1 INTRODUCTION

The livestock sector contributes an estimated 8 to 10 per cent to the country's Gross Domestic Product (GDP) and 26 per cent to the agricultural output at current prices (Economic Survey, 1997-98). It is the principal source of draft power in rural areas and provides milk, meat, eggs, wool, hides and skins, manure and fuel. Since early 1970s, this sector has witnessed several significant changes, most of which are direct or indirect consequences of Operation Flood, green revolution or upsurge in demand. These changes have important implications for future growth of livestock sector, diversification of rural economy and growth and structure of country's agricultural GDP.

Inspite of its importance, this sector has not received as much economic research attention as the crops sector. Studies on growth patterns deal largely with issues related to population numbers (Dandekar, 1964, 1969 and 1970; Mishra, 1966,1970 and 1973; Raj, 1969 and 1971; Rao, 1969; Kumar, 1969; Nair, 1976; Vaidyanathan, 1978 and 1992; Mehla *et* a/, 1980; Shah, 1991; Patel, 1993). There has been some research on resource productivity (Jacob *et* a/, 1969 and 1971; Kumar and Raut, 1971; Moore, 1978; Ratnam, 1982; Rao, 1985; Sharma and Singh, 1993), technology (Patel *et* a/, 1976; Lalwani, 1989; Lavaraj and Gore, 1987; Dhas, 1990; Gaddi and Kunnal, 1996), marketing (Raut and Singh, 1974; Rathod *et* a/, 1978; Keramulla and Srinivasan, 1992; Mondal and Pandey, 1993), institutions (George and Srivastava, 1975; Thakur, 1975; Dantwala, 1981;Ram and Kalla, 1983; Shiyani and Singh, 1994), employment and income generation (Srivastava and George, 1977; Verma and Pant, 1978; Seabright, 1989; Singh, 1994; Gangwar, 1994; Singh and Tiwari, 1994) and feed and fodder (Vaidyanathan, 1988; George and Nair, 1990). Unlike crops sector (Jha and Evenson1973; Kumar and Mruthyunjaya, 1992; Kumar and Rosegrant, 1994; Desai and Namboodiri, 1998), there is no empirical evidence on sources of growth, particularly relating to productivity changes. For example, it has been argued that technology has contributed to the growth and expansion of this sector but empirical evidence is not available to support this contention. The objectives of the present study are as under:

i. To study the growth pattern and compositional changes in livestock population and output in India and
ii. To analyse productive performance of livestock sector at aggregate level.

2 METHODOLOGY

2.1 Database

The present study is mainly based on secondary data from various sources. These include the Livestock Censuses, National Income Statistics. Technical Committee Report for Direction and Improvement of Animal Husbandry and Dairying Statistics, Annual Reports of the Poultry, Indian Poultry Industry Yearbook, Agricultural Prices in India, Agricultural Wages in India. However, some data, which were not readily available in the published sources, were estimated (Annex I). The objective of this exercise was to develop time series data on livestock sector at the national level (Annex III and IV).

2.2 Growth and Compositional Changes in Population and Output of Livestock

Besides tabular analysis, annual compound growth rates were computed for livestock population and output. The latter covered two time periods: 1950-51 to 1970-71 and 1971-72 to 1995-S6.

2.3 Total Factor Productivity

Total factor productivity (TFP) measures the increase in total output, which is not accounted for by increases in total inputs. The TFP index is computed as the ratio of the index of aggregate output to the index of aggregate inputs. Growth in TFP, is, therefore the growth rate in total output less the growth rate in total inputs. In this analysis Tornqvist-Theil TFP indices are computed for Indian livestock sector at aggregate level for the period 1950-51 to 1995-96. (Copalbo and Vo, 1988).

The output index covered milk and milk products, meat & meat products, animal draft power, dung (fuel + manure), eggs and poultry meat, hides & skins, wool & hair and some other unspecified by-products (Unspecified by-products include guts, blood, bones, horns, silkworm cocoons and honey). To estimate the input index, feed, labour and livestock population was considered. Livestock feed comprises of (i) roughage and (ii) concentrates including salt, medicines and other miscellaneous feed. Roughage include cane trash, grass, fodder (green + dry), stalks, straw etc., while concentrates are made up of oilcakes, crushed pulses, grains, rice bran, husk, oilseeds, gur etc. The Annex I describes the data adjustments and assumptions.

3 POPULATION DYNAMICS

3.1 Temporal Changes

According to the 1992 Livestock Census, Karnataka accounts for 6.4 per cent of country's cattle, 5.1 per cent of buffaloes, 10.9 per cent of sheep, 5.4 per cent of goats, 3 per cent of pigs and 5.3 per cent of poultry. The changes in population of different species are presented in Tablet

Table 1 :
Trends in livestock population in Karnataka,1972-1992.

Species	Population (in lakhs)			Compound annual growth rate (%)		
	1972	1982	1992	1972-82	1982-92	1972-92
CATTLE	101.5	113.0	131.6	1.10	1.54	1.31
Indigenous	101.5	107.5	125.4	0.58	1.55	1.06
Male	50.9	52.7	61.5	0.36	1.56	0.95
Female	50.6	54.0	63.9	0.64	1.70	1.17
Sex ratio	1004	976	962	-	-	-
Crossbred	N.A	5.5	6.2	-	1.21	-
Male	N.A	1.3	1.5	-	1.44	-
Female	N.A	4.2	4.7	-	1.13	-
Sex ratio	N.A	310	319	-	-	-
BUFFALO	32.7	36.4	42.4	1.08	1.54	1.31
Male	7.2	6.3	7.4	-1.29	1.62	0.15
Female	25.5	30.1	35.0	1.68	1.52	1.60
Sex ratio	282	209	211	-	-	-
SHEEP	46.6	48.0	54.3	0.29	1.24	0.77
Indigenous	46.6	46.7	52.8	0.02	1.24	0.63
Crossbred	N.A	1.3	1.5	...	1.44	-
GOAT	37.3	45.5	62.9	2.09	3.29	2.62
PIGS	2.6	3.2	3.8	2.10	1.73	1.92
Indigenous	2.6	2.9	3.4	1.10	1.60	1.35
Crossbred	N.A	0.3	0.4	-	2.92	-
POULTRY	101.6	121.0	157.3	1.76	2.66	2.21

Source: Computed from data provided in Livestock Census reports.

3.1.1 Bovine

Bovine production system in the state is predominantly cattle based. Indigenous stock accounts for more than 90 per cent of total cattle stock (Table 1). As indigenous cattle is the predominant supplier of draft power to agriculture besides performing its usual function of milk production. This is implied in the sex ratio (males per 1000 females). It stood at 962 in 1992. Cattle population between 1972 and 1992 increased from 101 lakhs to 132 lakhs at a compound growth rate of 1.31 per cent. The growth however, slowed down during 1972-82. Further, male population increased at a slower rate, compared to female. The changes when analysed by breed reveals that population of crossbred increased slowly compared to indigenous cattle.

The share of crossbred in total cattle population in the state hardly ever exceeded 10 per cent. This is primarily because of its non-adaptability to predominant arid and semi-arid climatic conditions of the state. Frequent and high acquisition costs could also be responsible for this phenomenon. The first generation animals need to be replaced frequently as the offspring's produced from successive crosses do not perform as well as the first cross animals (McDowell, 1984; Alderman, 1987)3. Further, a crossbred male is rarely valued as source of draft power. This is corroborated by a highly adverse sex ratio to males (Table 1).

Development of input and output markets also influence rate of technology adoption. Increase in demand for milk causes a shift in favour of high yielding milk species. The peri-urban dairying is a case in point. Peri-urban dairying is largely based on crossbred cattle and buffalo. Data from Integrated Sample Survey Report, 1995-96 reveals that in Bangalore (urban) district of the state, crossbred cattle comprise about half the dairy animals and their productivity is higher than any other district of the state. This trend is likely to be strengthened as a result of increasing urban population. Lack of attention to specific needs and constraints of marginal and small farmers is also a major reason for the low adoption of crossbreeding technology in rural areas of the state (Rajapurohit(1979).

3 McDowell (1984) observed that more than half of second generation cows that are 75 per cent exotic do not live long to produce milk whereas cows that are 25 per cent exotic have little if any advantage over local breeds. Field observations by Alderman (1987) indicated that more than 50 per cent of the farmers in Karnataka depend on market for getting crossbred female cattle. This is to avoid the risk of getting an unwanted low utility crossbred male and the difficulty of breeding and feeding to the calf, if bred on own farms.

Buffalo is the other bovine species raised primarily for milk. Population of buffaloes has been growing steadily. It increased from 32.7 lakhs in 1972 to 42.6 lakhs in 1992 at a rate of 1.31 per cent a year (The consistent increase in buffalo population is not confined to Kamataka alone. This has been the case in many Indian states since last few decades (Vaidyanathan, 1988)). Highest growth was recorded during 1982-92. The sex ratio has remained low throughout. This is because the male buffalo is not an efficient source of draft power. During these two decades, male population increased at a rate of just 0.15 per cent per annum. The growth however, is erratic. Between 1972-82, it declined at a rate of 1.29 per cent a year. In the following period, there was considerable recovery.

3.1.2 Ovine

In Karnataka, goats are mainly valued for meat. Sheep is reared for both meat and wool. Crossbred sheep comprise only about 3 per cent of the total sheep population. During the period 1972-92 sheep population has increased steadily at a rate of 0.77 per cent per annum. The pattern of increase is not smooth. The total population increased at a rate of 0.29 per cent during 1972-82. However, in subsequent years population of crossbred increased faster than the indigenous sheep. Population of goats has grown rapidly between 1972 and 1992 at an annual rate of 2.62 per cent. Most of this growth resulted during 1982-92.

3.1.3 Pigs

Pigs are raised for meat production, mostly by the socially and economically backward sections of the society. However, piggery is not a popular avocation in the state. The system of production is limited to scavenging and hardly any input goes into production. Pig population in the state is low and has been hovering around 3 to 4 lakhs over the last two decades. Crossbred accounts for a meagre 10 per cent of the total population.

3.1.4 Poultry

Poultry is raised under both traditional and intensive systems of production. Traditional backyard poultry production is predominant in rural areas. The data from Integrated Sample Survey, 1995-96 indicates that only about 5 per cent of the poultry units in the state have more than 20 birds. Between 1972 and 1992, poultry population grew at a rate of 2.21 per cent a year. The rate of increase however, was higher in the latter period. The share of improved poultry is low. In 1992, improved poultry accounted for only 18 per cent of the total poultry population.

3.2 Spatial Distribution

Evolution of production systems is a long run phenomenon. The systems of production and characteristics thereof vary, depending on agro-ecological and socio-economic parameters. The National Bureau of Soil Survey and Land Use Planning classifies Karnataka into four broad ecosystems viz. arid, semi-arid, semi-arid moist, and coastal. The main characteristics of these systems are presented in Annex Table I.

Semi-arid moist ecosystem is the largest ecosystem and occupies 40 per cent of the state's geographical area. The net sown area comprises 47 per cent of total area of which 23 per cent is irrigated. More than 10 per cent of the land area is under pastures and grazing lands, which is much higher compared to other systems. The coastal climate prevails only on 12 per cent of the state's geographical area. More than half of the coastal area is under forests and only 21 per cent of the area is available for cropping activities. Arid and semi-arid ecosystems cover 21 and 26 per cent of the geographical area of the state respectively. About 70 per cent of the area in these ecosystems is under cropping activities. Average size of land holding in semi-arid and arid ecosystems is smaller, compared to semi-arid moist and coastal systems. The coverage by animal health infrastructure and dairy co-operatives in semiarid and semiarid-moist ecosystems is comparatively better.

These differences influence composition and density of livestock across the systems. While all the ecosystems accommodate different livestock species, their share in state's total livestock population in relation to area share vary. The semi-arid moist ecosystem is more flexible to accommodate all the species and has proportionately greater population compared to its area share (Table 2). Cattle, sheep and poultry are the dominant species in this ecosystem. Buffaloes and goats are also found in good numbers. The average size of land holding in this ecosystem is small, and given the favourable ecological conditions and infrastructure facilities, farmers raise a variety of species to supplement crop income. The share of semi-arid ecosystem in population of buffaloes and small ruminants is analogous to its share in total area. Arid conditions are best suited to raise small ruminants, while coastal climate does not favour small ruminant farming.

Agro-ecological and socio-economic conditions also exert considerable influence on technology adoption. Data suggests that semi-arid moist and coastal climates are more favourable to the adoption of crossbreeding technology. The proportion of crossbred cattle, sheep and pigs is higher in these systems, compared to arid and semiarid systems.

Table 2 :
Distribution of livestock across agro-ecological systems in Karnataka, 1990.

	Cattle	Buffalo	Sheep	Goat	Pig	Poultry
Zonal share in population (per cent)						
Arid ecosystem	15.92	17.33	20.97	27.81	15.46	10.70
Semi-arid ecosystem	21.83	29.77	22.65	25.08	20.99	14.09
Semi-arid moist ecosystem	50.42	44.31	56.28	46.04	42.36	58.64 ;
Coastal ecosystem	11.83	8.59	0.10	1.07	21.13	16.57
Density of livestock population (Numbers per sq km)						
Arid ecosystem	39.92 (1.30)	17.24	24.44 (0.94)	25.42	1.17 (2.88)	41.32
Semi-arid ecosystem	45.60 (3.51)	24.65	21.96 (1.16)	19.08	1.32 (3.94)	45.35
Semi-arid moist ecosystem	65.40 (10.55)	22.78	33.89 (2.82)	21.76	1.66 (9.20)	117.24
Coastal ecosystem	53.30 (7.13)	15.29	0.21 (5.26)	1.74	2.86 (14.44)	114.62
State	53.40 (7.11)	21.19	24.82 (2.05)	19.47	1.61 (8.22)	82.38

Figures in parentheses are per cent of crossbred animals. The number of districts in arid, semi arid, semi arid -moist and coastal ecosystems are 3, 4, 10 and 3, respectively. Source: Integrated Sample Survey Report, 1995-96.

3.3 Equity in Livestock Holdings

Organisation of production in the state is subsistence oriented. Average herd size is small and the pattern of distribution is closely related to distribution of land holdings. Marginal and small farm households that comprise 57 per cent of the total households, share 58 per cent of cattle, 43 per cent of buffalo, 41 per cent of sheep and goats and 74 per cent of poultry (Table 3).

Participation of the landless in dairying is low. Among the landed class, size of the bovine herd is positively associated with the size of land holding. This is true for both cattle and buffalo. However, compared to cattle, the concentration of buffaloes is higher among the medium and large farmers. Buffalo is generally stall -fed and feed fodder supply among these farmers is not a constraining factor.

Table 3 :
Distribution of livestock in Karnataka by size group of land holdings, 1992.

(No. of heads per 100 households)

	Landless (<0.002ha)	Marginal (0.002-1.0ha)	Small (1.0-2.0 ha)	Medium (2.0-4.0 ha)	Large (>4.0ha)	All
Number of households (00)	10592 (18.74)	22943 (40.59)	9223 (16.32)	8198 (14.50)	5571 (9.86)	56527 (100.00)
Total Cattle	26.93 (3.29)	135.92 (35.95)	208.00 (22.11)	236.00 (22.30)	254.51 (16.35)	153.46
Adult male	4.60	34.17	95.99	117.01	130.11	60.19
Indigenous	4.60	33.30	94.99	116.01	129.32	59.45
Crossbred	0.00	0.87	1.00	1.00	0.79	0.74
Adult females	14.33	40.25	30.77	29.66	28.16	34.24
Indigenous	9.66	34.90	26.44	23.30	24.93	28.86
Crossbred	4.67	5.35	4.33	6.36	3.23	5.38
Total Buffalo	15.13 (5.23)	36.08 (27.03)	54.00 (16.26)	81.00 (21.69)	163.74 (29.79)	54.17
Adult male	1.87	5.00	16.00	14.00	10.69	8.08
Adult female	6.73	22.08	25.00	45.00	112.00	31.87
Sheep and Goats	4.47 (1.27)	32.35 (19.91)	87.00 (21.53)	132.00 (29.04)	188.95 (28.25)	65.93
Pigs	0.00 (0.00)	1.00 (64.36)	0.00 (0.00)	1.00 (22.96)	0.81 (12.68)	0.63
Poultry	23.87 (3.22)	179.24 (52.35)	183.00 (21.49)	151.00 (15.76)	101.38 (7.19)	138.97

Figures in parentheses indicate per cent distribution.
Source: Report on Land and Livestock Holdings, 1992, National Sample Survey Organisation, Govt. of India.

Substantial variation is observed in the composition of bovine stock across different land holding classes. Except on the marginal holdings, adult male cattle outnumber adult female cattle. In terms of per centage, there is a positive relationship between ownership of adult male and size of land holding. This is plausible, as the size of land holding increases, draft power requirements too increase. One notable feature concerning cattle herd composition in the state is that the landless have a higher proportion of crossbred in their cattle stock, compared to other categories. Although, in absolute terms crossbred herd size increases with the size of holding. Adult female buffaloes outnumber adult males on all classes of land holdings and their proportion is the highest on large holdings, followed by marginal and medium holdings. This suggests that land holding is an important determinant of size of dairy herd.

It's a general belief that those who have little or no access to cultivated land raise mainly those animals that require low investment and operational expenses. Sheep and goats fall in this category. This however, does not hold true for the state of Karnataka. It is evident from

Table 3 that the distribution of these animals is heavily skewed towards medium and large holdings. The skewed distribution is largely on account of the deterioration of common property resources that provide main support to small ruminant farming by the landless and marginal farm households. Study by Pasha (1991) also indicates that distribution of small ruminants in the state is slowly getting skewed towards medium and large farm households. Supply of quality manure for crop production and ample availability of fodder from owned land are cited as principal reasons. These households also share common property resources for grazing, which invariably puts more pressure on these resources and reduces the access of the poor households.

Distribution pattern of pigs and poultry is in sharp contrast with that of ruminants. As usual, the share of landless in poultry population is low. Distribution of poultry is favourable to marginal landholders and the number of poultry birds owned per household decreases with the size of land holding. Pigs are concentrated mainly among marginal farm households.

4 TOTAL FACTOR PRODUCTIVITY

Results of output, input and TFP growth over different time spans are presented in Table 6. Over the entire period of the study (1950-51 to 1995-96) the livestock output grew at 2.59 per cent per annum. During the same period, input index increased by 1.79 per cent per annum and TFP grew at about 0.8 per cent. However, sub-period wise results are more revealing. There was no TFP growth in the first period (till 1970-71) implying no technical change. Output growth proceeded along the traditional production function and was entirely driven by growth in measured inputs. Not surprisingly, the resulting growth in output was a modest 1.3 per cent per annum. There was increasing concern about nutritional implications, as population and demand growth was substantially higher. There was a sharp uptrend since then. Input as well as TFP growth picked up significantly. Output growth increased to 3.6 per cent. The Table 6 and Fig. 3 show that the real upswing started in the eighties when sectoral output growth touched nearly 4 per cent per annum and TFP growth jumped to a very respectable 1.8 per cent per annum.

Table 6 :
Compound annual growth rate of output, input and TFP indices

Item/Period	I	II	III	IV	V
	1950-51 to 1970-71	1970-71 to 1995-96	1950-51 to 1995-96	1970-71 to 1980-81	1980-81 to 1995-96
Output index	1.28	3.59	2.59	2.80	3.98
Feed	0.79	1.57	1.18	1.13	1.74
Labour	0.37	0.44	0.42	0.54	0.28
Population Stock	0.16	0.19	0.18	0.20	0.17
Tot.Input index	1.32	2.25	1.79	1.87	2.19
TFP index	-0.04	1.39	0.81	0.93	1.79

These results indicate that technical change has gradually become the driving force imparting dynamism to the livestock sector. In the pre-1970 period, its role was not visible. Growth of inputs was the only determinant of output growth. Consequently, output grew very slowly. The contribution of technical change started to manifest itself since then. In the seventies, it accounted for 33 per cent of output growth rising to about 45 per cent in the post-1980 period. Labour and population stock, which together accounted for over 40 per cent of output growth in the first period, contributed only 11 percent in the post-1980 phase. Better feeding and technology contributed nearly 89 per cent. Over time, the relative shares of different inputs (feed, labour and population stock) have remained almost stable (Table 7) but growth and technical change has affected composition of livestock feed. In 1970-71, dry fodder accounted for around 58 per cent of the total livestock feed (Fig. 4). This came down to 35 per cent in 1995-96. The share of green fodder increased from 40 per cent to 57 per cent during the above period. The per centage share of concentrates was around 2 per cent in 1970-71 and remained almost constant upto 1981-82 but since then it has increased significantly and has reached 7.63 per cent in 1995-96.

Figure 3 : Trends in input, output and TFP indices in India's livestock sector (1951-1995)

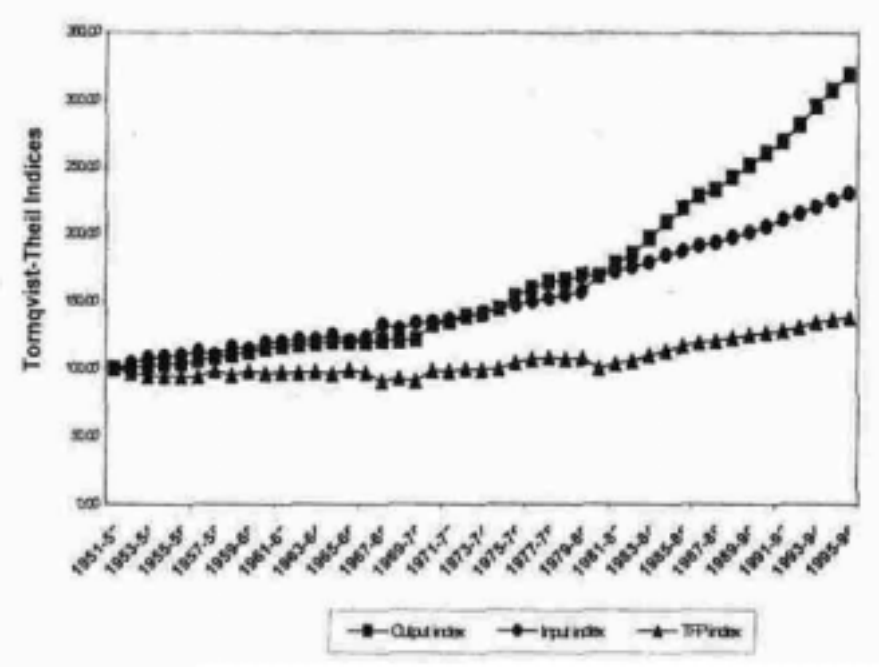
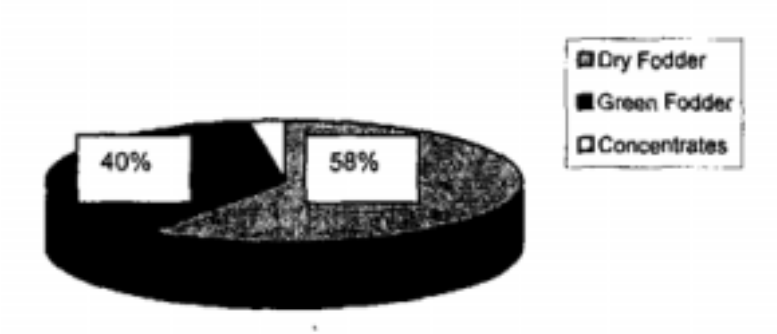


Table 7 :
Relative factor shares (per centage)

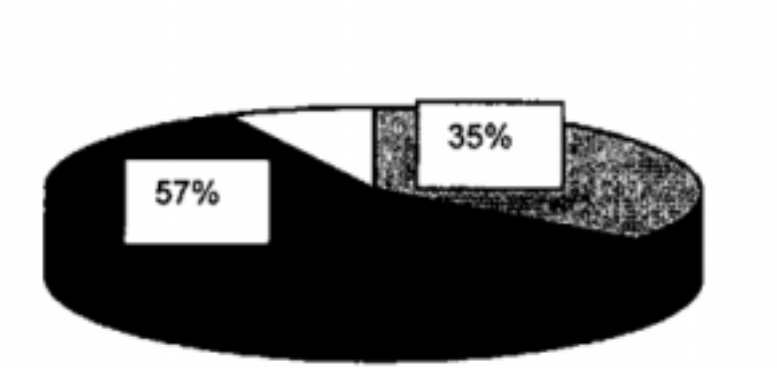
Item/Period	1950-51 to 1970-71	1970-71 to 1980-81	1980-81 to 1995-96	1970-71 to 1995-96	1950-51 to 1995-96
Feed	60.69	60.57	62.93	61.72	61.39
Labour	23.39	24.13	23.54	23.92	23.60
Population Stock	15.92	15.30	13.53	14.36	15.01

Figure 4 : Composition of livestock feed consumption

1950-51



1995-96



This implies that during seventies the shift in feeding pattern of livestock has taken place in favour of green fodder while during 80's and afterwards it was more pronounced in favour of green fodder and concentrates (Table 8). With better market opportunities and commercialisation, producers now have the incentive to switch from subsistence-oriented, supplementary livestock rearing to market-oriented pattern. Similar results were obtained by Lavaraj and Gore (1987), Lalwani (1989) and Gaddi and Kunnal (1996). Lalwani (1989) indicated that the adoption of milch crossbred cattle has brought about an immediate upward shift in the threshold level of milk yield, enabling the farmers to get more milk at the existing level of input use. However, the sample farmers had failed in consolidating such technological gains as they were unable to adjust to the new requirements of the crossbred technology. The contribution of the technological efficiency in per cent terms to the total gain in milk yield was the least for the landless class of the dairy producers and the highest for the small farm size-group. Among the landed class of dairy producers, the total gain due to the technological efficiency component declined with the increase in the farm size. Gaddi and Kunnal (1996) observed that the total growth in milk yield per cow per lactation by shifting to new milk production technology was about 145 per cent. However, the estimated growth in milk output was 146 per cent of which 47 per cent was contributed by technology i.e. 47 per cent more output could be produced with new milk production using old milk production technology level of inputs. The contribution of increased level of inputs was 99 per cent. Among the inputs, the contribution of feed (40 per cent) was the highest, followed by labour (26 per cent), fodder (21 per cent) and capital (12 per cent). The contribution of feed suggested the importance of well-organised sector for producing and distributing quality feeds for

accelerating output growth through technical change. Lavaraj and Gore (1987) have analysed the process of adoption of crossbred goats in Narayangoan town of Pune district in Maharashtra and concluded that ultimately 39 per cent of the goat owners would adopt cross-breeding.

Table 8 :
Composition of livestock feed in India

(in percentaqe)

Item/Period	1950-51	1970-71	1981-82	1995-96
Dry Fodder	59.74	57.76	46.75	35.38
Green Fodder	37.74	40.19	50.62	56.98
Concentrates	2.52	2.05	2.63	7.63

Higher TFP growth in the second period implies that the livestock economy of India has gathered momentum during the past two and half decades, having come out of its sluggish past. The mild trend underlying the livestock economy for decades past was accelerated by modernised marketing (along the AMUL model in case of milk), multi-dimensional research (Annex II) and by determined measures for the protection of health and improvement of breed. Further analysis of sources of growth in TFP is extremely essential to understand the factors promoting productivity gains.

5 CONCLUSION

On the macro level, the livestock sector in India looks bright and is steadily marching to prepare itself for the challenges in the next millennium. In India the land: man ratio is quite low and the distribution of land is skewed, the diversification of a crop based rural economy into an animal husbandry mixed farming system must be encouraged for rapid economic development and generating equitable income and employment in the country. Technological change embodied in better breeds, improved health, nutrition and processing must be accorded high priority alongwith credit, marketing and organisation of producers to further this trend.

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Annex I: Data adjustments and assumptions

1. It was assumed that one draft animal would be equal to 0.5 HP. The working day per animal was assumed at 100 days in a year. Further the quantum of draft power was converted into fuel equivalent required by a tractor to do the same amount of work. Finally, average price (at 1980-81) of diesel was multiplied to get the value of output of draft power at constant price. The value at current price was obtained by multiplying current average prices of diesel oil to the quantity of draft power for the respective years.
2. Data on workforce engaged in livestock sector were taken from different rounds of National Sample Surveys (NSS) on Employment and Unemployment. 200 mandays were assumed engaged per unit ACU in a year. Wage rates are taken from Agricultural Wages in India.
3. To work out the value of livestock population, all species of livestock were converted into adult cattle unit (ACU). These ACU's were multiplied by prices. The conversion ratios as suggested in National Commission on Agriculture (NCA), 1976 were used to convert all species of livestock into ACU. Interest @ 12 % was charged on this value to work out the share of population stock in the input cost.
4. The estimates for cakes/concentrates, dry fodder and green fodder availability were used to highlight the shift in composition of livestock feed consumption over time. For constructing input index value of livestock feed were largely taken from National Accounts Statistics. However suitable adjustments and assumptions were made based on our own estimates. (For details of estimation procedure kindly refer to Mishra and Sharma, 1989).

Annex II: Livestock sector research in India

The research investment on livestock sector by Indian Council of Agricultural Research (ICAR) has been on the rise over the years. This is clearly evident from the table appended below.

Plan Period	Research Allocation by ICAR (Rs Crores)		
	Crop Science	Animal Science	Total
IV Plan (1969-74)	20.0	15.2	91.4
V Plan (1974-78)	31.9	25.9	153.5
VI Plan (1980-85)	69.8	35.6	340.0
VII Plan (1985-90)	90.4	44.6	425.0
VIII Plan (1992-97)	322.8	140.0	1300.0
*IX Plan (1997-2002)			

* proposed

The growth and spread of the livestock research has been phenomenal starting from the Imperial Bacteriological Laboratory, Pune in 1889 now named as the Indian Veterinary Research Institute (IVRI), Izatnagar and the Imperial Dairy Institute, Bangalore now named as the National Dairy Research Institute (NDRI), Karnal. On date, there are 6 central research institutes (CRIs), 2 national institutes, conducting research on livestock (buffalo, sheep, goat and poultry), 1 National Bureau of Animal Genetic Resources and 7 national research centres (NRCs) on equine (Hissar), camel (Bikaner), Yak (Arunachal Pradesh), Mithun (Nagaland) and Meat (Izatnagar) and 2 project directorates one each on cattle (Meerut) and Poultry (Hyderabad).

There are 16 All India Co-ordinated and network projects operating in cattle (3), buffalo (1), sheep (1), goat (1), poultry production and improvement (3), pig breeding (1), embryo transfer technology (1), micro-nutrients in animal production (1), crop based production systems (1), epidemiological studies on foot and mouth disease (1), blood profista (1), and animal disease monitoring and surveillance (1).

Animal Breeding

Our country has the world's best breeds of dairy buffaloes Murrah, Nili Ravi, Surti, Jaffarabadi and Bhadawari, draft cattle Ongole, Mariana, Kankrej, Kangayam, Nagori; carpet wool sheep Magra, Chokla and goats Jamunapari and Beetal.

To maintain our biodiversity steps have been taken to evaluate genetic resources and to develop programmes for their conservation, management, documentation and improvement. The National Bureau of Animal Genetic Resources in collaboration with respective institutes, state animal husbandry departments and the State Agricultural Universities (SAUs) have developed programmes for their evaluation, characterisation, conservation and improvement. Work on evaluation and characterisation of cattle Hariana and Rathi, buffalo Bhadawari, sheep Malpura and Chokla, Yak and Mithun is in progress. A number of data bases have been developed and linked for inflow of information.

Crossbreeding with improved exotic breeds has been adopted to improve the low productivity of the Indian breeds. In cattle new genotypes KARAN SWISS and KARAN FRIES and FRIESWAL have been evolved. AVIKALIN, AVIVASTRA and BHARAT MERINO have been evolved in sheep. Small ruminant, the rabbit has been bred successfully for meat and wool. The broiler rabbit SOVIET CHINCHALLA, WHITE GIANT, GREY GIANT and NEW ZEALAND WHITE are some of the promising breeds developed for rabbit. A strain of MOHAIR goat has been developed by crossing the exotic ANGORA with the local SANGAMNERI. New strains of poultry for meat and egg are in commercial production. IBL 80 and IBB 83, the two hybrids of poultry broilers weigh substantially higher than the previous broilers. Similarly ILI 80, ILR90 and ILM 90 produce higher eggs per annum.

Animal Nutrition

To bridge the gap between demand and supply of animal feed resources an All- India Coordinated Research Project on the Utilisation of Agricultural By-products and Industrial Waste Materials for Evolving Economic Rations for Livestock was started in 1967 at 4 centres. More centres have been added on over the years and the scope of the project has been widened. In 1995, a full-fledged institute, the National Institute of Animal Nutrition and Physiology, Bangalore has gone functional. While new varieties of conventional feeds continue to be evolved, newer and alternative feed resources are regularly being tapped and analysed to feed the massive livestock population of the country and the crossbreds that require superior nutrition to express their genetic potential.

Animal Health

Research in animal health is more than a century old. The vaccine to control the highly virulent Rinderpest disease is in use ever since 1927. The important vaccines developed much earlier still guard against Anthrax, Haemorrhagic Septicaemia, Blackquarter, Fowl Cholera, Ranikhet disease, Swine Fever and Rabies. The newer ones are those that guard against the Foot and Mouth disease, Sheep Pox, Goat Pox, Fowl Pox, clostridial diseases in sheep, Theierosis, Canine distemper and Equine Influenza.

Processing

The advancements achieved in processing include preservation of raw milk at ambient temperature, preparation of khoa, kulfi mix, gulab jamun mix, rasogulla-mix, paneer and chhena. Formulations recommended by the NDRI for the preparation of infant foods, malted milk and low-lactose milk are of international standards. The technologies have also been developed to prolong the shelf life of different poultry, meat and egg products.

Annex III: Value of output from livestock sector (Rs. Crore at 1980-81 prices)

	Milk Group	Meat & Meat Prod	Beef	Pork+ Mutton	Other Meat Prod.	Hides & Skins	Hides	Skins	Eggs & Poultry Meat	Eggs	Poultry Meat	Wool & Hair	Wool	Hair	Dung	Fuel	Manure	Draft Power	Inc. in Stock	Other Prod.	TVOL
		2	2.1	2.2	2.3	3	3.1	3.2	4	4.1	4.2	5	5.1	5.2	6	6.1	6.2	7	8	9	10
1950-51	3437	690	66	553	71	175	93	82	307	94	213	72	32	40	1088	575	513	1117	59	77	7022
1951-52	3464	695	67	556	72	176	93	83	317	98	219	74	33	41	1090	577	513	1127	65	76	7084
1952-53	3489	700	68	560	72	178	93	85	327	101	226	75	33	42	1093	580	513	1138	73	74	7147
1953-54	3516	706	68	565	73	180	94	86	338	105	233	77	34	43	1096	582	514	1149	81	76	7219
1954-55	3544	716	68	573	75	182	94	88	352	109	243	74	34	40	1100	586	514	1160	91	72	7291
1955-56	3571	723	69	579	75	184	95	89	364	113	251	75	35	40	1106	590	516	1171	99	74	7367
1956-57	3618	728	70	583	75	187	96	91	378	117	261	76	35	41	1113	593	520	1183	161	80	7524
1957-58	3664	727	71	581	75	190	98	92	393	122	271	77	36	41	1139	607	532	1206	176	85	7657
1958-59	3722	734	74	583	77	192	100	92	407	127	280	77	36	41	1161	618	543	1230	186	85	7794
1959-60	3781	736	73	586	77	195	102	93	424	132	292	77	36	41	1184	630	554	1254	200	86	7937
1960-61	3867	756	74	603	79	198	104	94	450	138	312	77	35	42	1209	642	567	1279	214	86	8136
1961-62	3910	761	76	606	79	200	105	95	461	141	320	78	36	42	1222	649	573	1305	244	90	8271
1962-63	3937	766	75	611	80	200	105	95	467	143	324	78	36	42	1227	652	575	1311	247	89	8322

1963-64	3977	771	76	615	80	202	105	97	472	144	328	79	37	42	1232	655	577	1318	249	93	8393
1964-65	4021	777	76	620	81	203	105	98	478	146	332	79	38	41	1237	658	579	1325	253	97	8470
1965-66	4022	783	77	623	83	203	105	98	485	148	337	80	39	41	1220	649	571	1332	232	103	8460
1966-67	4127	824	102	647	75	196	105	91	410	180	230	79	37	42	1133	570	563	1339	257	91	8456
1967-68	4186	822	103	643	76	197	106	91	424	186	238	79	36	43	1140	573	567	1338	260	97	8543
1968-69	4091	836	101	654	81	198	106	92	439	193	246	80	36	44	1169	581	588	1338	263	105	8519
1969-70	4155	848	101	669	78	200	107	93	456	200	256	81	36	45	1175	585	590	1336	267	108	8626
1970-71	5197	706	99	548	59	176	114	62	509	262	247	81	39	42	1173	592	581	1333	151	118	9407
1971-72	5280	717	99	558	60	177	115	63	530	273	257	82	39	43	1179	594	585	1337	159	113	9536
1972-73	5497	738	105	571	62	177	113	64	552	283	269	82	39	43	1210	616	594	1341	151	125	9835
1973-74	5613	710	113	535	61	174	115	59	575	293	281	83	40	43	1215	619	596	1348	167	128	9973
1974-75	5801	725	110	S51	63	175	115	60	600	305	294	85	40	45	1238	623	615	1355	193	125	10242
1975-76	6367	747	114	569	65	177	116	61	627	318	309	86	41	45	1245	628	617	1362	163	125	10887
1976-77	6632	787	110	579	97	182	118	64	768	338	430	88	42	46	1249	628	621	1369	177	128	11340
1977-78	6790	826	116	606	104	186	119	66	764	358	406	91	45	46	1339	687	*652*	1376	185	152	11669
1978-79	6828	851	121	625	106	187	120	67	812	406	406	93	46	47	1332	677	655	1372	192	157	11783
1979-80	6941	897	141	639	118	190	123	67	864	430	434	95	47	48	1341	682	659	1369	196	177	12028

1980-81	6884	876	178	605	93	210	125	85	795	351	444	49	39	10	1352	673	679	1366	255	176	11963
1981-82	7385	937	183	653	101	216	127	89	859	380	479	51	41	10	1408	723	685	1362	272	163	12653
1982-83	7718	982	192	691	99	222	129	93	908	399	509	54	43	11	1407	720	687	1359	294	193	13137
1983-84	8334	1041	193	741	107	233	131	102	1005	422	583	57	45	12	1435	724	711	1355	314	206	13980
1984-85	8897	1111	218	781	112	243	135	108	1141	492	649	60	48	12	1487	753	734	1351	337	218	14845
1985-86	9530	1155	234	806	115	238	132	106	1220	548	672	63	50	13	1434	704	*730*	1347	360	220	15567
1986-87	9912	1184	221	848	115	243	135	108	1335	588	747	64	51	13	1507	795	712	1343	389	232	16209
1987-88	10119	1235	255	869	111	218	106	112	1378	590	788	66	52	14	1541	833	708	1339	417	239	16552
1988-89	10517	1294	278	904	112	221	106	115	1494	639	855	66	52	14	1578	850	728	1336	450	250	17206
1989-90	11188	1402	255	1033	114	218	101	117	1582	685	897	66	54	12	1525	803	722	1332	230	299	17842
1990-91	11711	1493	282	1093	118	229	105	124	1621	715	906	64	53	11	1527	801	726	1328	223	314	18510
1991-92	12161	1574	283	1170	121	231	112	119	1688	746	942	58	47	11	1526	815	711	1324	254	285	19101
1992-93	12570	1823	336	1318	169	299	119	180	1762	776	986	67	53	14	1532	812	720	1320	269	342	19984
1993-94	13191	1853	354	1325	174	307	125	182	1894	833	1061	72	56	16	1583	862	721	1316	423	333	20972
1994-95	13821	1852	352	1335	165	312	129	183	1983	869	1114	74	57	17	1608	875	733	1313	498	342	21803
1995-96	14429	1882	358	1356	168	317	131	186	2040	910	1130	77	60	17	1634	889	745	1309	586	355	22629

Note: TVOL stands (or Total Value of Output from Livestock Sector
Source: National Accounts Statistics, various issues

1 INTRODUCTION

1.1 Background

India's livestock sector is in a transitional mode. Economic liberalisation is opening up new opportunities for market-led growth of the livestock sector. Demand for livestock products is highly income elastic (Gandhi and Mani, 1995), and is increasing continuously with sustained economic growth and rising per capita income (Bhalla and Hazell, 1997; Kumar, 1998) (By 2020 the demand for milk, meat and eggs is projected at 496, 10 and 7.7 million tonnes respectively, by Bhalla and Hazell assuming a 5.5 per cent growth in GDP. On the other hand Kumar on the presumption of a 5 per cent annual income growth projects milk demand at 143 million tonnes and meat and eggs at 8 million tonnes). This has fostered growth in livestock output in recent years. Since early eighties, milk output has increased at an annual rate of 5.6 per cent. Poultry meat, eggs and mutton production grew at a rate of 6.5, 6.6 and 3.5 per cent a year, respectively (World Bank, 1996). It is believed that if these production trends are sustained, demand for meat and eggs would be adequately met by domestic supplies (World Bank, 1996).

Production conditions and state of technology in the livestock sector would determine whether or not current output trends are sustained in the future. Current production environment has several constraints. Livestock is raised under extensive systems of production and is characterised by small herd size and low levels of productivity. Feed-fodder scarcity is a chronic feature and common grazing resources are deteriorating rapidly. Livestock population structure continues to be dominated by low yielding indigenous species. The needed growth would necessarily have to be technology/ productivity- driven. In certain areas like breed improvement (cattle, sheep and poultry), health and nutrition, significant research advances have been made. Their success at field level however, has been variable (The crossbred cattle and sheep comprise about 10 and 5 per cent of the country's total cattle and sheep populations, respectively. In certain states like Kerala and Punjab crossbred cattle comprise more than 50 per cent of total cattle population. This has made a noticeable impact on milk production. In case of Kerala, Nair (1979) observed that most of the growth in milk production between mid sixties and mid seventies resulted due to shift in herd structure in favour of crossbred cattle. While in Tamil Nadu, Dhas (1990) found that milk yield of both cattle and buffalo has been rising, its contribution to output growth has started to decelerate) due to several constraining factors. In the meat production sector, productivity has been stagnating, as major research advances are yet to occur.

The livestock sector is therefore, on the threshold of major changes. These changes are likely to impact income, employment and equity. It is presumed that gains in growth and technology in the livestock sector is employment and equity oriented as livestock wealth is more equally distributed than land. The sector employs 8 per cent of country's labour force, including millions of landless, marginal and small farmers. Marginal and small farmers who comprise about 62 per cent of rural households in the country, raise 71 per cent of cattle, 58 per cent of buffaloes and 65 per cent of sheep and goats (NSSO, 1996). A major issue relates to the equity effects of changes in this sector. Empirical evidences indicate that any increase in income from livestock activity would lessen income inequalities (Patel and Das, 1990; Sambarani, 1990; Adams, Jr. and He, 1995; Birthal, 1997). However, this is a contentious issue. Given that the ownership of land is an important determinant of herd size, Vyas and Jodha (1973), Verhagen (1990) and Doornbos and Nair (1990) suspect whether the landless and marginal farmers would gain much from the growth and technological developments in this sector.

This study examines trends and sources of growth in the livestock sector of Karnataka at a disaggregated level. An attempt is also made to understand the issues of technology, productivity and equity. The choice of the state is deliberate as early efforts were initiated to

popularise the crossbreeding technology in cattle (Singh, et al 1985). Additionally, the growth of state's livestock sector has kept pace with the national average.

1.2 Objectives

Specific objectives of the study are:

i. To examine the growth trends in population, production and productivity of livestock.
ii. To assess the contribution of productivity to output growth, and
iii. To derive implications of (i) and (ii) for livestock research and development.

2 DATA AND METHOD

Data used in this study were compiled from the following sources:

1. Report on Integrated Sample Survey for Estimation of Milk, Egg, Meat and Wool, 1995- 96; Directorate of Animal Husbandry and Veterinary Services, Government of Karnataka.
2. Reports on Quinquennial Livestock Census, 1972, 1982, 1992; Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.
3. Report on Land and Livestock Holdings, 1992; National Sample Survey Organisation, Ministry of Programme, Planning and Implementation, Government of India.

The process of growth has been examined for milk, meat, eggs and wool for the period 1975-76 to 1995-96 (data from the Integrated Sample Survey Report). Growth rates in productive stock, output and yield have been estimated by using the semi-log production function. The contribution of yield to output growth is quantified by taking ratio of yield growth to output growth. To capture changes in growth over time, the entire period is divided into two sub-periods, that is 1975-76 to 1986-87 and 1987-88 to 1995-96. The demarcation is deliberate because of the sudden spurt in certain outputs of livestock after 1986-87.

3 POPULATION DYNAMICS

3.1 Temporal Changes

According to the 1992 Livestock Census, Karnataka accounts for 6.4 per cent of country's cattle, 5.1 per cent of buffaloes, 10.9 per cent of sheep, 5.4 per cent of goats, 3 per cent of pigs and 5.3 per cent of poultry. The changes in population of different species are presented in Tablet

Table 1 :
Trends in livestock population in Karnataka,1972-1992.

Species	Population (in lakhs)			Compound annual growth rate (%)		
	1972	1982	1992	1972-82	1982-92	1972-92
CATTLE	101.5	113.0	131.6	1.10	1.54	1.31
Indigenous	101.5	107.5	125.4	0.58	1.55	1.06
Male	50.9	52.7	61.5	0.36	1.56	0.95
Female	50.6	54.0	63.9	0.64	1.70	1.17
Sex ratio	1004	976	962	-	-	-
Crossbred	N.A	5.5	6.2	-	1.21	-
Male	N.A	1.3	1.5	-	1.44	-
Female	N.A	4.2	4.7	-	1.13	-
Sex ratio	N.A	310	319	-	-	-
BUFFALO	32.7	36.4	42.4	1.08	1.54	1.31
Male	7.2	6.3	7.4	-1.29	1.62	0.15
Female	25.5	30.1	35.0	1.68	1.52	1.60
Sex ratio	282	209	211	-	-	-
SHEEP	46.6	48.0	54.3	0.29	1.24	0.77
Indigenous	46.6	46.7	52.8	0.02	1.24	0.63
Crossbred	N.A	1.3	1.5	...	1.44	-
GOAT	37.3	45.5	62.9	2.09	3.29	2.62
PIGS	2.6	3.2	3.8	2.10	1.73	1.92
Indigenous	2.6	2.9	3.4	1.10	1.60	1.35
Crossbred	N.A	0.3	0.4	-	2.92	-
POULTRY	101.6	121.0	157.3	1.76	2.66	2.21

Source: Computed from data provided in Livestock Census reports.

3.1.1 Bovine

Bovine production system in the state is predominantly cattle based. Indigenous stock accounts for more than 90 per cent of total cattle stock (Table 1). As indigenous cattle is the predominant supplier of draft power to agriculture besides performing its usual function of milk production. This is implied in the sex ratio (males per 1000 females). It stood at 962 in 1992. Cattle population between 1972 and 1992 increased from 101 lakhs to 132 lakhs at a compound growth rate of 1.31 per cent. The growth however, slowed down during 1972-82. Further, male population increased at a slower rate, compared to female. The changes when analysed by breed reveals that population of crossbred increased slowly compared to indigenous cattle.

The share of crossbred in total cattle population in the state hardly ever exceeded 10 per cent. This is primarily because of its non-adaptability to predominant arid and semi-arid climatic conditions of the state. Frequent and high acquisition costs could also be responsible for this phenomenon. The first generation animals need to be replaced frequently as the offspring's produced from successive crosses do not perform as well as the first cross animals (McDowell, 1984; Alderman, 1987)3. Further, a crossbred male is rarely valued as source of draft power. This is corroborated by a highly adverse sex ratio to males (Table 1).

Development of input and output markets also influence rate of technology adoption. Increase in demand for milk causes a shift in favour of high yielding milk species. The peri-urban dairying is a case in point. Peri-urban dairying is largely based on crossbred cattle and buffalo. Data from Integrated Sample Survey Report, 1995-96 reveals that in Bangalore (urban) district of the state, crossbred cattle comprise about half the dairy animals and their productivity is higher than any other district of the state. This trend is likely to be strengthened as a result of increasing urban population. Lack of attention to specific needs and constraints of marginal and small farmers is also a major reason for the low adoption of crossbreeding technology in rural areas of the state (Rajapurohit(1979).

3 McDowell (1984) observed that more than half of second generation cows that are 75 per cent exotic do not live long to produce milk whereas cows that are 25 per cent exotic have little if any advantage over local breeds. Field observations by Alderman (1987) indicated that more than 50 per cent of the farmers in Karnataka depend on market for getting crossbred female cattle. This is to avoid the risk of getting an unwanted low utility crossbred male and the difficulty of breeding and feeding to the calf, if bred on own farms.

Buffalo is the other bovine species raised primarily for milk. Population of buffaloes has been growing steadily. It increased from 32.7 lakhs in 1972 to 42.6 lakhs in 1992 at a rate of 1.31 per cent a year (The consistent increase in buffalo population is not confined to Kamataka alone. This has been the case in many Indian states since last few decades (Vaidyanathan, 1988)). Highest growth was recorded during 1982-92. The sex ratio has remained low throughout. This is because the male buffalo is not an efficient source of draft power. During these two decades, male population increased at a rate of just 0.15 per cent per annum. The growth however, is erratic. Between 1972-82, it declined at a rate of 1.29 per cent a year. In the following period, there was considerable recovery.

3.1.2 Ovine

In Karnataka, goats are mainly valued for meat. Sheep is reared for both meat and wool. Crossbred sheep comprise only about 3 per cent of the total sheep population. During the period 1972-92 sheep population has increased steadily at a rate of 0.77 per cent per annum. The pattern of increase is not smooth. The total population increased at a rate of 0.29 per cent during 1972-82. However, in subsequent years population of crossbred increased faster than the indigenous sheep. Population of goats has grown rapidly between 1972 and 1992 at an annual rate of 2.62 per cent. Most of this growth resulted during 1982-92.

3.1.3 Pigs

Pigs are raised for meat production, mostly by the socially and economically backward sections of the society. However, piggery is not a popular avocation in the state. The system of production is limited to scavenging and hardly any input goes into production. Pig population in the state is low and has been hovering around 3 to 4 lakhs over the last two decades. Crossbred accounts for a meagre 10 per cent of the total population.

3.1.4 Poultry

Poultry is raised under both traditional and intensive systems of production. Traditional backyard poultry production is predominant in rural areas. The data from Integrated Sample Survey, 1995-96 indicates that only about 5 per cent of the poultry units in the state have more than 20 birds. Between 1972 and 1992, poultry population grew at a rate of 2.21 per cent a year. The rate of increase however, was higher in the latter period. The share of improved poultry is low. In 1992, improved poultry accounted for only 18 per cent of the total poultry population.

3.2 Spatial Distribution

Evolution of production systems is a long run phenomenon. The systems of production and characteristics thereof vary, depending on agro-ecological and socio-economic parameters. The National Bureau of Soil Survey and Land Use Planning classifies Karnataka into four broad ecosystems viz. arid, semi-arid, semi-arid moist, and coastal. The main characteristics of these systems are presented in Annex Table I.

Semi-arid moist ecosystem is the largest ecosystem and occupies 40 per cent of the state's geographical area. The net sown area comprises 47 per cent of total area of which 23 per cent is irrigated. More than 10 per cent of the land area is under pastures and grazing lands, which is much higher compared to other systems. The coastal climate prevails only on 12 per cent of the state's geographical area. More than half of the coastal area is under forests and only 21 per cent of the area is available for cropping activities. Arid and semi-arid ecosystems cover 21 and 26 per cent of the geographical area of the state respectively. About 70 per cent of the area in these ecosystems is under cropping activities. Average size of land holding in semi-arid and arid ecosystems is smaller, compared to semi-arid moist and coastal systems. The coverage by animal health infrastructure and dairy co-operatives in semiarid and semiarid-moist ecosystems is comparatively better.

These differences influence composition and density of livestock across the systems. While all the ecosystems accommodate different livestock species, their share in state's total livestock population in relation to area share vary. The semi-arid moist ecosystem is more flexible to accommodate all the species and has proportionately greater population compared to its area share (Table 2). Cattle, sheep and poultry are the dominant species in this ecosystem. Buffaloes and goats are also found in good numbers. The average size of land holding in this ecosystem is small, and given the favourable ecological conditions and infrastructure facilities, farmers raise a variety of species to supplement crop income. The share of semi-arid ecosystem in population of buffaloes and small ruminants is analogous to its share in total area. Arid conditions are best suited to raise small ruminants, while coastal climate does not favour small ruminant farming.

Agro-ecological and socio-economic conditions also exert considerable influence on technology adoption. Data suggests that semi-arid moist and coastal climates are more favourable to the adoption of crossbreeding technology. The proportion of crossbred cattle, sheep and pigs is higher in these systems, compared to arid and semiarid systems.

Table 2 :
Distribution of livestock across agro-ecological systems in Karnataka, 1990.

	Cattle	Buffalo	Sheep	Goat	Pig	Poultry
Zonal share in population (per cent)						
Arid ecosystem	15.92	17.33	20.97	27.81	15.46	10.70
Semi-arid ecosystem	21.83	29.77	22.65	25.08	20.99	14.09
Semi-arid moist ecosystem	50.42	44.31	56.28	46.04	42.36	58.64 ;
Coastal ecosystem	11.83	8.59	0.10	1.07	21.13	16.57
Density of livestock population (Numbers per sq km)						
Arid ecosystem	39.92 (1.30)	17.24	24.44 (0.94)	25.42	1.17 (2.88)	41.32
Semi-arid ecosystem	45.60 (3.51)	24.65	21.96 (1.16)	19.08	1.32 (3.94)	45.35
Semi-arid moist ecosystem	65.40 (10.55)	22.78	33.89 (2.82)	21.76	1.66 (9.20)	117.24
Coastal ecosystem	53.30 (7.13)	15.29	0.21 (5.26)	1.74	2.86 (14.44)	114.62
State	53.40 (7.11)	21.19	24.82 (2.05)	19.47	1.61 (8.22)	82.38

Figures in parentheses are per cent of crossbred animals. The number of districts in arid, semi arid, semi arid -moist and coastal ecosystems are 3, 4, 10 and 3, respectively. Source: Integrated Sample Survey Report, 1995-96.

3.3 Equity in Livestock Holdings

Organisation of production in the state is subsistence oriented. Average herd size is small and the pattern of distribution is closely related to distribution of land holdings. Marginal and small farm households that comprise 57 per cent of the total households, share 58 per cent of cattle, 43 per cent of buffalo, 41 per cent of sheep and goats and 74 per cent of poultry (Table 3).

Participation of the landless in dairying is low. Among the landed class, size of the bovine herd is positively associated with the size of land holding. This is true for both cattle and buffalo. However, compared to cattle, the concentration of buffaloes is higher among the medium and large farmers. Buffalo is generally stall -fed and feed fodder supply among these farmers is not a constraining factor.

Table 3 :
Distribution of livestock in Karnataka by size group of land holdings, 1992.

(No. of heads per 100 households)

	Landless (<0.002ha)	Marginal (0.002-1.0ha)	Small (1.0-2.0 ha)	Medium (2.0-4.0 ha)	Large (>4.0ha)	All
Number of households (00)	10592 (18.74)	22943 (40.59)	9223 (16.32)	8198 (14.50)	5571 (9.86)	56527 (100.00)
Total Cattle	26.93 (3.29)	135.92 (35.95)	208.00 (22.11)	236.00 (22.30)	254.51 (16.35)	153.46
Adult male	4.60	34.17	95.99	117.01	130.11	60.19
Indigenous	4.60	33.30	94.99	116.01	129.32	59.45
Crossbred	0.00	0.87	1.00	1.00	0.79	0.74
Adult females	14.33	40.25	30.77	29.66	28.16	34.24
Indigenous	9.66	34.90	26.44	23.30	24.93	28.86
Crossbred	4.67	5.35	4.33	6.36	3.23	5.38
Total Buffalo	15.13 (5.23)	36.08 (27.03)	54.00 (16.26)	81.00 (21.69)	163.74 (29.79)	54.17
Adult male	1.87	5.00	16.00	14.00	10.69	8.08
Adult female	6.73	22.08	25.00	45.00	112.00	31.87
Sheep and Goats	4.47 (1.27)	32.35 (19.91)	87.00 (21.53)	132.00 (29.04)	188.95 (28.25)	65.93
Pigs	0.00 (0.00)	1.00 (64.36)	0.00 (0.00)	1.00 (22.96)	0.81 (12.68)	0.63
Poultry	23.87 (3.22)	179.24 (52.35)	183.00 (21.49)	151.00 (15.76)	101.38 (7.19)	138.97

Figures in parentheses indicate per cent distribution.
Source: Report on Land and Livestock Holdings, 1992, National Sample Survey Organisation, Govt. of India.

Substantial variation is observed in the composition of bovine stock across different land holding classes. Except on the marginal holdings, adult male cattle outnumber adult female cattle. In terms of per centage, there is a positive relationship between ownership of adult male and size of land holding. This is plausible, as the size of land holding increases, draft power requirements too increase. One notable feature concerning cattle herd composition in the state is that the landless have a higher proportion of crossbred in their cattle stock, compared to other categories. Although, in absolute terms crossbred herd size increases with the size of holding. Adult female buffaloes outnumber adult males on all classes of land holdings and their proportion is the highest on large holdings, followed by marginal and medium holdings. This suggests that land holding is an important determinant of size of dairy herd.

It's a general belief that those who have little or no access to cultivated land raise mainly those animals that require low investment and operational expenses. Sheep and goats fall in this category. This however, does not hold true for the state of Karnataka. It is evident from

Table 3 that the distribution of these animals is heavily skewed towards medium and large holdings. The skewed distribution is largely on account of the deterioration of common property resources that provide main support to small ruminant farming by the landless and marginal farm households. Study by Pasha (1991) also indicates that distribution of small ruminants in the state is slowly getting skewed towards medium and large farm households. Supply of quality manure for crop production and ample availability of fodder from owned land are cited as principal reasons. These households also share common property resources for grazing, which invariably puts more pressure on these resources and reduces the access of the poor households.

Distribution pattern of pigs and poultry is in sharp contrast with that of ruminants. As usual, the share of landless in poultry population is low. Distribution of poultry is favourable to marginal landholders and the number of poultry birds owned per household decreases with the size of land holding. Pigs are concentrated mainly among marginal farm households.

4 GROWTH IN LIVESTOCK OUTPUT

From the discussion in the previous section it is amply evident that livestock population in the state has been growing steadily. Though, inter-species variation in growth persists. Thus, it is of interest to examine the process of growth in livestock production. This and the subsequent sections investigate process of growth in milk, meat, egg and wool production.

4.1 Milk

Over the last two decades, milk production in Karnataka has more than doubled from 1264 thousand tonnes in TE 1978-79 to 2977 thousand tonnes in TE 1995-96 (Table 4). Cattle is the dominant milch species accounting for 55 per cent of the total milk production. Buffaloes account for rest. Also there is a trivial contribution from goats.

Table 4:
Structure and growth of milk production in Karnataka, 1976-96

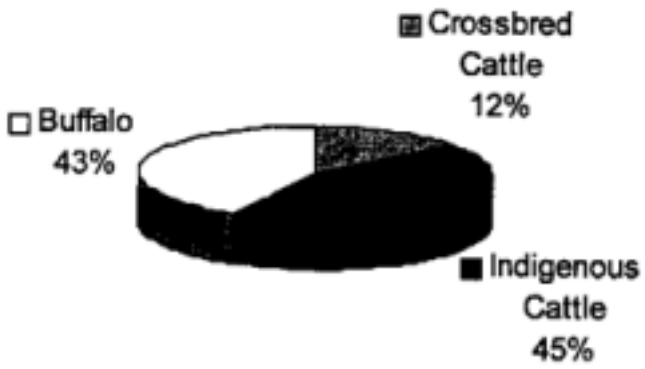
Year	Crossbred Cattle	Indigenous Cattle	Total Cattle	Buffalo	Total
Milk production ('000 tonnes)					
TE 1978-79	N.A	703.11 (55.64)	703.11 (55.64)	560.67 (44.36)	1263.78
TE 1986-87	305.37 (14.01)	945.58 (43.40)	1250.95 (57.41)	913.00 (41.90)	2178.95
TE 1995-96	548.21 (18.42)	1065.21 (35.78)	1613.42 (54.20)	1349.00 (45.32)	2976.75
Per cent annual growth					
1976-77 to 1986-87	NA	3.98	7.08	6.26	6.76
1987-88 to 1995-96	6.91	3.78	4.79	4.62	4.76
1976-77 to 1995-96	5.02	3.91	4.81	5.02	4.93

TE stands for triennium ending average. Figures in parentheses are per cent to total.
Source: Computed from data obtained from Integrated Sample Survey Report, 1995-96, Directorate of Animal Husbandry and Veterinary Services, Govt. of Karnataka.

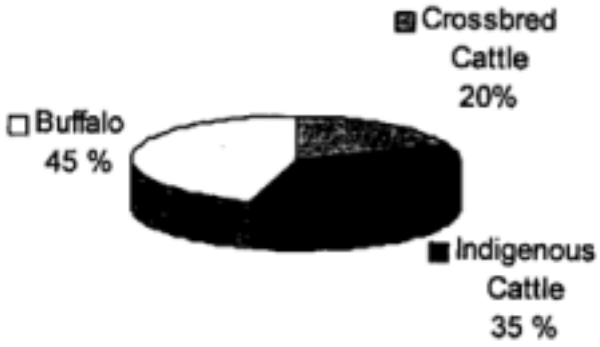
The structure of milk production has gradually undergone a transformation. Though the relative contribution of cattle and buffalo to total milk production has remained almost unchanged over the last two decades, substantial changes have occurred in the structure of cattle milk production. Share of indigenous cattle to total cattle milk production has declined substantially (Fig. 1). Contribution of crossbred cattle to total cattle milk production increased from 24 per cent during TE 1986-87 to 34 per cent during TE 1995-96.

Figure 1 : Composition of milk output in Karnataka

TE 1986-87



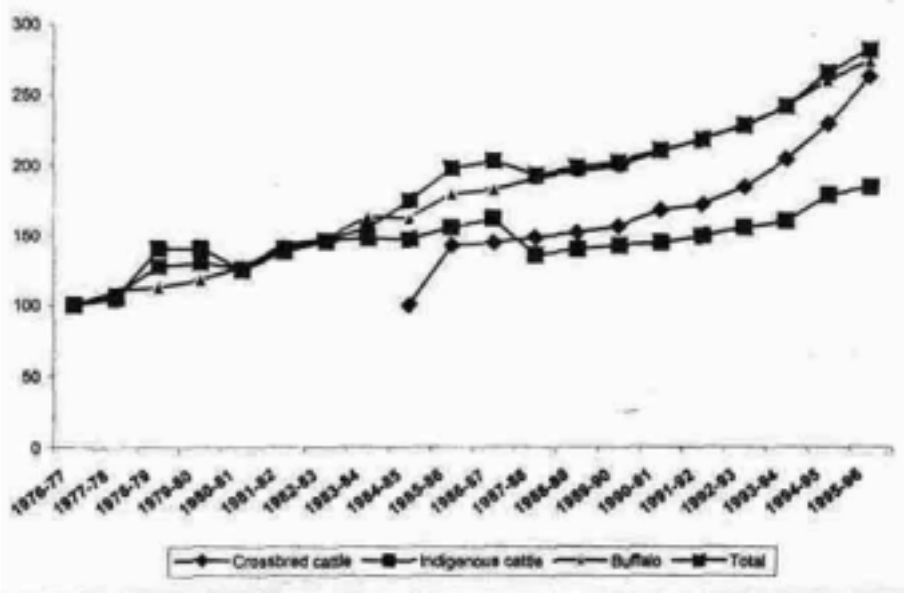
TE 1985-86



During the last 20 years, milk output increased at annual rate of 4.9 per cent. A similar trend is observed for both cattle and buffalo milk production. Among the cattle, milk production from crossbred increased at a faster rate. The growth in milk production slackened over time. It decelerated from 6.8 per cent during 1976-87 to 4.7 per cent during 1987-96. Growth rates of two periods are statistically different as the coefficient of differential slope dummy is negative and significant (Annex Table II). A similar pattern is observed for both cattle and buffalo. Cattle milk output that grew at a rate of 7 per cent per annum during 1976-87 dropped to 4.8 per cent during 1987-96. Higher growth in cattle milk production in the former period is partly due to higher growth in population of crossbred cattle. Though the information on milk output of crossbred cattle is available from 1984-85 onwards, the difference between growth rates in milk output from total cattle stock and indigenous stock lends support to this observation. Annual growth in buffalo milk output decelerated significantly from 6.3 per cent in 1976-87 to 4.7 per cent in 1987-96. The rate of deceleration however, is lower in comparison to cattle milk output.

The year 1987-88 was a drought year and *a priori* we expect drought conditions to impact milk production. This impact was however negligible (Fig. 2). After a mild decline in 1987-88, milk production maintained its increasing trend. This is also corroborated by the output regression equations estimated by incorporating an intercept dummy for the two periods. Intercept dummy is not significant in any of the equation. Further, the differential intercept coefficient turns out to be negative only in indigenous cattle output equation indicating that draft impacts mostly the less productive milch animals.

Figure 2 : Species-wise indices of milk production in Karnataka



Patel (1992) also noticed that milk production is less susceptible to draft conditions, compared to crop production. Farmers could manage to sustain the level of milk production by getting rid off the less productive animals. It is in order to note that the number of animals slaughtered in 1987-88 was almost twice the numbers slaughtered in 1986-87 (see Fig. 5). The important lesson that emerges is that milk production can be sustained even under stress if population is optimised concordant to available feed-fodder resources. Such lessons become vital for feed-fodder deficit states like Karnataka (Singh and Majumdar, 1992; Pasha, 1991; Prasad, et al, 1995). This underscores the income stabilising and risk-averting role of livestock.

4.2 Meat

Meat production between TE 1980-81 and TE 1995-96 increased five-folds at an impressive rate of over 9 per cent per annum (Total meat output is exclusive of poultry meat). More than 70 per cent of the meat supplies come from sheep and goats (Table 5).

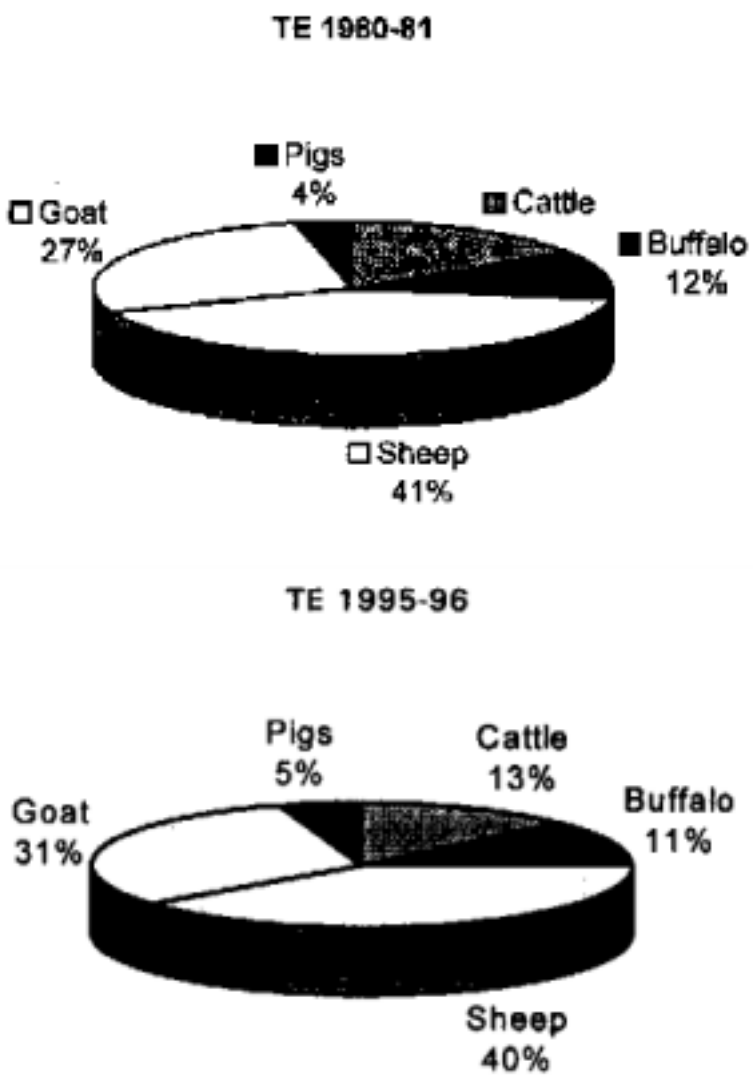
Table 5 :
Trend in meat production in Karnataka, 1978-96

Year/Period	Cattle	Buffalo	Sheep	Goat	Pig	Total
Meat output (tonnes)						
TE 1980-81	2002 (15.50)	1516 (11.74)	5374 (41.62)	3552 (27.51)	469 (3.63)	12913
TE 1986-87	2832 (8.93)	1843 (5.81)	13342 (42.07)	13019 (41.05)	679 (2.14)	31715
TE 1995-96	8389 (13.04)	7312 (11.36)	25634 (39.83)	19844 (30.84)	3175 (4.93)	64355
Per cent annual growth						
1978-79 to 1986-87	5.27	2.20	16.03	22.99	7.17	15.36
1987-88 to 1995-96	4.64	9.74	2.64	3.09	11.11	4.06
1978-79 to 1995-96	4.95	5.97	9.33	13.04	9.14	9.17

Figures in parentheses are per cent to total.

Of the 6.4 lakh tonnes meat produced in the state during TE 1995-96, the contribution of sheep was 40 per cent (Fig. 3). Cattle and buffalo contribute 11 and 13 per cent respectively.

Figure 3 : Composition of meat output in Karnataka

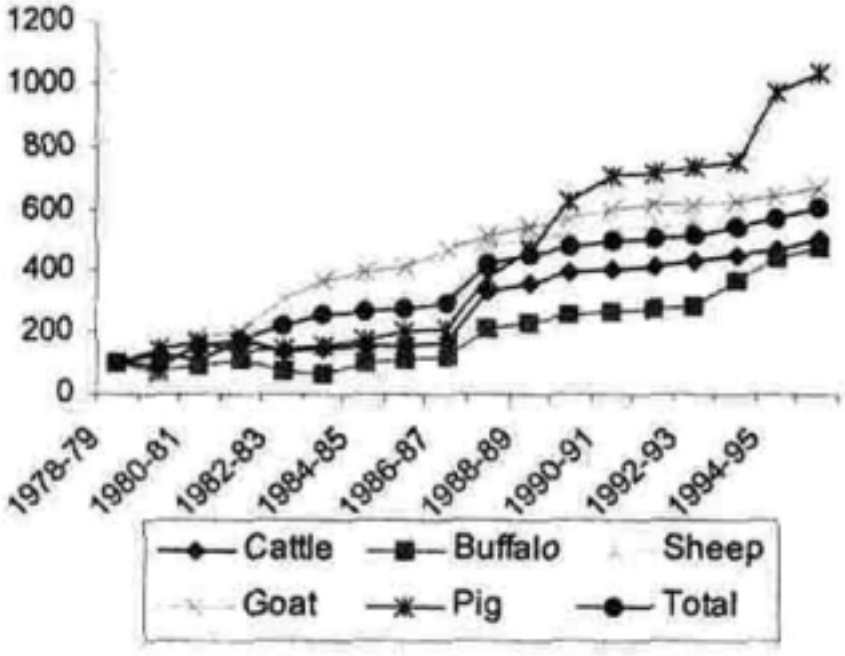


Over time wide fluctuations are observed in the contribution of different species. Share of cattle, buffalo and pig declined between TE 1980-81 and TE 1986-87, but increased in the succeeding period. On the other hand, share of goats increased from 28 per cent in TE 1980-81 to 41 per cent in TE 1986-87 and dropped to 31 per cent in TE 1995-96. Sheep has upheld its share of about 40 per cent over the period.

Meat production in 1987-88 over 1986-87 increased drastically and this trend continued thereafter (Fig. 4). The positive and significant differential intercept in cattle, sheep and goat meat growth equations ; substantiates this (Annex Table II). Substantial rise in meat production in 1987-88 was mainly on account of drought conditions that forced the livestock owners to dispense unproductive and infertile animals (The number of cattle and buffalo slaughtered during 1987-88 doubled over the previous year and the number of sheep, goats and pigs slaughtered increased by a factor of 1.4,1.2 and 1.7 respectively. Subsequently, the slaughter rates in all the cases kept on increasing). Continuance of this trend after 1986-87is due to the increase in intern and external demand for different types of meat. The demand for meat highly income elastic. As per capita income increases, consumption pattern of the

masses undergoes a distinct shift. Once the social/consumption taboos break they have a propensity to persist. The post 1987-88 trend in meat production is an indicator to this.

Figure 4 : Species- wise indices of meat production in Karnataka



Export demand for meat has also grown in recent years. Between 1987-88 and 1995-96 the meat export in quantity terms increased by 188 per cent (Kondaiah, 1997). The performance however varied depending on the type of meat exported. The data indicates a negative trend in sheep and goat meat export during 1984-89. Subsequently, this trend has reversed. Export of mutton is constrained by high domestic demand and high domestic price. Bovine meat exports increased sharply in 1987-88 over 1986-87 and thereafter maintained a sustained rise mainly due to its price competitiveness. A favorable trade policy regime in the latter period also helped sustain the rise in meat production. Government of India chipped in with numerous incentives to stimulate exports.

Establishment of Export Oriented Units and Export Processing Zones and financial assistance to Export Oriented Units were the major steps in this direction.

There is substantial variation in growth performance of different species. All through, goat and sheep meat production grew at a rate of 13 per cent and 9 per cent a year, respectively (Table 5). Cattle and buffalo meat output grew at a rate of 5 and 6 per cent per annum respectively.

Growth in meat production started to taper off after 1986-87. It decelerated from 15 per cent to 4 per cent. The difference is statistically significant at 5 per cent (Annex Table II). However, this is not applicable to all the species. Sheep and goat meat production decelerated sharply and significantly. There was a marginal decline in cattle meat output growth. On the other hand, buffalo and pig meat output grew at an accelerated rate during the latter period, which is largely export-led (Kondaiah, 1997).

4.3 Eggs

Karnataka is one of the major egg producing states in the country with a share of about 6 per cent in country's total poultry population and 4 per cent of the total eggs produced. During the last two decades, egg production grew at a rate of 2.5 per cent a year. (Table 6). However,

over time the growth in egg production has decelerated significantly (Annex Table II). It declined from 3.1 per cent during 1976-87 to 1.4 per cent during 1987-96.

Table 6 :
Trend in egg and wool production in Karnataka, 1976-96

Year/Period	Eggs produced (Nos. in lakhs.)	Wool production (tonnes)
TE 1978-79	6003.00	2062.67
TE 1986-87	10624.33	3434.33
TE 1995-96	14815.67	4040.67
Growth rate (per cent per annum)		
1976-77 to 1986-87	3.07	6.40
1987-88 to 1995-96	1.38	1.52
1976-77 to 1995-96	2.48	3.79

Source: As in Table 4.

The deceleration in growth is by and large due to the poor adoption rates of hybrid layers and stagnation in egg yield. Per centage of hybrid layers in total layers increased marginally from 29 per cent in 1984-85 to 32 per cent in 1995-96. Presently hybrid layers contribute more than 50 per cent to total egg production in the state. One of the reasons for the slow adoption of hybrids is their vulnerability to diseases, while the *Desi* breeds are inherently disease resistant (POP, 1997).

4.4 Wool

Over the last two decades wool production has witnessed a moderate growth of 3.8 per cent a year. (Table 6). It may be noted that in southern parts of the country including Karnataka sheep are primarily raised for meat. About half of these do not yield any wool (CSWRI, 1997). Most of the wool produced is coarse and hairy. The growth in wool production slackened. It dropped from 6.4 per cent during 1976-87 to 1.5 per cent during 1987-96. This deceleration is an outcome of rapid increase in slaughter rates of sheep, particularly lamb that fetches a premium price.

5 SOURCES OF OUTPUT GROWTH

Livestock sector in Karnataka has performed reasonably well considering growth in major outputs of livestock. As output is determined by population and productivity, this section examines changes in productive stock and its productivity, and contribution thereof to output growth.

5.1 Milk

Growth in milk production is mainly productivity driven. Two-thirds of the growth in cattle milk production resulted due to yield improvements (Table 8). In other words, productivity of cattle has increased faster than the stock. Cattle milch stock and its productivity over the last 20 years grew at a rate of 1.7 and 3.1 per cent respectively (Tables 7 and 8). However, these parameters vary across crossbred and indigenous breeds. The growth rates in stock as well as productivity are higher for crossbred cattle. Since population and productivity of buffalo grew at identical rates (2.5 per cent a year), they account equally for the growth in milk production.

Table 7 :
Compositional changes and growth trends in milcll stock in Karnataka, 1976-96

Year	Crossbred Cattle	Indigenous Cattle	Total Cattle	Buffalo	Total
Population (lakhs)					
TE 1978-79	NA	26.00 (63.28)	26.00 (63.28)	15.09 (36.72)	41.09
TE 1986-87	2.32 (4.35)	30.63 (57.48)	32.92 (61.83)	20.34 (38.17)	53.29
TE 1995-96	3.37 (5.60)	33.00 (54.83)	36.37 (60.43)	23.82 (39.57)	60.19
Per cent annual growth					
1976-77 to 1986-87	NA	2.22	3.02	3.99	3.38
1987-88 to 1995-96	4.31	0.60	0.92	1.45	1.13
1976-77 to 1995-96	4.13	1.64	1.67	2.51	1.98

Figures in Parentheses are per cent to total.
Note: For crossbred cattle, the information is available from 1984-85 onwards, hence growth rates for the period 1976-87 are not reported.
Source: As in Table 4.

The structure of output growth has changed over time. Contribution of productivity to cattle milk output growth increased from 57 per cent during 1976-87 to 81 per cent during 1987-96. In case of buffalo, it almost doubled from 36 per cent to 69 per cent. This is on account of higher growth in productivity.

Growth in total milch stock slackened in post 1987 period. It fell from 3.4 per cent to 1.1 per cent and the difference between the two is statistically significant (Annex Table III). Growth in population of milch cattle decelerated from 3 per cent during 1976-87 to below one per cent during 1987-96. The deceleration however, is sharper in case of indigenous breeds. On the other hand, productivity increased at a rate of about 4 per cent in both the periods. Growth in buffalo milch stock decelerated significantly from 4 per cent during 1976-87 to 1.5 per cent during 1987-96. Its productivity however, increased at a faster rate during the latter period. Yet, the difference in productivity growth of two

periods is not statistically significant. Thus, in case of both cattle and buffalo deceleration in population growth transformed the structure of production in favour of productivity.

Table 8 :
Growth in milk yield and its contribution to output growth in Karnataka, 1976-96

Year	Crossbred Cattle	Indigenous Cattle	Total Cattle	Buffalo
Milk yield (Kgs per annum)				
TE 1978-79	NA	270.43	371.55	307.56
TE 1986-87	1316.25	308.71	488.87	406.06
TE 1995-96	1626.74	322.79	566.33	492.18
Per cent annual growth				
1976-77 to 1986-87	NA	1.76	4.06	2.27
1987-88 to 1995-96	2.61	3.18	3.87	3.17
1976-77 to 1995-96	2.46	2.26	3.14	2.51
Contribution of yield to output growth (%)				
1976-77 to 1986-87	NA	44.22	57.34	36.26
1987-88 to 1995-96	37.77	84.13	80.79	68.61
1976-77 to 1995-96	49.00	57.80	65.28	50.00

Source: As in Table 4.

It is in order to note that despite rapid deceleration in the stock of indigenous cattle, overall growth in cattle milk yield remained almost unaffected. This is on account of two factors. First, in the post 1986-87 period the productivity of indigenous cattle increased faster, though starting from a lower base as indicated by the significantly negative differential intercept coefficient (Annex Table IV). The second reason being the increasing share of crossbred cattle to total milk production. There are substantial differences between milk yields of indigenous, crossbred cattle and buffalo (Table 8). Crossbred cattle and buffalo have comparative advantage over indigenous cattle in milk production because of their better feed conversion efficiency (Nair,1979). During TE 1995-96 the average milk yield of a crossbred cattle was estimated to be 1627 kgs per annum, which is about 5 times that of an indigenous cattle. Similarly, the annual milk yield of buffalo is about 1.5 times than that of indigenous cattle.

Though growth in numbers has declined on account of limits to carrying capacity, growth in productivity has sustained. Thus, future growth in milk would result from improvements in productivity and a shift the herd structure in favour of crossbred cattle and buffalo is inevitable if the current output trends are to be maintained. Gaddi and Kunnal (1997) observed that milk productivity in Karnataka can be raised by 47 per cent by bringing about changes in herd structure in favour of crossbred cattle without any additional demand for feed and fodder. However, crossbreeding technology has been censured on grounds of being exotic and non-adaptable to varied climatic conditions. Cattle breeding research should therefore, explicitly focus on issues relating to ecological adaptability.

Population of buffalo has been increasing steadily because of its adaptability to varied climates. Its productivity too has been on a rising trend. Thus, genetic improvement in buffalo is likely to provide a big push to the milk economy. It is in order to mention that a notable breakthrough has taken place in crossbreeding of buffalo in China and results are quite promising (Sasaki, 1997). In this context, about two decades ago Rajapurohit (1979) held that if the production potential of buffalo could be improved through artificial insemination most farmers may prefer crossbred buffalo to crossbred cattle. This is

because even those farmers operating under resource constraints are well acquainted with buffalo management practices.

Shift in herd structure and breed improvements are long term strategies for raising milk production. In the short run, however, there is considerable scope to raise the contribution of productivity to output growth by improving animal nutrition. Nutritional technologies such as urea treatment of fodder, urea molasses blocks, bypass protein, etc. help raise milk yield and reduce feed fodder requirements (Chatterjee and Acharya, 1992; Patil, et al, 1993; Singh, et al, 1995) (It has been reported that Urea treatment of fodder and urea molasses blocks increase milk yield by about 20 percent. By-pass protein technology reduces concentrates abd dry-matter requirements by 30 and 40 percent respectively).

5.2 Meat

From the late 70's, meat production in the state has grown at a rate of over 9 per cent per annum. The leap in meat production especially after 1986-87 is *via* the increase in number of animals slaughtered (Table 9). The slaughter rate of sheep increased from about 11 per cent during TE 1980-81 to 37 per cent during TE 1995-96. The corresponding rates for goat are estimated to be 9 and 54 per cent. This phenomenon was triggered off by the drought in 1987-88 and continued thereafter (Figure 5). This is also captured by the distinct upward shift in the intercept value (Annex Table III). The shift however, is more prominent in case of cattle, sheep and goat.

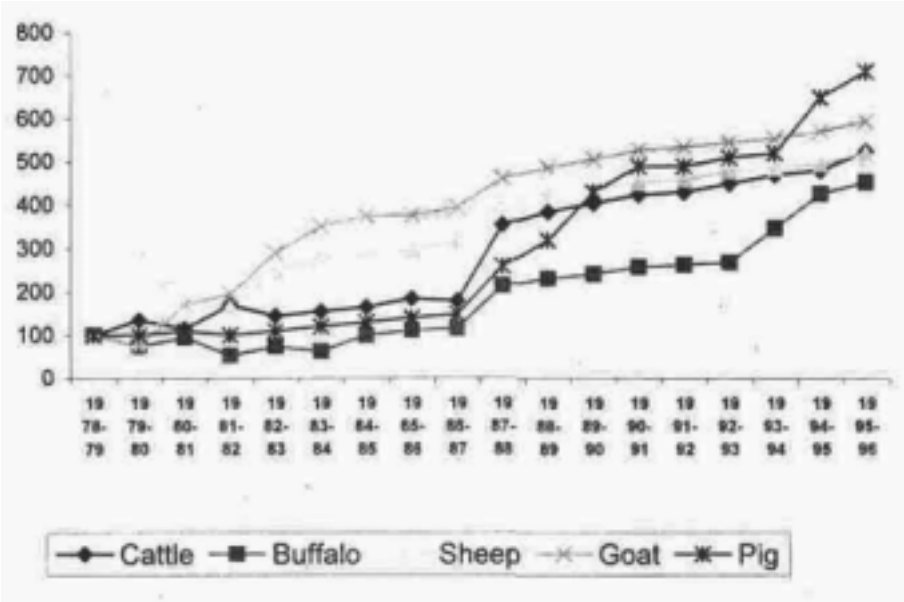
Table 9 :
Growth in number of animals slaughtered in Karnataka, 1978-96.

Year/Period	Cattle	Buffalo	Sheep	Goat	Pig	Total
Number of animals slaughtered (lakhs)						
TE 1980-81	0.23 (0.21)	0.17 (0.49)	4.95 (10.81)	3.20 (8.80)	0.11 (3.58)	8.66
TE 1986-87	0.35 (0.33)	0.21 (0.54)	12.34 (24.50)	10.65 (24.95)	0.14 (4.95)	23.69
TE 1995-96	0.98 (1-14)	0.78 (1.70)	20.45 (36.69)	16.00 (53.96)	0.63 (27.04)	38.84
Per cent annual growth						
1978-79 to 1986-87	6.54	3.49	16.34	20.95	5.25	17.69
1987-88 to 1995-96	4.30	9.26	2.74	2.84	10.94	3.03
1978-79 to 1995-96	5.42	6.37	9.54	11.90	8.09	10.36

Figures in parentheses are per cent animals slaughtered.
Source: As in Table 4.

Total number of animals slaughtered in the state increased at a rate of 10.4 per cent per annum. Considerable variation is observed in growth rates across species. Slaughtering of goats, sheep and pig increased at a rate of 12 per cent, 10 per cent and 9 per cent a year respectively. This is estimated at 6.4 per cent for cattle and 5.4 per cent for buffalo. It 7 It has been reported that Urea treatment of fodder and urea molasses blocks increase milk yield by about 20 per cent. By-pass protein technology reduces concentrates and dry-matter requirements by 30 and 40 per cent respectively. This is estimated at 6.4 per cent for cattle and 5.4 per cent for buffalo may be noted that for most species, growth rates in slaughtering are comparable to growth rates in their outputs.

Figure 5 : Species - wise indices of animals slaughtered in Karnataka



Between the period 1978-87 and 1987-96 substantial differences in growth rates of slaughtered animals are observed. Growth in slaughtering decelerated significantly in the latter period largely on account of shift in the base (Annex Table III). However, this is not uniform across the species. Growth in slaughtering of sheep and goats decelerated sharply and significantly. In case of pigs it got almost doubled. Growth in slaughtering of buffaloes too accelerated, but not significantly. On the other hand, growth in cattle slaughtered declined marginally. Differences in growth rates between two periods are attributable to inter-species differences in slaughter rates. The current slaughter rates of sheep and goat are almost equivalent to their potential. In case of buffalo, pig and cattle there is considerable scope to raise their slaughter rates (At the national level, about five per cent of the cattle and ten per cent of buffaloes are slaughtered every year which is equivalent to one-third of the potential off-take and about two-thirds of potential off-take of buffaloes (World Bank, 1996)). The slaughter rate of both cattle and buffalo in the state has never exceeded 2 per cent. This is true for a majority of the states in the country. Religious and cultural reasons are responsible for the low consumption of bovine meat. In many states including Karnataka slaughtering of cattle is banned. Unlike cattle, buffalo slaughtering is not subject to taboos, yet its slaughter rate is low and confined mainly to males.

Performance of meat sector in terms of productivity is dismal. Meat yields of almost all the species have been stagnating over the last two decades (Table 10). Meat yield of cattle and buffalo declined at a rate of 0.5 and 0.4 per cent a year respectively. The trend however, is not uniform. During the period 1978-87, meat yield of cattle showed a declining trend, but it improved significantly in the subsequent period and turned out to be positive at the margin (Annex Table IV). Similar is the case with buffalo, but the improvement in yield is not statistically significant. Sheep meat yield showed a negative trend throughout. In the latter period, the rate of decline was slightly checked. Goat meat yield increased at a rate of 2 per cent a year during 1978-87. In the following years it displayed a significant downward trend. An identical pattern is observed for pigs.

Table 10 : Growth in meat yield and its contribution to output growth in Karnataka, 1976-96

	Cattle	Buffalo	Sheep	Goat	Pig
Meat output per slaughtered animal (Kgs)					
TE 1980-81	87.04	89.18	10.86	11.10	42.67
TE 1986-87	80.91	87.76	10.81	12.22	48.52
TE 1995-96	85.60	93.74	12.54	12.40	50.40
Per cent annual growth					
1978-79 to 1986-87	-1.27	-1.29	-0.31	2.04	1.92
1987-88 to 1995-96	0.34	0.48	-0.10	0.25	0.17
1978-79 to 1995-96	-0.47	-0.40	-0.21	1.14	1.05
Contribution of yield to output growth (%)					
1978-79 to 1986-87	-24.10	-58.64	-1.93	8.87	26.78
1987-88 to 1995-96	7.33	4.93	-3.79	8.09	1.53
1978-79 to 1995-96	-9.49	-6.70	-2.25	8.74	11.49

Source: As in Table 4.

Thus, numbers has driven growth in meat output so far (Table 10). Except for goat and pig, the growth in production is exclusively due to growth in number of animals' slaughtered. In fact, output growth shrunk by 9.5 and 6.7 per cent for cattle and buffalo respectively due to decline in productivity. Plummeting productivity in 1978-87 acted as a drag on the output growth. In the subsequent period meat yield of both the species improved and its share in output growth turned marginally positive.

Yield has contributed negatively to output growth in both the periods in case of sheep. In case of goat, yield has contributed positively and consistently (about 9 per cent) to output growth. Yield contributed the most to output growth in case of pigs. During 1978-87 its contribution was estimated to be 27 per cent, but during the subsequent period it fell below 2 per cent. The sharp decline in contribution of yield during the latter period was on account of slowing down of growth in yield. Faster growth in yield during 1978-87 could partly be attributed to introduction of high meat yielding crossbred pigs. Information on pig population is available from 1982 onwards. In 1982, the crossbred pigs comprised 10.4 per cent of total pig population in the state and since then their proportion has almost remained constant. That meat production in the state is determined by slaughter rates is clearly brought out by the identical growth rates between the number of animals slaughtered and their meat output.

A host of economic factors are responsible for the poor growth in meat yield and contribution thereof to output growth. Large animals, i.e. cattle and buffalo are raised for milk production and provide meat as an adjunct. Generally, animals slaughtered are of poor quality. Surplus buffalo males and unproductive animals of both cattle and buffalo are used for meat production. Animals slaughtered among cattle are usually old, infertile and malnourished. Buffalo meat production is mainly sourced from the male. This is confirmed by the highly adverse sex ratio to males. In 1992, the sex ratio for adults and young stock was 375 and 136 respectively (Calculated from figures provided in Livestock Census, 1992.). Slaughtering young calves is a potential waste of meat.

Stagnation in yield of small ruminants is a matter of concern. Quantitative and qualitative deterioration of common property resources, extensive system of production and lack of technological breakthrough are the prominent reasons for stagnating yields. Common property resources in the state have deteriorated invariably. This emerges from a study of 12 villages in Karnataka undertaken

by Jodha (1992) which shows that between 1950-51 and 1981-82, community grazing land declined by 40 per cent and the number of watering points by 75 per cent.

Simultaneously, grazing pressure on land kept on increasing due to the increase in livestock population and intensification of agriculture.

The system of production is largely subsistence oriented. It may be recalled that flock density per household in the state is rather low. Only a small proportion of sheep and goat population is raised under intensive or semi-intensive systems of production. In this context, it is important to note that unlike in northern and western regions, where the small ruminants production system is characterised by nomadism, in the southern parts of the country the small ruminant production system is predominantly sedentary (World Bank, 1996). Animals sustain mainly by grazing and the feedlot system is yet to develop.

Small ruminant research has received relatively less attention in India. Evidences indicate that the allocation of livestock research expenditure to small ruminants is disproportionately low compared to their contribution to gross value of livestock output (World Bank, 1990; Jha, et al, 1995). In recent decades, breed improvement efforts for increasing body weight are underway. Their impacts at the field are yet to be realised. Paying attention to nutritional and health aspects can increase meat yields of existing stock in the short run. Yazman et al (1995) observed that under field conditions physical as well as economic goat meat yield improved with supplementary feeding. Regarding role of technology in sustaining output growth, Devendra and Burns (1983) mention that 'improved veterinary care, nutrition and other aspects of husbandry may achieve spectacular gains when first introduced, but sooner or later breeding policy will have to be considered, and the genetic potential of stock assessed. It is worth mentioning here that goat meat yield in Pakistan is about twice that in India (Malhotra, 1997), despite having similar agro-climatic conditions. Though India is rich in animal genetic diversity, their potential is yet to be fully assessed (CIRG, 1997; CSWRI, 1997).

5.3 Eggs

Growth in egg production in the state is largely on account of the population of layers (Table 11). In the last two decades, population of layers increased at an annual rate of 2 per cent, while its yield showed a growth of just 0.48 per cent. Annual egg production per bird increased from 142 during TE 1978-89 to 159 during TE 1986-96 at an annual rate of 0.66 per cent. Subsequently, there was significant deceleration in productivity. Growth in population slackened from 2.4 per cent in the period 1976-87 to 1.2 per cent in the following period. The deceleration in population growth is largely due to the upward shift in the base year population in 1987-88 over 1986-87 (Annex Table III). This reveals the coping strategy of the farmers during times of crisis through enterprise diversification like poultry that requires little investment and operational expenses but generates continuous stream of income.

Table 11 : Trend in contribution of yield to egg output growth in Karnataka, 1976-96

Period	No. of layers (lakhs)	Eggs/bird per annum	Contribution of yield to output growth (%)
TE 1978-79	42.35	141.75	-
TE 1986-87	66.97	158.64	-
TE 1995-96	102.42	144.65	.
Annual growth rate (%)			
1976-77 to 1986-87	2.41	0.66	21.50
1987-88 to 1995-96	1.24	0.14	10.14
1976-77 to 1995-96	2.00	0.48	19.35

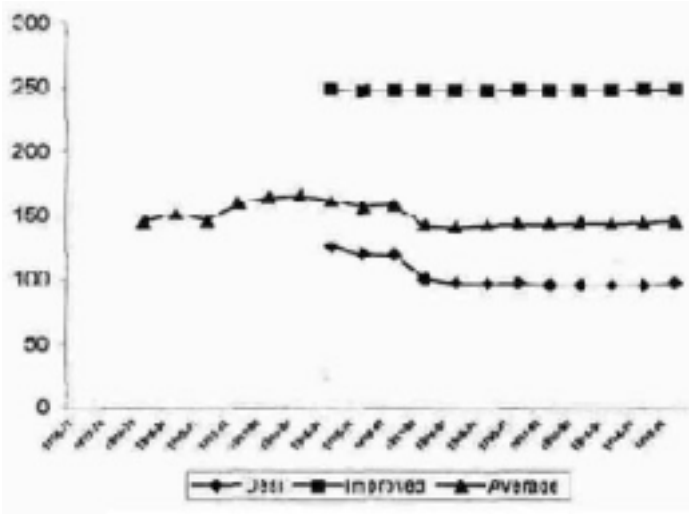
Source: As in Table 4.

Yield is largely determined by the technological composition of the flock. An improved layer has the potential to lay 2-3 times more eggs than a *Desi* layer. It may be recalled that in pre 1987-88 period the proportion of hybrid layers in total layers was high compared to the latter period. Thus, higher growth in egg yield during 1976-87 was mainly technology driven. Another factor causing deceleration in yield growth was the decline in yield of *Desi* layers (Fig 6).

The problems of feed supplies and incidence of diseases during early nineties are responsible for the relatively low adoption rate of hybrid layers. For example, the poultry industry faced an acute shortage of feed in April 1992, resulting in the sharp increase of feed prices (World Bank, 1996). This resulted in the premature culling of layers and a consequent decline in the population of layers. The outbreak of infectious diseases like *Gumboro* in 1993 in many parts of the country including Karnataka also had an adverse effect on the growth of egg production.

Poultry in the rural segment of the state is gradually undergoing technological transformation. However, productivity improvements account for only about 20 per cent of the growth in egg production. The contribution of yield has declined over time, owing largely to factors discussed above. Nonetheless, the role of technology in egg production , needs no emphasis and a shift in the poultry population in favour of hybrid layers would result in increased egg production.

Figure 6 : Trend in contribution of yield to wool output growth in Karnataka, 1976-96



As rural poultry is raised under extensive systems of production, efforts are required to intensify the system of poultry production. Hardly about 5 per cent of poultry units have more than 20 birds per unit (Integrated Sample Survey Report, 1995-96). By virtue of its being located away from urban centres from where the most of demand for eggs originates it faces problems of feed supply, support services, marketing and transportation. This acts as a disincentive for intensive poultry farming. That about two-thirds of the eggs produced are meant for home consumption (Integrated Sample Survey Report, 1995-96) lends support to our argument.

5.4 Wool

Wool productivity in the state is about 0.7 kgs, less than the national average of 0.9 kgs. However, wool yield has been increasing continuously. Yield accounted for about two-thirds of the growth in wool production in the state (Table 12). This however, varied substantially between two sub-periods. During 1976-87, wool production per sheep grew at a rate of 5.6 per cent a year, while the growth in sheep population was below one per cent. Thus, the growth in wool production during this period was mainly productivity-led. In the following period, population grew at a rate of 1.3 per cent, significantly higher than that in the previous period (Annex Table III). Though wool yield kept on increasing all through, its rate of increase slowed down in the latter period.

Table 12 : Trend in contribution of yield to wool output growth in Karnataka, 1976-96

Period	Sheep population (lakhs)	Wool Yield (gms)	% contribution of yield to output growth
TE 1978-79	45.47	453.60	-
TE 1986-87	49.80	689.62	-
TE 1995-96	55.73	725.04	-
Annual growth rate (%)			
1976-77 to 1986-87	0.76	5.65	88.12
1987-88 to 1995-96	1.32	0.19	12.50
1976-77 to 1995-96	1.31	2.48	65.44

The structure of wool production underwent substantial transformation as a result of variation in population and yield growths. Contribution of yield to output growth dropped from 88 per cent during 1976-87 period to 13 per cent in the later years. Limits to growth in productivity and technological backwardness are plausible reasons behind the drop.

In the country, breed improvement efforts in sheep have largely focussed on raising wool yield through crossbreeding. Under field conditions, crossbred sheep have been found to perform better than indigenous sheep (Sharma, et. al, 1995). In Punjab, where crossbred sheep account for about 25 per cent of the sheep population, wool yield is estimated to be above 2 kgs. In recent years, sheep population in Karnataka has increased. But, the share of crossbred sheep in total sheep population has not exceeded 3 per cent. Adoption of crossbreeding technology in the state is rather low as sheep is raised more for meat than wool.

Therefore, certain studies have reported that at existing level of technology, sheep husbandry is not an economically attractive enterprise (Swain, et al, 1982; Rath, 1992). This however needs a further probe.

Notwithstanding reasons for low adoption of crossbred sheep, findings clearly bespeak that in the long run growth in wool production would result from a shift in flock structure in favour of genetically improved breeds. The shift would largely be determined by the relative profitability of wool and meat production. Quantitative and qualitative improvements in common property resources and changes in organisation of production in favour of intensive sheep production would also influence this shift.

6 DETERMINANTS OF PRODUCTIVITY

Irrespective of whether the past growth is driven by numbers or productivity, the latter is crucial to sustain output growth in the long run. Productivity is mainly defined by the genetic constitution of the animal. The extent to which the genetic potential can be realised depends on quantity and quality of feeding, management, health care, etc. In this section a probe is made into the factors that influence milk and meat yields.

6.1 Determinants of Milk Yield

At the existing level of technology and prevailing organisation of production; there is considerable scope to raise productivity of the milch stock. This is manifested by the difference in actual and attainable yield (Attainable yield varies across breeds. *Amritmahal, Hallikar, Deoni* and *Khilari are* the prominent cattle breeds in Karnataka. The attainable yield per lactation is reported to be 542 Kgs for *Hallikar,* 880 Kgs for *Deoni,* 215 kgs for *Khilari* and about 500 Kgs for *Amritmahal.* For crossbred cattle the attainable yield is about 3000 kgs per lactation. *Murrah* and *Surti are* the important breeds of buffalo found in Karnataka with milk production potential of about 1600 and 1800 kgs per lactation . For details see, Pundir and Sahai (1997)) . Further, there are interregional differences in the adoption of technology and performance of dairy animals (Annex Table V). Notwithstanding interregional differences in production performance, current mean yield of indigenous cattle is about three-fourths of the attainable yield for the predominant breeds in Karnataka -*Hallikar* and *Amritmahal* and *Deoni.* Yield gap for crossbred cattle is to the tune of 50 per cent. A gap of similar magnitude exists for buffaloes too.

To examine the factors that influence productivity of milch stock, regression equations are estimated using district level cross-section data with annual milk yield per milch animal (AMYD) as the explanatory variable. Means and standard deviations of the variables are provided in Annex Table VI.

6.1.1 Selection of variables

Technological change is likely to have a profound impact on the future structure of output growth. Since breed improvement in cattle has been an important component of India's livestock development policy, per centage of crossbred in total milch cattle population (XBRED) serves as a good proxy for technological change in dairy sector.

Further, in many parts of the country including Karnataka, buffalo population is growing faster than cattle. Moreover, milk yield of buffalo is higher than that of indigenous cattle. Thus, to assess whether such a shift in herd structure could help increase milk production/productivity, per centage of milch buffaloes in the total milch stock (BUFF) is considered as one of the factors in raising overall milk productivity.

Gains from technology and shifts in herd structure cannot be realised to its full capacity if inputs such as feed fodder, animal health services, etc. are in short supply. Feed fodder supply is central to any livestock activity. Since milch bovines are largely stall-fed, area under fodder crops in a district in relation to bovine milch stock (FMA) is taken as a proxy for feed fodder supplies. Feed fodder supplies however, vary across the land holdings. *A priori,* it is expected that the feed fodder constraint is more severe on marginal and small holdings, compared to medium and large holdings. Therefore, the per centage of marginal and small land holdings in the total holdings (PSMF) is also included in the set of explanatory variables.

Role of institutions and infrastructure in livestock development needs no underscoring. In India, animal health infrastructure and dairy cooperatives have witnessed significant growth over the last two decades, which are likely to impact milk yield. Incorporating the density of

public funded animal health institutions (DAHS) in the regression analysis captures impact of animal health services on milk yield.

Dairy co-operatives have emerged as a powerful catalyst in transforming the dairy sector in some of the states in the country. Consequentially, milk production increased *via* popularising dairying as a profession. Vertical marketing linkages between producers and consumers got strengthened in the process. While the role of dairy co-operatives in augmenting milk production is well recognised, their impact on productivity is ambiguous (Alderman, 1987). This is captured by including intensity of primary dairy co-operatives (DCOP) in a district in the analysis.

Independently, each of the specified variables is important in milk production. Some of these particularly XBREED, DAHS and DCOP are highly correlated and embodiment of all these together in the equation would affect the regression estimates (Correlation between variables XBRED and DAHS is rather high (0.88). Similarly, it is 0.75 between DAHS and DCOP). In order to arrive at an unbiased and precise estimates, different combinations of explanatory variables were tried, separately for cattle and buffalo as well for their weighted milk yield (Linear and log-linear functions were tried to examine the effect of various factors on milk yield. Based .on coefficient of determination and significance of variables the linear form gave a better fit. We also tried to capture the variation in yield across different agro-ecological zones by including zone dummies, however none of these turned out to be significant). The equations for the weighted milk yield however, provided the best fit (Table 13).

Table 13 :
Linear estimates for determinants of milk yield, 1995-96

Dependent variable: Annual milk production in Kgs per milch animal (AMYD)

Explanatory variables	Eq. I	Eq.II	Eq. III	Eq. IV	Eq. V	Eq. VI
Per cent of crossbred milch cattle in total milch cattle (XBRED)	16.98 (6.03)***	-	15.16 (5.86)""	-	-	17.51 (9.33)***
Per cent of milch buffalo in total milch stock	3.10 (1.41)	-2.11 (0.78)	-	-	-	4.80 (2.77)**
Number of veterinary institutions per 100 sq. km of geographical area (DAHS)	-	163.52 (3.50)*"	-	16.88 (3.64)***	181.87 (5.56)***	-
Number of dairy co-operatives per 100 sq. km of geographical area (DCOP)	1.99 (0.23)	2.80 (0.45)	4.67 (0.52)	6.01 (0.48)	-	-
Area under fodder crops per 1 00 milch bovines (FMA)	9.58 (0.56)	43.17 (1.78)*	20.79 (1.25)	36.15 (1.63)	40.32 (2.02)**	-
Per cent of marginal and small land holdings in total holdings (PSMF)	-2.46 (1.59)	-5.43 (2.50)**	-3.37 (2.37)**	-4.79 (2.41)**	-4.76 (2.46)**	-
Constant term Coefficient of determination (R^2)	364.55 0.86	552.59 0.73	539.4 0.84	429.21 0.73	419.51 0.72	150.36 0.84
F value	17.64	7.87	20.23	9.95	13.85	43.6

Figures in parentheses are t-values. ***,** and * indicate significance level at 1, 5 and 10 per cent respectively.

6.1.2 Results

As anticipated, XBRED has a positive and significant impact on AMYD, endorsing our observation that future growth in milk production would be technology driven. The regression estimates for cattle milk yield also indicate the same (Annex Table VII). The relationship between BUFF and AMYD is positive and significant in only one of the estimated equations. Here only herd-structure variables are considered. Nevertheless, this suggests that effecting a shift in herd structure in favour of buffaloes can augment milk production and productivity.

Coefficient of FMA is positive and significant in several equations. This underscores the fact that adequacy of feed fodder resources would be a critical factor in realising the potential of the dairy sector. Lalwani (1989) also made similar observations. The impact however, varies across economic classes as the association between AMYD and PSMF is negative and significant. Thus, yield improvements on marginal and small land holdings would be constrained by feed fodder scarcity. Alderman (1987) too observed that milch stock owned by the landless and marginal farmers is less productive than those owned by others. This implies that medium and large farm households who hold 39 per cent of cattle and 51 per cent of buffalo would gain relatively more from yield improvements resulting due to improved feed fodder supplies.

The association between AMYD and DAHS is positive and significant. This is on expected lines. Development of animal health services in the country has significantly reduced the incidence of animal diseases and avoided yield loss (Singh, et. al., 1998). Animal health services also influence milk production through dissemination of yield increasing technology and breeding services. It may be noted that in Karnataka the animal health coverage is better in regions with relatively higher incidence of crossbred cattle, and the correlation coefficient between the two is high (0.88). This corroborates the fact that crossbred animals require better health care, compared to indigenous animals. As production growth becomes technology oriented, quantitative and qualitative improvements in health services would be indispensable. So also breeding programme must have an explicit emphasis on development of disease resistance.

The impact of dairy co-operatives is positive on milk yield but insignificant. This can be explained by looking into the objectives and performance of dairy co-operatives. The primary objective of dairy cooperatives is to strengthen the vertical marketing linkages. Provision of inputs and other livestock related services to the farmers are incidental and a bonus. In this context, Prasad et al (1995), observed that despite the existence of a good network of milk co-operatives in the state, their involvement in activities such as fodder development and input supply was rather limited. Further, the performance of dairy co-operatives in the state is not very encouraging. By 1990, about 50 per cent of the dairy cooperatives were in the red (World Bank, 1996).

These finding support our earlier observation that future growth in milk production would result from a shift in herd structure in favour of high milk breeds of cattle and buffalo, and improvement in feed fodder supplies. Institutional support in terms of health, breeding services, and marketing would catalyse this process.

6.2 Determinants of Meat Yield

Meat yields of all the species have remained stagnant over the last two decades. A significant breakthrough in breed improvement of meat producing animals is yet to occur. Meat yield of sheep and goat is expected to be influenced by variation in availability of grazing lands (GLAND), climatic condition- mainly normal rainfall (RAIN) and intensity of animal health services (DAHS). The estimates of regression are presented in Table 14.

Table 14 :
Linear estimates of determinants of ovine meat yield , 1995-96.

Explanatory variables	Sheep	Goat
Forests, pastures and grazing lands (Hectares/ 100 ovine)	0.00034 (6.10)***	-0.0000052 (0.14)
Number of veterinary institutions per 100 sq. km of geographical area	0.0603 (1.09)	-0.01734 (0.47)
Annual rainfall (mm), 1994-95	-0.00073 (9.75)***	-0.000046 (0.91)
Constant term	13.05	12.47
Coefficient of determination (R^2)	0.86	0.10
F value	31.94	0.57

Figures in parentheses are t values. ***Significant at one per cent level.

Explanatory variables account for 86 per cent of the variation in sheep meat yield. The association between SMEAT and GLAND is positive and highly significant, which highlights the role of common property resources in sheep production systems. This has implications for production growth particularly in the short run suggesting that sheep meat yields can be increased through proper management of grazing resources.

Evidence suggest that sheep perform better under arid and semiarid conditions because of adaptability factors (ICAR, 1996). A negative and significant relationship between rainfall and sheep confirms this (Dummies for different regions were tried in the regression exercise. They however, proved to be insignificant). As in case of milk, health services also influence the sheep meat yield, though the association between the two is statistically non-significant.

On the other hand, goat meat yield (GMEAT) is not influenced significantly by any of these variables. As in case of sheep, it was expected that availability of grazing lands would have a positive and significant influence on meat yield of goat, however, the coefficient turn out to be negative and non-significant. This is on account of differences in grazing habits between sheep and goats. While goats can graze on shrubs, herbs and grasses, sheep graze mainly on grasses on the ground. Rainfall has a negative but non-significant impact on the performance of goats. This is because goat is hardier than sheep and can adapt to all types of climates and management conditions (CIRG, 1997). Animal health services too do not have any significant influence on goat meat productivity.

Results indicate that arresting degradation of common property resources would be critical in breaking the stagnation in yield. Though common grazing land does not appear to be an important determinant of goat meat yield, role of common property resources should not be undermined in the development of small ruminant sector. Furthermore, support to small ruminant farmers in terms of animal health services, extension, etc. is rather weak. The relationship between animal health services and meat yield bears testimony to this argument.

7 CONCLUSIONS AND IMPLICATIONS

The main objective of the study is to examine the trends and sources of output growth in the livestock sector of Karnataka. Over the last two decades livestock sector in the state has been on a steady growth path. Milk production has grown at a rate of 5 per cent a year. Meat output increased at an impressive rate of above 9 per cent per annum. However, the momentum of growth has slowed down since mid eighties.

In milk production, dairy herd continues to be dominated by indigenous cattle, though priorities are gradually shifting towards crossbred cattle and buffalo. Milk yields of both cattle and buffalo have grown faster than milch stock, contributing increasingly to output growth. Nonetheless, there exists a large yield gap. The short run strategy therefore, should focus on bridging this gap through better nutrition and health management.

Growth in the long run has to be productivity-led, which by and large should follow from technological change. Dairy breeding policy in India has mainly centred on cattle. Substantial research advances have been made in crossbreeding of cattle. Their adoption has however been slow and sporadic. This calls for a reassessment of crossbreeding programme in cattle particularly in respect of ecological adaptability of the animal and response to management. Buffalo holds promise of increasing milk production in the country. On the research agenda, it has received disproportionately less attention. The rising trend in buffalo population in the country is mainly market driven and a breakthrough in buffalo breeding is likely to provide a big push to the milk economy. Shift in herd structure in favour of improved breeds would involve a trade off between milk production and draft power. Thus, hard decisions would have to be made in the choice of milch stock.

Accumulating evidences reveal that feed fodder scarcity would limit yield improvements particularly on marginal and small holdings. Though this study did not investigate the technical relationships between feed fodder supplies and milk production in detail, results indicate that growth in milk production can be sustained even under stress feed fodder conditions if animal population is optimised accordingly. Farmers respond to stress conditions by culling less productive and smaller animals. Further, in the years ahead, rising competition between man and livestock would limit expansion of area under fodder cultivation. Genetic research would have to address feed fodder supply issues through quality improvement. Kristjanson et al (1998) showed that a per cent increase in digestibility of sorghum and millet residues would result in increases in milk, meat and draft power outputs ranging from 3.2 to 10.7 per cent.

The impressive growth in meat production in the state is an outcome of increase in number of animals slaughtered. Meat yields are stagnating and a technological breakthrough in breed improvement is seriously lacking. Moreover, common grazing resources are under stress. This is a matter of concern particularly for the development of small ruminants, which by and large sustain on common grazing resources. Thus, sustaining growth *via* the numbers route does not seem to be a practical option. India is home to a diverse range of breeds of sheep and goats, however their genetic potential is yet to be assessed (CIRG, 1997; CSWRI, 1997). All this underscores the need to accord high priority to small ruminant research and management of common property resources.

An alternative option to sustain output growth is to effect changes in structure of meat production in favour of large ruminants whose slaughter rates have been low. This has to result from policy intervention and public awareness. There are restrictions on cow slaughtering. Removing restrictions on cattle is Pareto-optimal as it is likely to improve welfare of both vegetarians and non-vegetarians (Mishra, 1966). This option remains unexplored due to socio-political reasons. Internalising this view, Mishra (1995) has raised an important question - 'if India cannot produce bovine meat for herself, can she benefit from export of live meat bovines raised for the purpose?'

Though buffalo is not subjected to a slaughtering ban, its meat production potential remains under utilised. Buffalo is raised for milk and it is mainly the males that find way to slaughterhouses and are disposed of at a very young age to save on milk. Whether this is economically rational or not, is a matter of further investigation. Slaughtering young stock is indeed a potential waste. There exist enough prospects for buffalo meat export because of its price competitiveness.

Poultry sector in the country has witnessed substantial growth mainly due to private initiatives. This however holds true for peri-urban and urban poultry. Rural poultry is raised largely under traditional systems of production based on *Desi* birds. Future growth in egg production would have to come from structural shifts in favour of hybrid layers and intensive systems of production. As in case of poultry, the growth in wool production too would also result from a shift in sheep population structure in favour of crossbred sheep. Relative profitability in wool and meat production would however determine this.

Technology-led growth would necessarily demand more of support services in terms of extension, breeding, health, etc. Support services to livestock sector have been weak in comparison to the crop sector. Moreover, within the livestock sector; there is a bias towards large ruminants. Many technologies with proven economic viability do not reach farmers in absence of an effective technology transfer mechanism and support services. In this regard, some organisations like National Dairy Development Board (NDDB) and Bhratiya Agro-Industries Foundation (BAIF) have met with fairly high degree of success. However, their coverage is restricted to select areas and species. The livestock extension system need to be strengthened and broad based.

Issues of equity will get prominence in the process of technological metamorphosis of livestock sector particularly in view of a strong positive relationship between land and livestock holdings. The technology may not remain scale neutral. Evidences suggest that crossbred cattle generally are less favoured by landless and marginal farmers (Verhgaen, 1990; Subrahmanyam and Nageswara Rao, 1995). The experience of green revolution is relevant in this context. The seed-fertiliser technology aggravated economic inequalities because of uneven distribution of land and lack of counterbalancing institutional arrangements. To prevent this happen in livestock sector; adequate institutional and policy measures should be carefully thought about beforehand.

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Annex Table I : Zonal agro-ecological characteristics and distribution of livestock, 1990.

Characteristics	Arid	Semi-arid	Semi-arid moist	Coastal
Per cent of state geographical area in the zone	21.3	25.6	41.2	11.9
Land use pattern (%)				
Forests	6.2	8.2	15.7	52.5
Pastures and grazing lands	1.4	2.0	10.5	3.1
Net sown area	67.4	72.6	46.7	21.1
Net sown area irrigated (%)	25.9	17.9	23.3	26.5
Net sown area under fodder crops(%)	0.04	0.89	0.97	0.51
Average size of land holding (ha)	3.2	2.8	1.4	1.4
Annual rainfall (mm)	476	721	1148	3804
Infrastructure				
No. of veterinary institutions per 100 sq. km of geographical area	1.16	1.81	2.20	1.57
No. of dairy co-operatives per 100 sq. km of geographical area	1.15	3.0	5.8	2.0

Source: Computed from data obtained from Integrated Sample Survey Reports, Directorate of Animal Husbandry and Veterinary Services, Govt. of Karnataka.

Annex Table II : Regression estimates for trend in outputs of livestock.

The following equation was estimated to examine the differences in growth rates and intercepts between two periods:

$$LnY_i = \alpha + \beta_1 T_i + \beta_2 D_i + \beta_3 D_i T_i + \mu_i$$

Where Y_i is output/ population/ yield, T_i is time trend, D_i dummy for the period. It takes value 1 for 1976-87 and 0 for 1987-96. For meat group the first period starts from 1978-79. The coefficient β_2 gives the difference in intercepts between two periods.β_3 the coefficient of $D_j T_j$, provides the magnitude of difference in the slopes.

1 . Milk production	
Indigenous cattle $Y_i = 6.4790 + 0.0398\ T_i - 0.241\ 6\ D_i - 0.001\ 9\ D_i T_i$ t = (97.910) (6.305) (1.667) (0.180)	$R^2 = 0.83$
Crossbred cattle $Y_i = 3.8685 + 0.1\ 839\ T_i + 1.0959\ D_i - 0.1147\ D_i T_i$ t = (54.186) (3.643) (2.075) (2.236)	$R^2 = 0.94$
Total cattle $Y_i = 6.3704 + 0.0707\ T_i + 0.0877\ d_i - 0.0228\ D_i\ T_i$ t = (82.001) (9.548) (0.516) (1.830)	$R^2 = 0.94$
Buffalo $Y_i = 6.2022 + 0.0626\ T_i + 0.11\ 60\ D_i - 0.0164\ D_i T_i$ t = (238.546) (25.188) (2.033) (3.925)	$R^2 = 0.98$
Total $Y_i = 6.9841 + 0.0676\ T_i + 0.0994\ D_i - 0.0199\ D_i T_i$ -t = (167.986) (16.928) (1.092) (2.994)	$R^2 = 0.98$
2. Meat production	
Cattle $Y_i = 7.5491 + 0.0527\ T_i + 0.7017\ D_i - 0.0063\ D_i\ T_i$ t = (78.331) (4.235) (3.684) (0.356)	$R^2 = 0.97$
Buffalo $y_i = 7.2490 + 0.02197\ T_i - 0.0647\ D_i + 0.0754\ D_i T_i$ t = (43.881) (1.030) (0.198) (2.501)	$R^2 = 0.94$
Sheep $Y_i = 8.2980 + 0.1603\ T_i + 1.4040\ D_i - 0.1339\ D_i T_i$ t = (56.870) (8.508) (4.871) (5.024)	$R^2 = 0.95$
Goat $Y_i = 7.7293 + 0.2299\ T_i + 1.6520\ D_i - 0.1990\ D_i T_i$ t = (38.222) (8.805) (4.134) (5.390)	$R^2 = 0.92$
Pig $Y_i = 5.9300 + 0.0717\ T_i + 0.2719\ D_i + 0.0.0394\ D_i\ T_i$ t = (52.611) (4.921) (1.223) (1.915)	$R^2 = 0.98$
Total $Y_i = 9.1954 + 0.1536\ T_i + 1.1862\ D_i - 0.1\ 130\ D_i\ T_i$ t = (82.921) (10.727) (5.412) (5.579)	$R^2 = 0.97$
3. Egg production $Y_i = 3.7232 + 0.03077\ T_i + 0.1836\ D_i - 0.0169\ D_i\ T_i$ t = (405.220) (35.130) (9.126) (11.509)	$R^2 = 0.99$
4. Wool production $Y_i = 7.5200 + 0.0640\ T_i + 0.4903\ D_i - 0.0488\ D_i\ T_i$ t = (276.050) (24.63) (8.211) (11.169)	$R^2 = 0.98$

Annex Table III: Regression estimates for trend in livestock population.

1 . Milch animals	
Indigenous cattle $Y_i = 3.2760 + 0.0223\ T_i + 0.1\ 167\ D_i - 0.0162\ D_iT_i$ t = (42.281) (2.999) (0.689) (1.299)	$R^2 = 0.48$
Crossbred cattle $y_i = 0.0457 + 0.0795\ T_i + 0.3398\ D_i - 0.364\ D_i\ T_i$ t = (1.139) (2.797) (1.143) (1.261)	$R^2 = 0.95$
Total cattle $Y_i = 3.2486 + 0.0302\ T_i + 0.1807\ D_i - 0.0210\ D_iT_i$ t = (50.411) (4.917) (1.281) (2.040)	$R^2 = 0.76$
Buffalo $Y_i = 2.6562 + 0.0399\ T_i + 0.2384\ D_i - 0.0254\ D_i\ T_i$ t = (38.905) (6.128) (1.595) (2.317)	$R^2 = 0.85$
Total milch stock $Y_i = 3.6890 + 0.0338\ T_i + 0.2006\ D_i - 0.0225\ D_i\ T_i$ t = (57.978) (5.568) (1.440) (2.206)	$R^2 = 0.82$
2. Animals slaughtered	
Cattle $Y_i = -1.5494 + 0.0654\ T_i + 0.8040\ D_i - 0.0224\ D_i\ T_i$ t = (18.975) (6.207) (4.982) (1.502)	$R^2 = 0.98$
Buffalo $Y_i = -2.0041 + 0.0349\ T_i + 0.0113\ D_i + 0.0577\ D_i\ T_i$ t = (9.854) (1.329) (0.282) (1.554)	$R^2 = 0.93$
Sheep $Y_i = 1.2764 + 0.1\ 634\ T_i + 1.2777\ D_i - 0.1360 D_iT_i$ t = (9.078) (9.002) (4.5981) (5.297)	$R^2 = 0.94$
Goat $Y_i = 0.7817 + 0.2095\ T_i + 1.5142 D_i - 0.1811\ D_iT_i$ t = (4.151) (8.618) (4.068) (5.268)	$R^2 = 0.92$
Pig $Y_i = -2.4118 + 0.0525\ T_i + 0.1182\ D_i + 0.0569\ D_iT_i$ t = (27.818) (4.687) (0.6889) (3.597)	$R^2 = 0.98$
Total $Y_i = -1.8246 + 0.1769\ t_i + 1.3222 D_i - 0.1466\ D_iT_i$ t = (12.284) (9.222) (4.504) (5.402)	$R^2 = 0.94$
3. Layers $Y_i = 1.5782 + 0.02413 T_i + 0.1947\ D_i - 0.1173\ D_iT_i$ t = (129.436) (20.750) (7.291) (5.994)	$R^2 = 0.99$
4. Sheep $Y_i = 3.7920 + 0.0076\ T_i - 0.0234\ D_i + 0.0057\ D_i\ T_i$ t = (240.890) (5.035) (0.680) (2.258)	$R^2 = 0.96$

Annex Table IV : Regression estimates for trend in livestock productivity.

1. Milk yield	
Indigenous cattle $Y_i = 5.5061 + 0.0176\ T_i - 0.0358\ D_i + 0.0143\ D_i\ T_i$ t = (75.456) (2.533) (2.242) (1.216)	$R_2 = 0.55$
Crossbred cattle $Y_i = 6.125 + 0.1044\ t_i + 0.75608\ d_i - 0.0783\ D_iT_i$ t = (166.15) (4.006) (2.773) (2.957)	$R_2 = 0.90$
Total cattle $Y_i = 5.4248 + 0.0406\ T_i - 0.0927\ D_i - 0.0018\ D_i\ T_i$ t = (50.163) (3.928) (0.393) (0.1015)	$R_2 = 0.78$
Buffalo $Y_i = 5.8484 + 0.0227\ t_i - 0.1\ 224\ d_i + 0.0090\ D_iT_i$ t = (78.323) (3.188) (0.748) (0.748)	$R_2 = 0.83$
2. Meat yield	
Cattle $Y_i = 4.4941 - 0.01\ 27\ T_i - 0.1\ 023\ D_i + 0.01\ 61\ D_iT_i$ t = (131.962) (2.895) (1.522) (1.502)	$R_2 = 0.40$
Buffalo $Y_i = 4.6480 - 0.01\ 29\ T_i - 0.1\ 784\ D_i + 0.0177\ D_i\ T_i$ t = (24.061) (0.517) (0.467) (0.502)	$R_2 = 0.04$
Sheep $Y_i = 2.4170 - 0.0031\ T_i + 0.1267D_i + 0.0021\ D_i\ T_i$ t = (88.994) (0.892) (2.364) (0.428)	$R_2 = 0.87$
Goat $Y_i = 2.3421 + 0.0204\ T_i + 0.1\ 381\ D_i - 0.0179\ D_iT_i$ t = (70.252) (4.721) (2.091) (2.934)	$R_2 = 0.75$
Pig $Y_i = 3.7382 + 0.0192\ T_i + 0.1537\ D_i - 0.0175\ D_i\ T_i$ t = (46.772) (1.865) (0.9733) (1.200)	$R_2 = 0.37$
3. Egg yield	
$Y_i = 2.1441 + 0.0066\ T_i - 0.0111\ D_i - 0.0052\ D_iT_i$ t = (180.143) (5.853) (0.424) (2.741)	$R_2 = 0.80$
4. Wool yield	
$Y_i = 6.0372 + 0.0565\ T_i + 0.5137\ D_i - 0.0546\ D_i\ T_i$ t = (146.280) (14.349) (5.684) (8.242)	$R_2 = 0.95$

Annex Table V : Regional disparities in livestock productivity, 1995-96.

	Arid	Semi- arid	Semi -arid Moist	Coastal
Milk yield (Kgs/milch animal/annum)				
Indigenous cattle	388.1 (27.7)	352.8 (20.3)	322.5 (21.7)	292.8 (17.3)
Crossbred cattle	978.7 (15.5)	1057.2 (27.6)	1878.54 (26.1)	738.6 (46.2)
Buffalo	568.6 (21.1)	599.1 (17.0)	557.8 (23.8)	605.9 (36.0)
Meat yield (Kgs/slaughtered animal)				
Cattle	85.9 (0.77)	85.1 (0.69)	85.4 (2.2)	-
Buffalo	92.3 (0-6)	94.9 (2.9)	95.1 (4.8)	-
Sheep	12.5 (3.1)	12.5 (1.4)	12.6 (1.8)	12.4 (11.5)
Goat	12.3 (0.6)	12.3 (1.1)	12.4 (1.6)	12.3 (0.3)
Pig	51.4 (0.25)	50.5 (0.28)	50.9 (1.4)	50.1 (0.8)
Egg yield (Eggs/layer/annum)				
Desi	98.7 (3.7)	97.7 (3.0)	97.4 (5.27)	96.8 (2.9)
Improved	248.3 (14.7)	248.7 (9.8)	249.4 (10.7)	247.5 (1.6)

Source: Computed from data obtained from Integrated Sample Survey Reports, Directorate of Animal Husbandry and Veterinary Services, Govt. of Karnataka.

Annex Table VI: Mean and standard deviation of the determinants of milk and meat productivity

Variable	Mean (Standard Deviation)
Milk Yield	
Cattle (Kgs/milch cattle/annum)	466.67 (272.39)
Buffalo (Kgs/milch buffalo/annum)	574.33 (129.76)
Cattle + Buffalo (Kgs /milch animal/annum)	509.63 (222.74)
Per cent of crossbred in total milch cattle	7.07 (12.36)
Per cent of milch buffaloes in total milch stock	39.91 (11.85)
Number of veterinary institutions per 100 sq. km of geographical area	1.81 (1.01)
Number of dairy co-operatives per 100 sq. km of geographical area	3.72 (3.82)
Area under fodder crops (Hectares/ 100 milch bovines)	1.19 (1.51)
Per cent of small and marginal holdings in total holdings (1991-92)	63.20 (16.73)
Meat Yield (Kgs/animal/annum)	
Sheep	12.53 (0.57)
Goat	12.39 (0.15)
Annual rainfall (mm) 1994-95	1315.40 (908.32)
Forests, pastures and grazing lands (Hectares/100 bovine)	35.20 (62.37)

Annex Table VII: Linear estimates of determinants of milk yield of cattle and buffalo.

Explanatory variables	Cattle Eq. I	Cattle Eq.II	Buffalo
Per cent of crossbred milch cattle in total milch cattle (XBRED)	20.35 (8.09)***	-	-
Number of veterinary institutions per 100 sq.km of geographical area (DAHS)	-	208.44 (3.67)***	14.24 (0.34)
Number of dairy co-operatives per 100 sq. km. of geographical area (DCOP)	4.54 (0.52)	9.24 (0.60)	13.07 (1.14)
Area under fodder crops per 1 00 milch bovines (FMA)	8.63 (0.53)	28.26 (1.03)	22.80 (0.92)
Share of marginal and small land holdings in total number of holdings (PSMF)	-2.23 (2.50)**	-4.95 (2.02)*	-1.61 (0.88)
Constant term	446.55	305.85	563.17
Coefficient of determination (R^2)	0.90	0.72	0.31
F Value	34.14	9.69	1.66

*** ** and * Significant at 1, 5 and 10 per cent. Figures in parentheses are t-values.