recorded and is a matter of concern. Climate change poses a threat to the farming community and sericulture is no exception. Even cropping pattern may have to be redrawn to address the climate change. There is every possibility of new pests causing damage and old pests behaving differently and new diseases making an outbreak. Hence, environmental friendly technologies need to be developed. It is necessary to address the climate change. New rearing houses are to be designed to address the climate change particularly with respect to temperature and humidity maintenance in the rearing house.
Fig. 17: Drum kit technology to address water scarcity and to provide protective irrigation. Inter cropping can be taken up to get additional income

6.102. Sericulture and new emerging areas (value addition and product diversification):  
1. Mulberry is a perennial plant, which can be grown as bush or tree. All parts of mulberry plant are useful economically.  
2. Mulberry leaves are composed of many nutrients and chemicals. Anti-bacterial astringent, diaphoretic and Phytosteroldeoxynomycin chemicals are found in mulberry leaves. Phytosteroldeoxynomycin chemical controls blood pressure and diabetes in human beings. Therefore, consumption of mulberry tea controls blood pressure and diabetes in human beings.  
3. Dried mulberry stems can be used in handicrafts, sport articles and decorative items. Dried stems are also used as fuel.  
4. Mulberry fruits are rich in Protein content; they are used to prepare delicious dishes like jam, jelly, juices, halva and pickles.
5. Vitamin-E, Amino acids are collected from pupae and utilized in preparation of medicines. Pupae are rich in protein; it is used as fish meal and feed in poultry. In addition, oil extracted from pupae is used in preparation of soaps and detergents.

6. Mulberry leaf and silkworm litter wastage obtained during silkworm rearing is used to prepare manure and biogas.

7. Pierced cocoons obtained during egg production process in grainages are useful in preparation of handicrafts like cocoon garlands, bouquet, greeting cards, dolls etc.

8. In the silk reeling process, the by-products generated viz., silk waste, pellade waste with pupae, can be effectively utilized to enhance earnings. The large amount of silkworm wastes from cocoon reeling activity and the crude methods of their disposal have been rather a deterring factor due to the foul smell and other pollution problems. Promotion of the silkworm pupae handling packages and silk waste processing units will help in effective utilization of the by-products with higher returns on one hand and addressing the pollution issues on the other hand.

6.103. The non-traditional areas are: It is imperative that adequate thrust on non-traditional uses of silk could create a positive pressure in the sector to concentrate on high quality raw material for high value addition leading to a quantum leap forward.

1. Medical application
   - Artificial skin
   - Artificial blood vessels
   - Artificial bone
   - Suture threads

2. Cosmetics such as facial masks, dermal lotions, powders, etc.

3. Liquid silk
   - Interior home decor and handicrafts, wall papers
   - Lampshades

Fig. 18: Women trained in preparation of various value-added products from cocoon and silk.
Way forward

6.104. In a nutshell, the following issues are worthy of consideration for sustainable sericulture with minimum impact on the environment:

- Drought and water stress management (per drop more crop)
- Mulberry tree cultivation
- Integrated nutrient management
- Integrated Farm Management
- Carbon sequestration
- Organic farming
- Bio control agents/bio pesticides
- Robust silkworm races for sustaining environment vagaries
- Silkworm disease control through eco friendly approaches
- Mechanization in sericulture
- Use of by-products
- Scientific processing of cocoons for producing uniform and quality silk
- Use of solar energy

Fig. 19: Steps to mitigate effects of environment change in Sericulture
6.105. The livestock sector provides self employment and livelihood opportunities to a large number of families, especially in the rural sector. During 2015-16, this sector contributed to 4.41% of Karnataka state’s GDP and 21.83% of income in agriculture and allied sector. There is a shift in the demand for protein products especially of animal origin. The growth rate in number of animals is low but there is considerable growth in the productivity of the livestock.

Table-16: Average Milk and Meat yield per animal in Karnataka

<table>
<thead>
<tr>
<th>year</th>
<th>Average daily Milk yield per animal (in kg)</th>
<th>Average Meat yield per animal (in kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crossbred cow</td>
<td>Indigenous cow</td>
</tr>
<tr>
<td>1985-86</td>
<td>5.172</td>
<td>1.722</td>
</tr>
<tr>
<td>1995-96</td>
<td>5.555</td>
<td>1.710</td>
</tr>
</tbody>
</table>

6.106. Among the Indian states, Karnataka stands 2nd in milk production, 11th in meat production and 7th in egg production. Production of milk, meat and egg has increased year after year. Annual milk production increased from 5.11 million tons in 2010-11 to 6.34 million tons in 2015-16. Annual egg production increased from 30674 lakhs to 47661 lakhs and meat production from 123910 tons to 196597 tons during the same period. Per capita availability of milk increased from 237 grams in 2010-11 to 282 grams in 2015-16.

6.107. Since decades, the state has been facing severe shortage of fodder, more so during drought and summer. Climate is a prime determinant of quality of fodder and forages. Temperature has greater influence on forage quality. Each degree of increase in temperature may decrease digestibility by 0.3 to 0.7%. In spite of excellent genetic potential in the livestock for production, availability of fodder both in quantity and quality has become a hurdle in eliciting the expected production. Improved health care facilities are available. But, non-availability of enough fodder of good quality has reduced average production per animal.

6.108. In the recent past frequent drought spells have not only reduced the availability of biomass for livestock but have also drastically affected the productive and reproductive performance of dairy animals, particularly crossbred cattle. Comparatively, indigenous breeds are well adapted to heat stress in tropical country like India. These animals are thermotolerant, disease resistant and handle roughages very efficiently; besides, as these animals are historically maintained on low nitrogen diets, they are efficient in nitrogen recycling. Further, small sized breeds are more efficient in heat dissipation compared to large sized animals due to more body surface area per unit mass. Development of indigenous cattle by selective breeding for better milk yield will not only lead to efficient handling of heat stress period but also relieve pressure on feed resources since they require less feed for their maintenance.

Changing livestock population scenario

Declining indigenous cattle population

6.109. The livestock population has undergone compositional changes as evident from the quinquennial livestock census figures. As per the 2012, 19th All India Livestock Census,
Karnataka has 95.16 lakh cattle, 34.70 lakh buffaloes, 95.83 lakh sheep and 47.96 lakh goats. Between 2007 and 2012, the cattle population decreased by 13.62% and buffalo population declined by 19.79%. It was noted that indigenous cattle population declined from 83.09 lakh to 66.03 lakh (20.52%) and crossbred cattle population increased from 21.93 lakh to 29.12 lakh. The number of crossbred milch cows increased to 17.32 lakh from 12.59 lakh whereas number of indigenous milch cows decreased to 22.00 lakh from 26.56 lakh. Goat population decreased by 22.05% and sheep population showed a marginal increase of 0.26%.

**Table-17: Livestock Population**

<table>
<thead>
<tr>
<th>Species</th>
<th>2007 Census</th>
<th>2012 Census</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>110.17</td>
<td>95.16</td>
<td>-13.62</td>
</tr>
<tr>
<td>Buffaloes</td>
<td>43.27</td>
<td>34.70</td>
<td>-19.79</td>
</tr>
<tr>
<td>Sheep</td>
<td>95.58</td>
<td>95.84</td>
<td>0.26</td>
</tr>
<tr>
<td>Goats</td>
<td>61.53</td>
<td>47.96</td>
<td>-22.05</td>
</tr>
<tr>
<td>Pigs</td>
<td>2.81</td>
<td>3.05</td>
<td>38.16</td>
</tr>
<tr>
<td>Poultry</td>
<td>418.58</td>
<td>531.22</td>
<td>26.91</td>
</tr>
</tbody>
</table>

Fig. 20: Distribution of Major Livestock (2012 Census)

Fig 21: Indigenous Cattle Population (Breed Survey 2013)
Krishna Valley breed is in the verge of extinction

6.110. **Causes for decline of indigenous cattle population**

- Post independence, the major thrust was on increasing the milk production for which crossbreeding was inevitable for rapid growth in production. Development of indigenous cattle breeds for improved production was not taken up simultaneously.
- Farmers preferred crossbred cows to indigenous cattle due to economical and profitable returns.
- Mechanization of agricultural operations reduced demand for draught power.
- Implementation of State Bovine Breeding policy was not monitored strictly. No concrete plans were in place for conservation of indigenous breeds. The genetic base irrevocably eroded besides threatening the existence of the local breeds.

**Remedial measures**

- Genetic diversity needs to be maintained for adapting to unpredictable challenges that may arise in future from climate change to emerging diseases. The advantages of selective breeding of indigenous cattle besides improvement in milk production reduces incidence of mastitis and reproductive problems since they are easy to manage and require less feed. These animals possess disease resistance and improved nitrogen efficiency compared to crossbred cattle. The existing state cattle breeding policy may be reviewed.
- The genetic closeness of non-descript cattle with descript breeds needs to be assessed and the variants may be bred by selection for further improvement of specified traits.
- The unproductive cattle whether crossbreds or indigenous, because of their large number, contribute to stress on the environment. Whether genetic imbalances contribute to environmental resilience or degradation needs to be ascertained.

**Table-18: Female and Milch animal population**

<table>
<thead>
<tr>
<th>Total Female population as per 2012 Livestock Census</th>
<th>Number of Milch animals (in lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous cattle</td>
<td>Crossbred cattle</td>
</tr>
<tr>
<td>38.32</td>
<td>27.07</td>
</tr>
</tbody>
</table>

- In situ conservation of indigenous cattle by farmers based on the data on prevailing genetic diversity.
- Selective breeding for increasing productivity of indigenous cattle will be economical for farmers as low input producers. Incentivize farmers for rearing indigenous cattle.
- Field performance recording for selection of elite females as bull mothers and progeny testing could be a long term strategy.
- Establishment of indigenous germplasm center in southern region of the country.

**Fodder resources and management**

**Present status**

6.111. The livestock production is dependent on the fodder resources. The health care and marketing of livestock products can be efficiently managed if there are adequate fodder resources. The feeding strategy should not only look into fulfilling the nutritional
requirements for maintenance and production but also at reducing the cost of production per unit. Efficient utilization of feed and fodder resources would directly contribute to increase in profitability, in terms of body growth rates and improved fertility.

6.112. Livestock in the state are reared in a traditional system by feeding crop residues and agricultural byproducts leading to low production. Very often nutritional deficiencies have led to infertility and uneconomical livestock farming. Although there has been considerable increase in milk production, the productivity per animal is still less because the genetic potential has not been fully utilized. The daily average milk yield of a crossbred cow is as high as 10.95 kg in Punjab, 9.02 kg in Kerala and 7.39 kg in Andhra Pradesh. In Karnataka, the average daily yield (6.09 kg) has not shown much improvement during the last five years. Non-availability of fodder as per demand has constrained the productivity growth and needs to be addressed through assessment of fodder resources in the state.

6.113. Occurrence of droughts in Karnataka is a common phenomenon due to spatial and temporal variations in rainfall which range from 4747 mm in the coastal region to as low as 477 mm in south interior Karnataka. There are variations within the same region also. As a result, different regions are prone to disasters like floods and droughts simultaneously in the state. The state is often affected by drought which covers almost the entire rain-fed agricultural area. Nearly 80 per cent of the taluks in the state are drought prone. Management of fodder during droughts is a herculean task.

**Green Fodder**

6.114. There is a significant increase in the availability of green fodder over the years because the total cropped area has increased. Area under fodder cultivation at national level is around 4% of the total cropped area and it almost remains static. Usage of multi-cut varieties of fodder is mostly limited to irrigated areas. Availability of seasonal grass from forest is less than 2%. The common property resources have been shrinking due to other priorities. Very little information is available about the nutritional value of tree leaves. With the limited land under fodder cultivation, there is a need to focus on improving productivity of fodder crops and common grazing lands.

**Dry Fodder**

6.115. Crop residues are the major dry fodder resources. Considerable quantities of dry fodder are wasted due to feeding of un-chaffed stover or straws. Animals also lose energy in chewing for a long time. Processing of crop residues for storage over longer periods needs to be explored. Post harvest losses need to be reduced to minimum.

6.116. The livestock require dry fodder, green fodder and concentrates for better production. There exists a wide gap in the demand and availability of the fodder and feed resources. The gap needs to be assessed and suitable plans have to be drawn to achieve self sufficiency in their availability. A policy is required to ensure fodder security, better utilization of crop residues and agri-byproducts.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Demand m.t./annum</th>
<th>Availability m.t./annum</th>
<th>Deficit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Green fodder</td>
<td>122.00</td>
<td>85.00</td>
<td>30.00</td>
</tr>
<tr>
<td>2</td>
<td>Dry fodder</td>
<td>25.40</td>
<td>15.00</td>
<td>40.90</td>
</tr>
<tr>
<td>3</td>
<td>Concentrates</td>
<td>29.50</td>
<td>7.50</td>
<td>74.50</td>
</tr>
</tbody>
</table>
Table-20: Availability of crop residues in Karnataka

<table>
<thead>
<tr>
<th>Crop</th>
<th>Crop residues (in lakh tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ragi</td>
<td>20.74</td>
</tr>
<tr>
<td>Maize</td>
<td>78.28</td>
</tr>
<tr>
<td>Paddy</td>
<td>44.40</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>3.60</td>
</tr>
<tr>
<td>Horse gram</td>
<td>3.50</td>
</tr>
<tr>
<td>Fieldbean</td>
<td>0.45</td>
</tr>
<tr>
<td>Mulberry</td>
<td>1.60</td>
</tr>
</tbody>
</table>

*Source: Shekara et al. Fodder Scenario In Karnataka, AICRP on Forage Crops and Utilization, V.C.Farm, Mandya, National Group Meet (Rabi, 2017-18), pp.1-6.*

Causes

117. In the light of severe shortage of fodder on one hand and failure to utilize the available resources on the other, fodder management is a serious challenge. The following causes are attributed to the shortage of fodder:

- **Limited land holdings:** As a majority of dairy farmers are marginal and own small holdings for cultivation, their priority for cultivation is to produce food grains. Organized fodder cultivation on commercial lines is presently non-existent. It is estimated that only 4.4% of the total cropped area is devoted to fodder production in the state.

- **Reduction of grazing lands:** Gradual transformation of agricultural lands due to urbanization is the prime reason for reduction of grazing lands. As a result, many organized dairy farmers are forced to move towards zero grazing system of feeding, while the small and marginal dairy farmers are left with no option but to get rid of animals.

- **Lack of preservation practices:** Shortage of fodder is ordinarily observed during every summer and becomes more acute under drought conditions. Except preservation of crop residues in the form of stalks at farmer level, other preservation practices such as silage bales, fodder blocks, etc. are totally absent among farmers mainly due to lack of awareness about preservation techniques.

- **Logistics involved in fodder transportation:** Due to wide gap between fodder availability and requirement within each district, transportation of fodder from one district to another is a major challenge because of the cost factor involved.

- **Continuous drought period:** The success of the efforts at reducing the prevailing deficit of fodder has been negated by the continuous droughts during the last 16 years. Temporary cattle camps and fodder banks are established at suitable places in drought affected areas to provide fodder and water to the livestock.
Strategies

6.118. The strategies for management of fodder are as follows:

- Augment forage production under prevalent cropping system with suitable production systems like cultivating perennial grasses in irrigated ecosystem, short duration forage crops under limited water availability, hydrophonic fodder, utilize marshy areas, waste lands, tank beds, horticulture groves, farm bunds, problematic soils, forest fringe areas and agro-forestry systems.
- Promote fodder seed production and planting material for perennial grasses.
- Employ latest post harvest technologies for optimal utilization of crop residues. Silage made out of Maize corn when packed and preserved in bales can be supplied to needy areas throughout the year to boost production.
- Avoid burning of paddy straw stubbles after machine harvesting. Collect such fodder and process through baling and preserve.
- Promote protein rich fodders such as alfalfa or lucerne during winter season and store in dry form as blocks as a solution to reduce concentrate feed in the ration.
- Ration Balancing Program (RBP) offers excellent solution for formulation of balanced ration to the livestock based on the locally available resources with less cost.
- Encourage Total Mixed Ration (TMR), the practice of mixing green fodder or silage with dry fodder and concentrates along with all other nutrients that increase digestibility and utilization of nutrients at optimum level.
• Establish fodder storage facilities at strategic points in drought prone areas.
• NGOs/co-operative societies including private players interested in pasture development in addition to the local bodies to promote rejuvenation of CPR. Ensure convergence of various stakeholders and funding sources like NLM, MGNREGS, IWMP, AFDP, etc.

**Conservation and Management of indigenous cattle and sheep**

**Climate Change and livestock**

6.119. Anticipated rise in temperature together with increased precipitation resulting from climate change is likely to aggravate the heat stress in dairy animals. This would adversely affect their productive and reproductive performances. Given the vulnerability of India to the effects of climate change, the impact of increased intensity of extreme events on the livestock sector would be large and devastating for the low income rural areas. The livestock sector which will be a sufferer of climate change is itself a large source of methane emissions, an important greenhouse gas. In India, although the emission rate per animal is much lower than in the developed countries, due to vast livestock population the total annual methane emissions from enteric fermentation and manure management are 10.65 Tg and 1.09 Tg respectively. The contributions of crossbred cattle, indigenous cattle, buffaloes, goats and sheep to methane emission are 4.63%, 48.49%, 38.96%, 4.71% and 1.79% respectively.

6.120. The animals employ physiological mechanisms to counter the heat stress. The adaptation to higher temperature is also complemented by the behavioral changes such as wallowing by buffaloes in summer to maintain thermal equilibrium. However, to counter the adverse effects of climate change on the animal production and health, human intervention for physical modification of the environment and improvement in nutritional management practices would be required.

**Methane emission by indigenous cattle**

6.121. Methane emission by indigenous cattle is more (48.49%) because of their large numbers. Indigenous dairy cows emit more methane compared to non-dairy cows due to less attention being paid on their feeding since they produce less milk. Increasing the digestibility of available biomass would increase milk production besides reducing methane emission.

**Strategies**

6.122. In the context of climate change, it is generally accepted that our indigenous cattle and sheep have an inbuilt tolerance to higher temperature and are resistant or less susceptible to infectious diseases. Hence, conservation and genetic improvement by selective breeding of indigenous cattle and sheep breeds of our state is the need of the hour. Therefore, a project titled "Conservation and Management of indigenous Cattle and Sheep in the wake of Climate Change” was proposed under the National Adaptation Fund for Climate Change (NAFCC).

6.123. Dietary modifications are a better strategy for large farms compared to situations where a farmer has one or two cows. Improvement in the quality of fodder, dietary supplementation of enzymes, adding oil to diet, supplementation of molasses, urea products and plant secondary products such as tannins as rumen modifiers are the suggested remedial measures.
Dietary supplementation of enzymes that improve fiber degradation lowers the acetate to propionate ratio in rumen fluid thus decreasing methane production.

Adding whole cotton seeds to the diet results in reduced methane production besides providing extra energy and enhanced milk production.

Lipid supplements rich in medium chain fatty acids such as coconut, palm oils or purified myristic acid are effective in depressing methane emission.

Molasses urea feeding is known to reduce methane emission by 11% and increase milk production by 10%.

6.124. Selective breeding for increasing productivity, conservation by rearing elite animals only in Government farms, genetic selection for low methane emission are the alternate means of reducing the impacts of climate change.

**Meat hygiene and public health**

**Present status**

6.125. Annually, Karnataka produces 27,928 tonnes of beef, 14,938 tonnes of buffaloe meat, 48,059 tonnes of mutton, 22,124 tonnes of pork and 83,546 tonnes of poultry meat (2015-16). The meat industry is among the neglected sectors. There are 95 registered slaughter houses and majority of them are meat vending outlets where a small number of animals are slaughtered daily. Meat inspection and certification are lacking. Modern slaughter houses do not exist. A system of taking animals to market and eventual slaughtering is also in practice. The waste generated is not being handled scientifically. Untreated slaughter wastes are being deposited in landfills leading to severe environmental damages.

**Table-21: No. of animals slaughtered (2015-16)**

<table>
<thead>
<tr>
<th></th>
<th>Cattle</th>
<th>Buffaloes</th>
<th>Sheep</th>
<th>Goat</th>
<th>Pig</th>
<th>Poultry</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>282948</td>
<td>140007</td>
<td>1831999</td>
<td>1257000</td>
<td>459008</td>
<td>57902053</td>
<td>61883015</td>
</tr>
</tbody>
</table>

**Fig. 23**: Species-wise Meat Production 2015-16 (in tonnes)

**Causes**

- Lack of modern slaughter houses in urban as well as rural areas.
• The meat industry is not organized. Hence, scope for better utilization of the products not explored.
• Lack of awareness among the consumers especially among the rural folk about food borne diseases.

Options

• Bio security practices minimize the risk of exposure to zoonotic disease at various levels from farm to vending outlets. High standards of animal welfare assist in delivering husbandry and hygiene practices that align with good bio security.
• A commitment from the farm or industry to manage risk related animal welfare to consumers and trading partners is required.
• Animals should be free from stress for which overcrowding should be avoided. Cleanliness, availability of feed and water should be ensured.
• Modern slaughter houses should be established depending on the daily market requirement. Centralized slaughtering and processing facilities to be created.
• Animal slaughter should be banned in unauthorized places.
• Meat vending outlets should be modernized.
• Provision should be made for infrastructure for scientific handling of slaughter wastes.
• There should be strict ante- mortem and post slaughter meat inspection procedures

Action points

6.126. Animal health and related issues have been dealt in the Chapter 8 on Health. For the overall development of the livestock sector, the following action points are suggested:

Breed Improvement

• Breeding of indigenous cattle should be viewed from farmers' commercial and conservation perspectives.
• Selective breeding to improve milk production in indigenous cattle should be encouraged. The state Livestock farms should serve as source of elite germplasm, as farmers can not depend on low productive cattle.
• Up-gradation of non-descript cattle and buffaloes should be done by using indigenous descript breeds.
• Tracking of genetic material and regulation of its usage in accordance with the prevailing breeding policy, e-marketing of live animals and frozen semen doses should be ensured.

Fodder Management

• Formulate and enforce state fodder policy to attain self sufficiency in fodder production;
• Fodder seeds production in Livestock farms;
• Improved fodder processing technology, establishment of silage making units in PPP model.

Meat Hygiene

• Mandatory registration of slaughter houses and meat vendor outlets and enforcement of hygiene protocol;
• Establishment of rural abattoirs;
Efficient and scientific slaughter waste management. Establishment of rendering units.

**HORTICULTURE**

**Introduction**

6.127. Meeting demand for food is going to be an uphill task in the future due to the combined effects of climate change, declining agricultural biodiversity and degradation of natural resources such as land, water and soil. Competition for scarce land, water and energy resources will intensify to meet the demands of a growing population. Hence, there is need to increase production as well as productivity with less water, land and other resources. Another important consideration is the large-scale malnutrition and wide spread mineral deficiency especially among children and women. This is primarily because of narrow food basket with few crop products and stereo type food being consumed daily. The only way to mitigate the situation is to widen the food basket and diet diversity with fruits and vegetables which provide much needed minerals, vitamins and dietary fiber to the body.

6.128. Horticulture is gaining importance because of higher production and productivity, better income to the producer and for providing the much-needed balanced diet. Horticulture comprises of five groups of crops, namely, vegetables, fruits, spices and plantation crops, medicinal and aromatic crops and flowers. At the national level, income from horticulture is one fifth of the combined income from agriculture. Horticultural crops play a vital role in combating malnutrition and in generating more employment opportunities in rural areas.

6.129. Karnataka is recognized as an important horticulture state owing to its excellent soil and climatic conditions and multifaceted expertise in the sector. The state is endowed with diverse agro-climatic conditions which are fully exploited by the enthusiastic farmers to grow a variety of crops such as fruits, vegetables, flowers, spices and plantation crops.

**Area and production trends of horticultural crops**

6.130. Karnataka occupies a prominent place in horticulture map of the country. During 2014-15, horticulture crops occupied an area of 20.05 lakh hectares with a production of 169.40 lakh metric tones (Table-22). Although the area under horticulture is only 16 per cent of the state’s net cultivated area, total income generated from horticulture sector accounts for over 40 per cent of the total income derived from the agriculture sector (NABARD, 2015). The average productivity of horticultural crops in the state is 8.45 MT/ha. Between 2010-11 and 2014-15, total area under horticultural crops in the state has gone up by 1.05 lakh hectares and production of 17.3 lakh MT indicating growth of 5.01% and 11.38% respectively. Karnataka occupies 4th position in production of fruit crops and 1st position in commercial flower production. The total horticultural production of 169.40 MT recorded during 2014-15 comprised of fruits (69.4 lakh MT), vegetables (88.7 lakh MT), plantation crops (4.07 lakh MT), spices (3.45 lakh MT), flower crops (2.29 lakh MT) and medicinal and aromatic crops (0.215 lakh MT).

**Table-22: Area and Production of horticultural crops in Karnataka**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Fruits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plantation crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicinal and aromatic crops</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Horticulture and environmental concerns

Horticultural diversity

6.131. Among the natural resources, plant diversity is the key to human existence and survival. Horticultural crops contribute to nutritional and livelihood security. Temperate, tropical and subtropical horticultural crops are characterized by their adaptation to varying ecological conditions and land use patterns. Karnataka state consists of three geographical regions, namely, coastal zone, the Western Ghats and eastern plains. These regions with varied soil and climatic conditions exhibit a wide range of horticulture biodiversity and are suitable for growing different types of horticultural crops. Due to introduction of high yielding varieties and improved production technologies, the productivity of horticultural crops has improved tremendously. However, it has happened at the expense of the local biodiversity. The loss of horticulture biodiversity is a matter of serious environmental concern. It is feared that if the current trend continues, as many as half of all plant species, mostly land races and wild relatives could face extinction. The reasons for decline of horticulture biodiversity include rapid industrialization, green revolution, globalization of the food system and marketing, replacement of local varieties by improved/exotic varieties/species and more importantly, habitat destruction due to large-scale anthropogenic activities. Traditional varieties and land races are important reservoirs of valuable traits for crop improvement programs and need special attention. The ecological effects of loss of biodiversity are reduced ecosystem services and the inter-specific and intra-specific genetic erosion and resultant reduction of production and productivity. Biodiversity crisis will put human nutrition, health and livelihoods at risk.

Droughts and floods

6.132. Karnataka has been facing natural aberrations such as drought and floods almost regularly. During the last 3-4 years, while most of the northern districts have been affected by moderate to severe floods, the southern districts are reeling under severe drought. During 2014-15, 157 taluks out of 177 taluks were declared as drought affected. Karnataka stands second to Rajasthan in terms of rain-fed and drought affected areas. Due to successive droughts, ground water levels have depleted and quality of water has deteriorated in terms of fluoride, nitrate and salinity. Drought also results in loss of vegetation and inadequate supply of water to surface water bodies. Floods cause soil degradation besides loss of vegetation, animal and human lives. Another important impact of both drought and floods is severe crop loss resulting in shortage in food supply and fall in farmers’ income.

Soil degradation
6.133. Soil degradation is a major problem facing the state. The main cause of soil degradation is soil erosion caused by water and wind. Excessive irrigation and faulty water regimes cause land degradation. Soil erosion causes depletion of soil organic matter and micro-organism count, removal of surface soil, salinity and alkalinity. Indiscriminate use of chemicals and fertilizers leads to contamination of soil and water, thereby affecting the environment. Eco-friendly alternatives such as use of bio-fertilizers, integrated nutrient management, regular crop rotation and use of bulk organic manure including green manure can contain the ongoing land degradation and usher in all round development.

**Introduction of Invasive species**

6.134. Due to diversification of horticulture and area expansion, new crops and varieties are being introduced in the state by public and private sector organizations and also by individuals. As a result of commercialization, survival of traditional and indigenous varieties has been threatened. Appropriate conservation practices need to be formulated to protect the traditional varieties, cultivars and land races of all crops, specifically perennial horticultural crops. While introducing new species, there is always a threat of entry of invasive species. The best examples are Lantana, Parthenium, Eupatorium and Ichornia which have caused enough damage. Hence, sufficient caution is required to prevent accidental entry of invasive species.

**Chemicals and Fertilizers**

6.135. Though the modern cultivation practices have helped in increasing productivity, these have become input intensive with increasing dependence on external resources such as higher doses of chemical fertilizers (both micro and macro nutrients), repeated application of crop protection chemicals, use of chemicals for ripening and enhancing self-life. These practices have not only increased the cost of production but have also incorporated chemical contamination in daily diet. The major aspects of high chemical input cultivation practices are as follows:

6.136. Plant requires major, secondary and micronutrients for its growth and productivity. Use of fertilizers in horticultural crops requires a scientific approach and application should be based on scientific testing of soil. However, use of fertilizers in our country is hardly scientific and done without appropriate soil test results. Suitable use of fertilizers based upon soil and leaf nutrient status would have certainly helped Indian horticulture to harvest bumper crops without negative effects. Indiscriminate use of fertilizers especially nitrogen fertilizers has led to multiple problems affecting soil health and overall environment. These have resulted in human and animal health disorders, pollution of water resources and greenhouse gas emissions. Among the various inputs, fertilizers alone account for 20-30 percent of total production cost. Horticultural crops are heavy feeders of plant nutrients and may absorb 500-1000 Kg N+P₂O₅+K₂O/ha/year or even more under good management conditions. Nutrient uptake by many fruits and vegetable crops is equal to or higher than that of cereal crops (Table-23). Application of fertilizers is needed for replenishment of lost nutrients from the soil so as to ensure sustained production. Fertilization schedule of horticultural crops has got serious drawbacks and results in nutritional disorders and environmental pollution. In view of the growing importance of horticultural crops for local and export markets, scientific management of fertilizer application is of utmost importance for ensuring quality and productivity without at the same time compromising on environmental safety.

**Table-23: Nutrient removal by some fruits and vegetable crops (Kg/ha)**
<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield(t/ha)</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>25</td>
<td>100</td>
<td>45</td>
<td>180</td>
</tr>
<tr>
<td>Banana</td>
<td>40</td>
<td>250</td>
<td>60</td>
<td>1000</td>
</tr>
<tr>
<td>Citrus</td>
<td>30</td>
<td>100</td>
<td>60</td>
<td>350</td>
</tr>
<tr>
<td>Grapes</td>
<td>20</td>
<td>170</td>
<td>60</td>
<td>220</td>
</tr>
<tr>
<td>Mango</td>
<td>15</td>
<td>100</td>
<td>25</td>
<td>110</td>
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<tr>
<td>Papaya</td>
<td>50</td>
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<td>25</td>
<td>130</td>
</tr>
<tr>
<td>Pineapple</td>
<td>50</td>
<td>185</td>
<td>55</td>
<td>350</td>
</tr>
<tr>
<td>Cabbage</td>
<td>70</td>
<td>370</td>
<td>85</td>
<td>480</td>
</tr>
<tr>
<td>Carrot</td>
<td>30</td>
<td>125</td>
<td>55</td>
<td>200</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>50</td>
<td>250</td>
<td>100</td>
<td>350</td>
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<tr>
<td>Cucumber</td>
<td>40</td>
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<td>120</td>
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<td>Eggplant</td>
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<td>Okra</td>
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<td>90</td>
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<td>Onion &amp; Garlic</td>
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<td>160</td>
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<tr>
<td>Tomato</td>
<td>50</td>
<td>140</td>
<td>65</td>
<td>190</td>
</tr>
</tbody>
</table>

**Pesticides**

6.137. In modern cultivation practices of horticultural crops, use of pesticides has become inevitable as around 30-35 percent horticulture produce is lost due to various biotic stresses such as pests and diseases. However, excess and wrong use of pesticides is very harmful to the environment and severely affects human and animal life. The use of chemicals in pest control has a poor reputation due to residual toxicity and deleterious environmental effects. India’s average pesticide consumption is 600 g/ha which is far below compared to other Asian countries. Among various chemicals used for pest control, insecticides account for 65% followed by fungicides (15%), Herbicides (16%) and others (4%). Persistent and non-judicious use of pesticides results in pesticide residues in food products which are hazardous to humans and animals. Indiscriminate use of pesticides also brings new problems such as reduction in pollinator population and contamination of air and water. In horticultural crops, good agricultural practices (GAP) are advocated to reduce pollution and residues. Pesticides are an important and reliable tool in the integrated pest management (IPM) system to contain pest problem. In IPM system pesticides are used sensibly and judiciously to save horticultural crops and increase production by applying correct chemical formulations in appropriate doses keeping environmental safety in view. Under this system, several bio-pesticides and botanicals have been tested and recommended for management of different pests. However, there is a need for creation of sufficient awareness for popularizing these safe bio-pesticides.

**Impact of Climate Change on horticultural crops**

**Impact on production and productivity**

6.138. Global warming induced climatic aberrations will have unpredictable effects on crops including horticulture crops. One of the most profound physiological responses of climate change is the shortened growing period causing distinctive reduction in production of fruits and vegetables. Production of horticultural plants particularly grown under open field conditions will be severely affected because of climate change. Due to high temperature, physiological disorders of crops will be more pronounced. Effects of global warming such as increase in temperature, heat stress, prolonged drought and winter, deprived soil water availability, untimely precipitation, cyclonic effects, etc. will alter the phenological and floral biological cycle of crop plants especially perennial crops. Under uncertain climatic conditions, flowering and fruiting of food crops get altered and farmers will not be able to
either attend to required cultural practices in time or take precautionary/corrective measures to save the crop. Another important and significant change noticed is epidemic outbreak of pest and diseases which affect both quality and quantity of the produce. Unprecedented heavy rainfall makes the pre-mature fruit crops fall off and the long dry spell during flowering season affects fertilization. Further, heavy wind and hail storm destroy the standing crops.

6.139. The most effective way to face climate change is to adopt conservation agriculture, use renewable energy, soil and water conservation, forest conservation and reforestation. Modification of present horticultural practices and greater use of greenhouse technology are needed to minimize the effects of climate change and to sustain production. Strategies to meet the challenge of climate change will include development of new cultivars of horticultural crops tolerant to high temperature, resistant to pests and diseases, short duration varieties and producing higher yields under stress conditions, adoption of high-tech horticulture, judicious use and management of natural resources. Crop based adoption strategies are needed keeping in view the nature of crop, its sensitivity level and agro ecological region. Horticultural crops have a major role in countering the negative consequences of climate change by providing a better carbon trade and carbon sink. Therefore, keeping an eye on carbon sink potential of different horticultural crops versus field crops will further aid in developing a blue print for combating climate change related issues.

**Pest and disease dynamics due to climate change**

6.140. Global warming and climate change will have serious consequences on diversity and abundance of pests and diseases. These biotic factors will impact both crop production and food security. Prediction of changes in geographical distribution and population dynamics of pests and diseases will be useful for adopting appropriate pest and disease management strategies. Outbreaks of pests and diseases will be more frequent, particularly during the extended periods of drought followed by heavy rainfall. Some of the components of pest and disease management such as host plant resistance, bio-pesticides, natural enemies and synthetic chemicals will be rendered less effective as a result of increase in temperature, UV radiation and decrease in relative humidity. Climate change will also alter the interactions between pests/diseases and their host plants. As a result, some of the cultivars and varieties that are resistant to pests and diseases may exhibit susceptible reaction under global warming. Adverse effects of climate change on the activity and effectiveness of natural enemies will be a major concern in future programs of pests and disease management. Rate of multiplication of pest and diseases might increase with an increase in CO₂ and temperature.

6.141. Under the National Initiative on Climate Resilient Agriculture (NICRA) project in mango it was reported that, until recently the major pests of mango were hoppers, fruit fly and stone weevil. However, due to extensive mono-cropping, intensive use of agro-chemicals and evident climate change, the pest problem has intensified and considerable shift in pest status of mango ecosystem has been noticed. Several minor or secondary pests became major and new pest problems which were previously rare or unknown are appearing in serious proportions in several mango growing regions leading to severe crop losses. The most commonly reported insect pests that have assumed serious proportions are scales, mealy bugs, thrips, mites, leaf miner, stem borer, fruit borer and leaf webber.

6.142. Thus, a definite change in host utilization pattern and also population dynamics of pests and diseases is quite evident. Therefore, there is need to have a concerted look at likely effects of climate change on crop protection and devise appropriate measures to mitigate the effects of climate change on food security.
Options and prospects

Organic Farming

6.143. Organic farming is being promoted due to increasing demand for safe food and as an approach towards sustainable agriculture. During recent years, organic farming and agri-business options have spread rapidly across the country including Karnataka. During the next 5-10 years, the state is likely to convert about 10 percent of its agriculture including horticulture into certified organic farming. India is among the few countries which have adopted organic standards and put in place an inspection and certification mechanism. The inherent characteristic of organic farming is that it encompasses the whole farming system. If the farmer is an organic fruit producer, other food crops, livestock husbandry, etc, will also be organic. Because of strong inter-linkages of these sectors within the farming activities, problems such as soil health, residue free products and pollution will get addressed comprehensively. Karnataka has formulated the organic farming policy in 2017. The state now produces a range of organic products and is also exporting to different countries. Organic foods are visible and becoming popular in big cities and small towns. In spite of a good organic production base, domestic market for organic products has not yet picked up because of low awareness, lack of access and weak supply chain system.

Integrated Nutrient Management (INM)

6.144. Integrated nutrient management refers to maintenance of soil health, fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of all possible sources of plant nutrients in an integrated manner. Nutrients are essential for productivity and quality of different horticultural crops. Inorganic fertilizers constitute one of the most expensive inputs in horticulture. However, their excessive and indiscriminate use has resulted in several environmental problems. Hence, to ensure high economic productivity and to sustain the available soil nutrient status at a desirable level, correct dose of manures, fertilizers and bio fertilizers must be applied based on reliable diagnostic tools. Considering energy, economy, environment, etc, it is imperative that manures, bio-fertilizers and chemical fertilizers should be used efficiently and effectively. Good soil and leaf nutrient status will go a long way in formulating efficient INM packages for different horticultural crops. Among the organic inputs, bio-fertilizers and different sources of organic manures and microbial inoculants form a key component in INM. These sources of organic carbon improve soil fertility and crop productivity. Harnessing earthworms as versatile natural bioreactors both through in vitro and ex situ vermi-composting is another important component. Intercropping of green manures and application of green leaf manures is an easier and cheaper method of incorporating bulk organic matter to increase the organic carbon level of the soil.

Integrated Pest and Disease Management (IPDM)

6.145. Integrated pest and disease management aims at judicious use of cultural, biological, chemical, host plant resistance/tolerance, physical-mechanical control and regulatory control methods. It also employs bio-pesticides, antagonists, etc. Different safe chemicals and bio-agents are employed in IPM and IDM to minimize the risk of pesticide residues in fresh and processed produce. IPM and IDM strategies include a number of components such as use of safe pesticides, proper field sanitation practices, practicing deep tillage and optimum fertility management operations, adopting beneficial agronomic manipulations like crop rotation, altering planting dates and crop duration, trap-cropping, conservation and utilization of natural enemies and destruction of alternate hosts. Due to the continued research by different
institutions, different IPM and IDM packages are available. Some of these packages have proven beneficial to the growers. The government has recognized the usefulness of biological approach in IPM and IDM programs and encouraged development of laboratories for mass production of biological agents through grants-in-aid. It is advisable to use biological suppression alone to produce pesticide residue free fruits, vegetables, spices, medicinal crops and other agricultural crops. Research should be strengthened on IPM and IDM for the development of cost effective and commercially viable mass production technologies of various candidate bio-control agents/bio-pesticides. At present, proper monitoring of the quality of bio-control agents being produced and traded is lacking. There is also need to promote establishment of units for development of neem based pesticides in the rural sector.

Dry land Horticulture

6.146. Karnataka has large extents of lands under dry farming with great potential to grow high value but less water demanding horticultural crops. In fact dry lands are the hope of the future for feeding the fast-increasing population. To improve the economic conditions of the farmers in the dry tracts and their nutrition and health standards it is necessary to encourage dry land horticulture. The state has accorded very high priority to watershed management of farm areas including farm pond development. There are abundant waste and marginal lands that can be utilized for cultivation of dry land horticulture crops. Growing of fruit crops such as borehannu, seetaphal, sapota, jamun, halasu, etc. holds promise and could be an excellent way of crop diversification in dry land which will also help in mitigating the climate change effects. Dry land horticulture not only provides higher income but also provides more stable returns to farmers. However, better agronomic practices need to be developed and advocated for these horticultural crops. The technology package involves identification of appropriate crop species and varieties suitable to local soil and rainfall pattern. Important factors for consideration in dry land horticulture will also include selection of proper crops and varieties, soil fertility management, in-situ and ex-situ moisture conservation, planting material, system of planting and after care including pest and disease management.

Mechanization of Horticulture

6.147. Non-availability of both skilled and unskilled labor is a major concern in the horticulture sector. Intensive horticulture requires mechanization and automation to attend to all farm operations timely and precisely. Mechanization starts with tools and machineries for nursery production, planting, fertilizer application, inter-cultivation, training and pruning, weeding, plant protection, harvesting and post-harvest management. With stringent World Trade Organization (WTO) and Hazard Analysis and Critical Control Points (HACCP) standards coming into force, it is imperative that the production and post-harvest management systems in diverse horticultural crops are made effective, safe and precision oriented. Different machines have been developed for different horticultural operations, but lot more needs to be done in this regard compared to most of the developed countries.

Integrated farming system

6.148. Integrated farming system (IFS) integrates different enterprises namely field crops, horticultural crops (both annual and perennial), livestock, other animal component, etc. which help in optimum utilization of natural resources such as land, water, inputs, work force, etc. Following are the advantages of IFS:

- Biological resources like land, space, water, nutrients, etc. can be utilized effectively;
- Better recycling - the crop residues of one activity become input for another activity;
- Available family labor as well as hired labor can be given assured employment throughout the year;
- Insulates the income of farmers from climatic and market vagaries and uncertainties;
- Ensures additional income round the year.

6.149. As most of the perennial horticultural crops have a gestation period of 4-5 years, there is sufficient space in between plants in the initial years for planting short duration vegetables and grain legumes. This protects the soil from excessive oxidation and provides additional income to the farmers. Integration of livestock component has an added advantage of providing much needed organic matter and optimum utilization of the fodder and crop residues.

**High density planting**

6.150. High density planting is one the methods to enhance productivity both in short duration and perennial horticultural crops. It is more useful in perennial crops, as it permits efficient use of land and water resources, realizing higher and quality yields and ensures optimum economic returns per unit area. There are five important methods to achieve high density planting, namely, (a) use of dwarf varieties, (b) adopting dwarfing rootstocks and inter stocks, (c) efficient training and pruning methods, (d) use of plant growth regulators and chemicals, and (e) suitable crop management practices. There are several fruit crops where desired success has been achieved using high density planting. In plantation crops also, such dense plantings can be best adopted using multi layered cropping systems. A major concern in adoption of high density planting is that it requires high capital to establish. However, taking into consideration the need for doubling the production and productivity, it is important that such intensive systems are adopted in Karnataka to replace the traditional planting densities and methods of growing different horticultural crops. This system appears to be more suitable for small and marginal land holdings.

**Quality planting materials**

6.151. Quality planting material plays an important role in the production of horticultural crops. Inadequate availability of quality planting material is one of the deterring factors in development of a sound horticulture industry. At present, 30-40 per cent of demand for planting material is being met by the existing infrastructure. Farmers do not have access to certified and disease-free planting material, and as a result, production, productivity and quality of the produce suffer. Farmers procure most of the planting materials from unregulated and unmonitored private sector. Majority of existing nurseries lack mother plant orchard for good scion material, modern infrastructure such as green houses, mist chambers, efficient nursery tools and gadgets and implements and machineries. The only exceptions are the government nurseries. Micro propagation (Tissue Culture) is also being commercially exploited in the state for production of tissue cultured plants in banana, pomegranate, ornamentals and spices. Though large support is being extended under the National Horticulture Mission (NHM) and National Horticulture Board (NHB) schemes, there is a big gap between demand and supply that needs to be bridged at the earliest to achieve desirable level of success.

**Post harvest processing and product development**

6.152. Fruits and vegetables are rich reservoirs of important nutrients which improve food quality and help in maintaining good health. Though India is one of the largest producers of fruits and vegetables, about 30-35% of the produce is lost after harvest at various stages of
operation. The magnitude of loss is especially high during glut season. This is mainly because of inadequate storage facilities and post harvest technologies. Since fruits and vegetables are highly perishable they need special treatment to make them available throughout the year. Though sufficient efforts are being made to minimize post harvest loss, the value chain management needs several interventions. Food processing, preservation and development of value added products need large scale investments both in public and private sectors. The success stories developed at various laboratories need refinement and up-scaling. The loss of tomato, onion, mango, banana, etc. is of very high order and the market loss adds to pollution problems too. The stage from harvest to market accounts for major portion of loss which needs technical and infrastructure support such as cold storages, air-conditioned transport facilities and proper packaging.

Opportunities in Horticulture and required policy support

6.153. Horticulture is a significant and upcoming sector in Karnataka and has proved to be the best diversification option for small and marginal agricultural land holding farmers because of assured and remunerative returns. The diverse agro-climatic conditions prevailing in the state are quite congenial for growing different horticultural crops successfully and profitably almost throughout the year. The usefulness of horticulture has been specially felt in scantly rainfall and drought prone areas of the state as several perennial horticulture crops provide an effective drought proofing against the vagaries of nature and assure the farmers satisfactory returns even during the years of deficit rainfall. This is why horticulture crops are fast replacing agriculture crops in the dry tracts of the state through diversification of cropping pattern. Another important benefit that farmers can avail is related to value addition of several horticulture produce which offers very good scope for meeting the needs of different strata of consumers. With the introduction of advanced horticulture technologies there are ample opportunities for local as well as export markets. Increasing awareness regarding consumption of quality foods for nutrition and health security has considerably increased because of hike in income and purchasing power. The aesthetic needs of the people have also expanded resulting in demands for flowers and flower-products. Nursery production in the horticulture sector is also important for employment generation and getting higher remuneration. The Department of Horticulture is responsible for the overall development of horticulture in the state with a definite policy covering various mandates.

Genetically Modified (GM) crops:

6.154. Traditional plant breeding is limited to introduction of the required characters into plant by crossing during sexual reproduction. To feed the ever-increasing population, more and more food has to be produced from less and less land, water and other natural resources. It is obvious that emphasis has to be given to new technologies to improve yield and quality of crop against adverse biotic and abiotic stresses. Earlier, biotechnological interventions were mainly on the development of tissue culture protocols of commercially important crops. The gene revolution as compared to green revolution is poised to benefit farmers and has immense potential in transforming global agriculture. In India, significant efforts have been made for developing several programs in biotechnology under private and public entities. A transgenic crop or genetically modified crop is one which contains a gene or genes of a different species artificially inserted in its genome, which may come from an unrelated plant or from a completely different species. Due to limitations of conventional breeding for attaining the desirable traits, use of recombinant DNA technology has been taken advantage of in the development of transgenic crops. Biotechnology is an extension of traditional plant breeding.
6.155. In India, there is a controversy regarding the acceptance and permission for cultivation of GM crops. So far only one crop has been approved for cultivation, namely, Bt Cotton hybrids, and majority of other crops are under various stages of development, testing and approvals. Various crops under research and development are brinjal, cabbage, castor, cauliflower, corn, groundnut, okra, potato, rice, tomato and mustard. The Indian government is in no hurry to introduce genetically modified food crops in the country including GM mustard. The government stand in this regard is that GM foods will not be allowed without full scientific evaluation on its long-term effects on soil, production and biological impact on consumer.

**Precision Farming**

6.156. Precision farming, though not a new concept, is emerging as an effective way of improving yield and quality with limited land and water resources. Though it is capital intensive and costly in the beginning, if managed as per the scientific guidelines, it pays rich dividends in subsequent years. Precision farming has proved very effective in short duration vegetable and flower crops as these are seasonal and demand driven crops. Vegetable crops like tomato, beans, gourds, okra, etc. and flower crops such as gerbera, chrysanthemums, carnation, anthuriums, orchids, etc. are suitable for precision farming. Israel has become a pioneer in precision farming with minimal water and sandy soil and produces tomato sufficient to meet half of the world demand. The system requires protected structures with automated system of moisture and nutrient supply with virtually no wastage of resources. Crop protection measures are meticulously followed to minimize loss and maintain quality. Government of Karnataka has drawn a massive financial assistance programme for popularizing the system.

**Crop Insurance, Price Commission, E-market, contract farming and Farmer producers companies (FPO)**

6.157. A horticulture enterprise is always faced with the prospect of partial or total crop loss due to climatic and market uncertainties. Pests, diseases, weeds, etc. add to these risks. However, the challenge lies in providing risk management solutions for uncontrollable risks like rainfall deficit, excess and distribution, extreme temperature conditions, hailstorm, extreme wind speeds and humidity variations. In order to minimize the loss, several solutions have been indicated in the financial system. At present, weather index based insurance covers the likelihood for diminished output/yield resulting from a shortfall of any of the predefined weather parameters for a specific geographical location and time period. With the launch of the Pradhan Mantri Beema Fasal Yojana (PMBFY), farmers in Karnataka can protect themselves against extreme changes in weather parameters.

6.158. Farmers are exposed to the risk of price fluctuation in commodity prices especially in horticultural crops due to their perishable nature. In order to safeguard the interests of the farmers, commodity exchanges were established in the country for trading. Price stabilization MSP is a major concern for most of the horticultural crops. Karnataka has formulated an agriculture price commission for recommending reasonable prices for various commodities.

6.159. E-market or internet marketing refers to on-line marketing of horticultural produce which includes advertisement and marketing efforts that use the web and e-mail services to drive direct sales through e-commerce. The horticultural crops being perishable in nature require special type of marketing infrastructure. The Department of Horticulture acts as a facilitator for creation of infrastructure facilities for marketing of fruits and vegetables in the
state and the Department of Agriculture Marketing is facilitating marketing of horticultural produce.

6.160. Contract farming is an agricultural production carried out according to an agreement between a buyer and farmers which establishes conditions for the production and marketing of a farm product or products. The farmer agrees to provide agreed quantities of a specific product or land and other resources. In turn the buyer commits to purchase the product and in some cases to support production through the supply of farm inputs, land preparation and provision of technical advice. There are various contract farming business models such as multiparty model, centralized model, nucleus estate model, etc.

6.161. To insulate the farmers against uncertain and fluctuating market prices of commodities, the Government of India has brought amendment to the Companies Act and enabled farmers to register their own companies. Farmers of a given area growing and producing a specific crop can come together and register their own company and market their produce in a systematic way avoiding exploitation by middle man and safeguard their own interest.

Way forward

6.162. Of late, Horticulture is playing a major role in nutritional and livelihood security, generation of greater employment opportunities and better income especially for small and marginal farmers. Karnataka is considered as an important horticulture state owing to its excellent soil and climatic conditions. It occupies a prominent place in horticulture map of the country. It is a major producer of fruits, vegetables and flowers. It is also expanding its areas under these crops. Now climate change has become a reality and its effects are felt at different magnitudes all over the world. Due to various threats being posed by different climate change effects, the production and productivity of crops in general and horticultural crops in particular is declining and farmers are put to financial hardships. Karnataka has been confronting natural hazards such as repeated drought and floods, depletion of soil nutrients and organic matter, lowering of underground water table, acute shortage of energy, unprecedented cyclones and hailstorms, etc. Besides, continuous land fragmentation, acute labor shortage, uncertainty and wide price fluctuation in the market have discouraged the farmers. As a result, farmers are losing interest in agriculture/horticulture and are migrating to cities. Hence, there is an urgent need to mitigate the situation by developing and adopting suitable strategies to insulate the farming communities from all odds and to make farming more attractive and remunerative. The following strategies are suggested in order to achieve the above objectives:

1. Rebuilding of soil health and fertility status to make it more productive;

2. In-situ and ex-situ moisture and water conservation through various rain water harvesting methods;

3. Judicious use of chemical fertilizers through integrated nutrition management and using more of organic manures and bio-fertilizers;

4. Adaptation of integrated crop protection methods involving botanicals and bio-pesticides and fungicides;

5. Promotion of total organic farming approach supported production and supply of recommended bio ingredients and quality control system;
6. Production and supply of quality planting and seed materials in time and at reasonable cost;
7. Promoting integrated farming system for better recycling of farm residue, good income and employment to farm families;
8. Popularization of protected and precision farming systems with sufficient financial support and technical know how;
10. Large scale supporting of post-harvest management and value-added product development activities and total value chain development approach;
11. Promotion of family farming, nutrition garden and urban horticulture especially among women;
12. Encouraging formation of farmer producer’s organizations /companies (FPOs/FPCs);
13. Massive programs for skill development among rural youths especially women;
14. Creation of awareness among farming community about climate change effects and mitigation strategies.

INLAND FISHERIES

Introduction
6.163. Fish are very diverse animals. According to FishBase, 33,100 species of fish had been described by April 2015. This is more than the combined total of all other vertebrate species: mammals, amphibians, reptiles and birds. Although most fish species have been discovered and described, about 250 new ones are still discovered every year (https://en.m.wikipedia.org). There are about 2,500 species of fish in India, of which 930 belong to freshwater, 1570 species are marine (Debashish, 2005). As regards Karnataka, the checklist of the riverine fish includes 240 species (109 species from Cauvery, 59 species from Godavari, 168 species from Krishna and 124 species from West flowing river basins) distributed under 102 genera, 38 families and 14 orders (H.S. Mogalekar, P. Jawahar and J. Canciyal, 2016). The diversity of fish species in the tanks/ponds of Karnataka do not appear to have been studied comprehensively, although studies carried out in some of the water bodies indicate rich diversity.

Fish production scenario in Karnataka
6.164. Karnataka has expansive inland water resources, comprising of reservoirs (82 Nos.), departmental tanks (3,399 Nos.) and Gram Panchayat tanks (22,624 Nos.), besides rivers (5,813 km), canals (3,187 km) and private fish culture ponds (9,000 ha). These water resources provide immense scope for development of inland fisheries. The annual estimated fish production potential of these resources is around 4.01 lakh metric tons. The inland fish production in the state during 2016-17 was 1.586 lakh tons. Thus there is tremendous scope for augmenting inland fish production in the state. Inland fisheries mainly consist of Indian major carps (catla, rohu, mrigal) and exotic carp (common carp). The commercially important native species are murrels, medium carps, freshwater eels, ompak, mystus, etc.

6.165. During 1950s and 1960s, the important activity of the State Fisheries Department in the inland sector was to import fish seed, mostly riverine major carp fry collection from West
Bengal and stock them in available tanks and reservoirs. Fish seed production and rearing farms have been set up in the Government sector in order to develop the much needed infrastructure for producing fish seed for stocking in tanks, ponds and reservoirs of the state. At present, there are 17 fish seed production farms, 30 fish seed rearing farms and 60 nursery farms under the Government sector. The State requires about 51 crore fingerlings fish seed to develop all water resources suitable for fish culture. The present annual fish seed production of the state is around 25-30 crore fingerlings.

6.166. Tank fishery development plays a strategic role in providing food and employment to the rural folk. The fishery rights of the tanks with achcut of more than 40 ha are vested with the Fisheries department. These water bodies are disposed either through preferential lease to local fishermen co-operative societies or through tender cum auction. Fishery rights of tanks up to 40 ha achcut area are being disposed by local Gram Panchayats.

Decline in diversity of indigenous fish species
6.167. By and large, the emphasis of the State Fisheries Department has been on the culture of fast growing Indian major carps like rohu, catla and mrigala and some exotic species in order to meet the ever growing demand. Although the introduction of these fast growing species has boosted fish production, it has also resulted in the decline in the population of the indigenous species. The decline in indigenous fish population and fish production from freshwaters can also be attributed to the damage caused to their habitat through construction of dams and anicuts, indiscriminate fishing, siltation, weed infestation, pollution by industrial and domestic effluents, etc. Therefore, urgent measures to restore the bio-diversity of indigenous fish and their habitats are required to be undertaken.

6.168. Fish is an important source of protein. It is an important food supplement. With the production of the fast growing and large varieties of fish in the ponds and tanks, major portion of the catch finds a ready urban market, leaving very little for the local rural folks. There are many indigenous fish species of smaller sizes which thrive well in the ponds and tanks. It is necessary to propagate these species which are not only tasty but also provide calcium as these can be eaten with their tiny bones. These small varieties of fish can be of immense benefit to the rural population as they are more likely to be sold and consumed locally.