A Frame Work for Conducting Carrying Capacity Studies for Dakshina Kannada District

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Introduction

Industrialization has taken place in many districts in Karnataka with unexpected results whereas Sir M Vishweshwaraiah felt that there will not be any industrialization in Bangalore city, we find several industries coming to Bangalore in sixties and the city becoming a fastest growing city choking the infrastructure. There is a feedback theory operating on such systems, but it comes into effect only after some damage is done. Industrialization is a spontaneous activity based on band wagon philosophy.

Many industries came up in Dakshina Kannada district and many have been approved. Several power plants are also coming up. This has created an apprehension in the minds of people about the ecology of western ghats in that district, the effect on coastal ecosystems and fish production, the pollution load, the effect of high rainfall and wind on fly ash, the effect on soils due to pollution from industries, the availability of resources like water and the overloading of traffic networks. In order to clear apprehensions, the government gave an assurance that it will take up industrialization in a phased and planned manner taking care of the ecological health of the area and will conduct a carrying capacity study for this district. It is the genesis for our work and this report.

A committee was appointed by the government of Karnataka under the chairmanship of Prof Madhav Gadgil of CES IISc. The committee members are Prof.R. Kumar of IISc, Prof Nadkarni Of ISEC, Fr.C.J. Saldanha, Capt. S. Raja Rao, Secretary, Secretary Pollution Control Board (Dr B. Shivalingiah, who is now the Chairman of the Board) and Dr. Balakrishaniah Director (Tech). The committee requested me to develop a frame work so that a coordinated approach is taken up to study this complex problem by various experts in the district and neighbourhood working in synchronism to fill in the gaps in the model.

Carrying capacity is very controversial term when applied to ecology, though it is well defined in engineering like carrying capacity of a transmission line. It has evolved from the limits to growth philosophy which was based on the facts that there are local shortages or water and food, there are atmospheric changes affecting people and many species are becoming endangered (including Indian lion and tiger).

Initially, carrying capacity was restricted to population and its value has very high variations thereby creating doubts in the minds of people. It was felt that carrying capacity depends on technology, usage patterns, social factors, comfort levels etc. Also it varies with time, when technology changes, productivity changes. Further, it was also felt that a focussed realistic view of carrying capacity will be meaningful.

Since we are looking at the aspect of industrialization in Dakshina Kannada district, this is our focus. We need to find the maximum level of industrialization in the district that will not saturate the resources, infrastructure and other systems; will not exceed pollution levels according to accepted standards; and will not affect fragile ecosystems. So this made our job simpler.

We are looking for a carrying capacity on industries based on the current level of living, current standards of living, current technological and social practices and current regeneration of resources.

We looked at the state of the district - population, growth rate, landuses, agriculture, industries, employment and human development indexes. We found the HDI of the district to be the highest for several alternatives. The percentage of people employed in agriculture is lowest services is a dominant sector, (similar to developed countries). We need to conduct critical studies on resources utilization though a cursory view shows that Dakshina Kannada district compares well in the industrial sector with respect to other districts excluding Bangalore.

We catagorise different resources. Then we define carrying capacity in our context of industrialization first qualitatively as the maximum industrialization subject to sustainability criteria. A modelling exercise was done to look at availability and usage of resources and a resource balance constraint was established. Industries are grouped based on their consumption and pollution characteristics. The models output is expected to be the number of industries in each group that can be set up in Dakshina Kannada district such that there is no scarcity of resources, pollution level does not exceed standards, and ecology is not affected.

An optimal model is prepared which can optimise (maximise) employment in the set of industries that can come up there (subject to the existence of skills).

A plan of action has also ben prepared. We had a number of meetings with several persons both in Dakshina Kannada district and Bangalore. Two meetings were held in D.C.S. office, at Mangalore organised by Dr.K.V. Rao, Secretary District committee for science and technology and Director, College development, Mangalore University. Both meetings were well attended by over 50 persons. Discussion were held on the resource characteristics, the capabilities that exist with experts who can handle the problems, methodologies for tackling the problem and their interest in lacking this problem. Everyone agreed that it is a unique problem and a great challenge and showed keen interest in handling sub problems.

This was followed by a series of meetings as listed below;

1) Fisheries College 7.3.98 10.00 am
2) Dakshina Kannada Dist Parisaraasakta Okkootta 7.3.98 2.00 pm (St. Aloysius College)
3) K.R.E.C. 8.3.98
4) Carrying Capacity committee 11.3.98
5) Discussion meeting at CES, IISc. 17.3.98
6) Discussion with Y.B. Ramakrishna, Dr.Vishnu Kamath 20.3.98
7) K.R.E.C. 24.3.98
8) Mangalore University 24.3.98
9) NMAM Inst of Technology Nitte 25.3.98
10) M.I.T. Manipal 26.3.98
11) Dr. Ravindranath Shanbag Udupi 25.3.98
12) Bangalore University Geology Dept. 2.4.98

Many discussions were held with individuals also. A list of names of some persons who participated is enclosed as annexure

A questionnaire (annexure) was also circulated. Many questions regarding carrying capacity were raised and answered.

Based on the above, a list of relevant sub problems and experts who can handle it is also presented. Conditions for the success of the studies are enumerated.

Dakshina Kannada District - An Introduction

The district of Dakshina Kannada is situated on the Western coast of Karnataka in the southern part of Uttara Kannada being in the northern region. It is a long strip of land from north to south.

It is a broken low plateau which spreads from the Western ghats to the Arabian sea when looked at from east to west.

Geographically, the region is seperated from the rest of Karnataka by the towering heights of Western ghats. The length of the coast line, which is almost straight, but broken by rivers creeks and bays is 140 kms. The district lies between 12^0 27" and 13^0 58" north latitude, and 74^0 35" and 75^0 40" east latitude. It is about 177kms in length, about 40kms wide at its narrowest and 80 kms wide at its widest part.

The district is bounded by Uttara kannada district in the north, Shimoga, Chikmagalur, Hassan districts on the east, Kodagu district in the southeast, Kerala in the south and Arabian sea in the west. The area of the district is 8158.5 sqkm. The district has eight taluks. Currently the district is divided into two districts- one at Mangalore and another at Udupi.

The population of the district was 19,39,315 according to 1971 census. The growth rate was 22.55% during 1971-81 and it came down to 13.27% during 1981-91 period while the growth rate for the state was 20.69%. The district has more females than males.

Whereas the district occupies the twelfth place amongst the districts with regard to area, it occupies the sixth place based on comparison of population. The density of population of the district was 186 persons per sqkm in 1961 and it has gone up to 319 in 1991 whearas the state has a density of 119 in 1991. This shows that it is a very populous and dense district, next only to Bangalore urban area in Karnataka. It accounts for 4.45% of the total area and 6.62% of the total population of the state.

The district can be divided into six natural divisions- divided by rivers Netravati, Kumaradhara, Gurpur, Sitanadi and Chakra.

The coast line is intended by several bays and creeks, formed by the river estuaries. The coast line is low and sandy with broken and rugged rocks cropping up in places, but the area near the seaboard is well planted with coconut trees.

We see coastal areas, mountains, forests, rivers, rural areas with a lot of vegetation, rice fields, plantations, spices and diverse timber and other species. The altitude varies from 60 to 120 mts near the coast and rises to about 180 mts near the foot of the ghat. Most of the habitation is along the coast

The district is a mountainous one with the Western ghats in the east. The range of mountains are in the form of steep cliffs in the north, but in the broad southern part, it has the character of parallel ridges intersected by deep valleys from which most of the rivers start.

The most interesting of the mountains is the Kudremukh group of three peaks on the highest ridge of the ghats- heights of 1881-1892 mts. Other peaks are Kodachadri (1341 mts high), Ballalaraya Durga (1504mts high), Kattegudda (1382 mts high), Subramanya (1727 mts high) and Sisalkal (1195 mts high)

There are several passes like Sampaje pass (to Mercara), Shiradi ghat (to Hassan), Chamundi ghat (to Chickmagalur), Agumbe, Hydergarh ghat and Kollur pass through which many roads connect the district to the neighbouring districts. The railway line from Saklespur to Subramanya also passes through a picturous and scenic forest area.

The district is a high rainfall district getting copious rains from South West monsoon during the period June to September. The average rainfall in the district is 3930mm. The rainfall increases from the coast towards the Westarn ghats in the east. Northern part of the coastal strip- Bhatkal to Baindoor region- gets heavier rainfall than the southern coastal strip. The number of rainy days in a year is 123 on the average; winds are stronger during this period.

The climate of the coastal part of the district is high humidity during monsoon season and hot weather.

The district has many rivers and streams because of the high rainfall and broken nature of the area. During monsoon, a large volume of water is carried by these rivers. Flooding and inundating of the surrounding area for a short period is common during the monsoon period.

Netravati is a major river in the district. Kumaradhara joins it at Uppinangadi and Gurpur river joins it in Mangalore. A common estuary is formed there. It discharges it's water into the backwater. It is the major source of water for agriculture, people and other activities. Mangalore city depends on it for water needs.

Deforestation has led to greater situation. Due to greater situation, the velocity of flow in the river as well as the volume of water flowing have come down during the dry season. This has resulted in a greater inflow of salt water from the back waters. So, now we find that the river water is not fresh water, but slowly for several kilometers near the sea in its length of travel. It is being observed that the length of salt water ingres is increasing over a period of years. This is creating a water shortage problem. People get water-excess quantity during monsoon, but experience shortage during the dry season.

Many rivers and streams in the Dakshina Kannada district depend on the heavy rainfall and the flow during the dry season is minimal leading to a general water shortage.

There are many estuaries formed on the coast by rivers joining the sea. There is one estuary at the junction of Netravati and Gurpur rivers, another at Gangolli where the Haladi stream forms a large salt water lake, the Sitanadi and Swarnanadi join the sea.

South Canara, another name for the district, is essentially a forest district. The estimates of forest area varies from 50% of the total area to 29% (2460 sqkm) in 1971. The forests contain many luxuriant flora, many timber species and evergreens with a rich bio-diversity. The heavy rainfall in this area stimulates the growth of forests which extend from the slopes of the Western ghats to within a few kilometers from the sea. Generally, heavy forests began about 30 to 40 kms from the coast. Originally, the forests in the district were evergreen. Hundreds of evergreen species have been identified. There are many timber species like matti, maravu, teak, jack, wild jack, benteak, myrobalan, kiral bhogi etc. Sandalwood, bamboo, cane, figs etc are also found in the forests of this district.

The forests in this district were originally largely evergreen, but now a days, we find various types- evergreen in the ghat belt, semi-evergreen in the foot hills, deciduous in the outer ridges and scrubs in the exposed laterite flat topped table land areas.

There is a heavy pressure on land due to increased population and setting up of industries. This pressure is steadily pushing back the forest from the coastal belt. Also the quality of forests has changed from evergreen to the scrub type in several places.

One of the main reasons in the early days for deforestation is cultivation. Cultivation is confined mainly to the plains near the coast and bottoms of the valleys, which wind amongst the hills and plateaus. The earlier Kumari cultivation- that is clearing of forest by fire and shifting cultivation has resulted in a large tracks of forests being cleared. Now only bushes grow in these areas.

Fuel wood requirements are also increasing with increased population. Tile industries consume a lot of firewood. The district has a long history of tile industries, the tile is known as Mangalore tiles produced from the good clay soil available in the paddy fields in several places in the district. The district with more than 60 factories has a dominant position in tile industry even today. Timber production is another major activity in the district.

Because of the large scale requirements and consumption of wood, deforestation is taking place in the district. We have reached a situation that today timber is imported into Mangalore port. Firewood usage is still affecting the forest areas. We need to find alternate solutions like the popularization of highly efficient wood burning stoves, and solar water heaters. Afforestation is also necessary. It should be done on a large scale carefully selecting the species for planting and managing the scheme. People's participation is a must.

Since the district has many groups actively working on ecological issues, they should be involved in the afforestation programs. Emphasis should be on selection of natural species and not on commercial species

The affirmative actions are very important because deforestation in the slopes affects the flows in rivers especially during the dry season leading to serious water scarcity. This will affect all activities in the district.

Another problem the district faces is soil erosion. Soil erosion is very high due to deforestation and loose nature of rock formations. A lot of soil is carried by the heavy currents of rivers during the monsoon period Due to high rainfalls in this period, there are landslides. Landslides are more frequent now adays.

We have seen that due to landslides the train movement between Sakleshpur and Subramanya is stoped during monsoon period. Many roads are cut off restricting movements and isolating many places. Deforestation is one of the causes for land slides.

So far we looked at the situation inland. Let us divert our attention to the coastal area. In addition to having several estuaries, mangroves and rich ecosystems, the coastal area is important from two aspects.

Firstly, fishing is an important activity employing a very large population in the area. The economics of the coastal area depends on fishing and fish processing industries to a large extent. It is essential to preserve the ecology of the area in order to protect this activity on which lakhs of people are dependent

Many industries like Mangalore Chemicals and Fertilizers, Mangalore Refineries and others let their waste / cooling water into the sea. If untreated water is let into the sea, it will affect the fish prmduction. Fish yields will go down. There are indications on fish kills in the recent years which the district did not experience before. Hence, efforts should be made to reduce activities on the CRZ and also to see that no waste waters are allowed into the sea.

Coastal erosion is another problem faced by the district in the recent years. The coastal rock formations, shells, bio-organisms and marine life protect the coast. But there are disturbances on these due to serious erosion near the coast. We need to prevent major erosions that may occur due to disturbances to the coastal ecosystem. This can be done by avoiding pollution of the coast, minimising activities on the coastal buffer and controlling offshore activities.

The setting up of several mega industries in the area and the proposals to start thermal power plants will lead to air pollution and possibly acid rains. It is not clear what is the amount of pollution from the present and proposed industries and the impact of this pollution on the plants and forests of the Western ghats. Also fly ash from the thermal plants have to be handled and a solution should be found for this problem also.

So we see that there are problems with ecosystems and coastal ecosystems due to increased population and activities. There is also water, air and land pollution which may increase due to rapid mega industrialization. In order to study the effect of activities on the district, we should know the available land, water, coast, energy, biological and mineral resources of the district and see whether it can meet the existing requirements and whether there is any excess quantity available for future growth. We should also know the impact of pollution and calculate the limits on activities that can be taken up in the area such that the natural systems are preserved.

With the above in mind, we are conducting studies to ascertain the Carrying Capacity of the area.

Population and Growth

The total population of Dakshina Kannada District is 26,94,264 with a male population of 13,06,256 and a female population of 13,88,008 as per 1991 census. Table 1 gives the population growth rates for different districts of Karnataka for the period 1961 to 1991, the values given in percentages. Whereas the decennial growth rate for the state has reduced from 24.22%in 1961-71 to 20.69% in 1981-91, the growth rate for Dakshina Kannada district has come down from 24.01% on 1961-71 (nearly same as that of the state) to 13.27% in 1981-91, a very large reduction, Kodagu and Chickamagalur Districts have a growth rate less than that of Dakshina Kannada district. It is desirable to look into the reason for this reduction - in fertility or any other reason. Also the rate needs to be verified with samples for later years.

Within the district, the population varies from a lowest value of 1,24,824 in Sullia taluk to a highest of 6,71,360 in Mangalore taluk. Udupi taluk has a population of 4,95,766. Mangalore taluk has an urban population of about 65%. All other taluks excepting Udupi have an urban population of around 10%. Urban population of the district has increased from 18% in 1961 to 28% in 1991.

When we look at the growth rate in various districts for rural and urban areas separately, we find that the growth rate for urban area for Karnataka is 29.62% for 1981-91 period, it is 31.12% for Dakshina Kannada district for the same period. This shows that the growth rates for urban areas follow a similar pattern of change. But the reduction comes in the growth rate for rural areas. It is 7.61% for Dakshina Kannada district for the period 1981-91 while it is 17.66% for the state for the same period.

Table 2. provides density of population for different districts in Karnataka, the unit being number of persons per square kilometre of area. The density for Dakshina Kannada district goes up from 186 to 319 in 1991. The density for Dakshina Kannada district is higher than the state average by about 25%. The growth rate over the period is less compared to the growth rate for the state. Higher population density coupled with more forest area reduces the land availability for industrial development. Whereas the population density values show similar disparities for rural and urban areas, comparison at the state level shows that the density at rural areas in Dakshina Kannada district is about 30% higher than that for the state and Dakshina Kannada district is one of the highly dense districts in Karnataka. Only Mandya and Bangalore have higher densities, But when we look at the population density for urban areas, we find that the density is on the lowest side-about half of the state average. Only Bellary district has a density less than that of Dakshina Kannada district.

Literacy

Table 3. gives the percentage of literate people in different districts of Karnataka from 1961 to 1991. Dakshina Kannada district has shown a good progress in literacy - the percentage going up from 32.35% in 1961 to 75.86% in 1991. The increase is more than

140%. This compares well with the increase in literacy in the state. The 1991 level of literacy in Dakshina Kannada district compares very well with the level in Bangalore urban district. These two districts have the highest literacy levels.

The literacy level for male persons is 84.40% in 1991 for Dakshina Kannada district being the highest of all districts. The literacy level for female persons in Dakshina Kannada district is 67.96% in 1991. This is close to the highest percentage of 68.81% for Bangalore urban district and is higher than the state average by more than 50% (The state average is 44.34%). The literacy percentage for rural population is highest for Dakshina Kannada district-72.37% compared to 48% for the state. 55%of rural female persons in Dakshina Kannada district are literate as against 28.77% for the state. This is a good progress.

Employment

Table 4. gives the percentage of workers to the total population in every district for the past four decades. There is a reduction in the percentage in the entire state and the trend in Dakshina Kannada district is also similar. Within the usual significance values, we can see that the percentage of workers in Dakshina Kannada district is similar to that for many districts, It is higher than the state percentage.

Let us look at the primary sector - agriculture - for employment, Table 5. gives the percentage of agricultural workers to total workers, The state percentage varies from 70.55% in 1961 to 63.12% in 1991, All districts excluding Bangalore urban, Kodagu, Uttara Kannada district and Dakshina Kannada district follow this trend. The trend for Dakshina Kannada District marks a major change-from 64.82% to 44.43% in 1981 and 35.79% in 1991. It will be a good exercise to look for reasons for this low percentage of workers in the primary sector. Two probable reasons are (i) many people, who are educated, are reluctant to take up jobs in the agricultural sector and hence migrate to other districts , and other states (like Mumbai) and (ii) the district is strong in the services - education, banking, hotels -sector and hence employment in agricultural sector is low

This trend in employment is similar to the current distribution of employment in developed countries. The dominant sector for employment is the services sector like banking, information technology, transportation, communications, commerce etc - in the western countries-more than 40% of the employment, There is a strong nucleus in Dakshina Kannada district for employment in services sector- education, previous history, synergy, experience, and hard work. This aspect should be looked at and the district should be encouraged to develop in these areas.

Table 6. gives the distribution of workers as per 1991 census in Dakshina Kannada district. This again confirms the fact that percentage of people employed in agriculture is around 35% More than 50% of the workers are in the services sector. So this again shows that this sector needs encouragement and special efforts for further development.

Landuse

Table 7. provides the land use in Dakshina Kannada district in 1993-94. Net area sown is 26.39%. Area available for other use will be 12.81% (including barren and uncultivable land and fallow land). If we include cultivable waste land, the percentage of land available for industrial and other uses will go up to 21.39% (198,356 hectares). The actual available area for industrial use will be less than this value-we should exclude additional land required for additional population, land converted to cultivation, land needed for water storage and land for holi purposes (like pajaka kshetra).

The landuse maps for each taluk showing the area available for other uses are included in this report. These are prepared by Dr C.R. Bannur, NRDMS, KSCST Bangalore. Buffer zones near sea, and rivers should be excluded from the area shown in these maps.

Table 8. compares percentage area used for agriculture (net area sown). Area used in Dakshina Kannada district for agriculture is on the lower side. Where as the percentage exceeds 50% in 12 districts, it is the lowest for Uttara Kannada district (11.40%) and the percentage of net area shown for Dakshina Kannada district comes next. Compare this figure of 26.6% with the figure of 56.60% for the state. This means that area used for agriculture is not high in this district. If we look at the percentage of net area sown to the total cultivable area, the percentage for Dakshina Kannada district has increased from 58.19% in 1970-71 to 68.39% in 93-94. This is the lowest for all districts, the state percentage being 83.01% in 70-71 and 84.68% in 93-94. This means that there is a scope for increasing area for agriculture in this district.

Percentage of net area irrigated to the net area sown varies from 36.5% for 1970-71 to 43.6% for 93-94 for Dakshina Kannada district - one of the highest percentages next only to Shimoga district. Percentage of irrigated area for the state is 11.1% in 1970-71 and 21.6% in 1993-94

Paddy is the major crop cultivated in 1,49,629 hectares, followed by arecanut, coconut, cashewnut, rubber and other cash crops. Average yield of rice (Kgs/ha) in Dakshina

Kannada district has gone up from 1424 in 1970-71 to 1991 in 1993-94. But this yield is on the lower side. The state average is 2439 in 1993-94. At least 13 districts have yields greater than that of Dakshina Kannada district.

Another index, we can look at to see the intensity of cultivation, is the per capita land available for cultivation and this is contained in table 9. The per capita area is the lowest (0.12 ha) for both Dakshina Kannada and Uttara Kannada districts.

The distribution of bovine population per sq km is also on the higher side for Dakshina Kannada district only. Bangalore, Mandya, and Hassan districts have higher numbers. The figures for Dakshina Kannada district is higher than the state average

Plantation Crops in Dakshina Kannada District

Several plantation crops like arecanut, coconut, cashewnut, cocoa, pepper, chillies, ginger, etc are produced in Dakshina Kannada district. Arecanut is cultivated in 9630 hectares in this district, as compared to 11655 ha in Shimoga, 7126 in Chikamangalur and 8120 ha in Uttara Kannada district. (the total area 58710 ha in the State).

Area under coconut is 16860 ha, just about 8% of the total area in the State. Cashewnut is produced from an area of 37112 ha as against the total area of 52224 ha in the State (more than 70%). Similarly cocoa is cultivated in 1120 ha of a State total of 1238 ha. Pepper uses an area of 2345 ha in Kodagu, 1498 ha in Uttara Kannada and a total of 7613 ha. Substantial production of ginger also comes from the district. The district also contributes to other species - fruits like mangoes, jackfruit, pineapple, banana etc. and flowers like Jasmine.

Industries

The number of factories in Dakshina Kannada district is 548 with number employed in the factories is 43929. Total number of small scale units registered in this district till the end of 31-3-94 is 9437 with total employment being 105754.

The density of industries with respect to population for various districts of Karnataka is given in table 10. Bangalore has the lowest value of 1691. Barring Bangalore urban, Dakshina Kannada has the largest number of factories. Industrialisation has kept pace with increases in population in Dakshina Kannada district

Table 11. lists the number of establishments and percentage of employment. Dakshina Kannada district has the largest number of establishments next to Bangalore. It has a share of 7.8% in industrial employment in 1994

If we look at the number of employees working in enterprises per 1000 population, the figure for Dakshina Kannada district is 179 in 1990 as compared to the state average of 132 and Bangalore urban's value of 230.

If we consider women employees in the organised sector, 33.4% of women employees are in Bangalore, and 14.5% in Dakshina Kannada district. If we look at women employees in public sector alone, Bangalore's share is 27.3% and Dakshina district's share in private sector is high - 24.5% and Bangalore's is the highest share of 41.9%. There is no significant contribution from other districts.

The statistics with respect to industries needs to be analysed carefully by segregating groups of industries and services, and gathering statistics for each group. We will need to gather information on pollution load, energy intensity of industries and energy consumption per person employed for each district. These indicators will provide a general level of industrialisation and can be used as parameters for planning additions of industries in a district - a simpler method than carrying capacity studies. We should use indices like percentage resource consumptions in industrial sector for each resource, energy intensity, percentage employment in industrial sector, percentage water pollution load etc for each district.

Another way of looking at the development of a district is to look at the human development indices for several districts and comparisons.

Human development Index (HDI)

In 1991, UNDP[1] published a human development report. It felt that income measures are inadequate to measure welfare. So it suggested an alternate scale that includes the problems of the developing countries. Based on this philosophy, several HDIs are being calculated for different states and districts in India. The government of Karnataka has a project on calculating HDI for different districts. We look at the calculations done by Vinod Vyasulu and B.P.Vani in 1997.

[1] UNDP - United Nations Development Programme

The HDI is a combination of income, literacy (education) and life expectancy/infant mortality (health) figures. Income need not be average income - it can be refined further. We can use average purchasing power of a population in per capita terms. This removes exchange rate fluctuation, currency to purchasing power relationships are normalised. The HDI does not change very fast since it is a combination of several factors, it is used more for comparison purposes, we need to look at individual components carefully to find avenues for improvement.

Table 12. gives the literacy rate, IMR[2], life expectancy and per capita income figures for all districts of Karnataka. We see from this that Dakshina Kannada district is near the top in all these factors.

Based on table 12, the authors have developed six HDIs:

HDI - 1	Income, life expectancy, total literacy
HDI - 2	income, life expectancy, male literacy
HDI - 3	income, life expectancy, female literacy
HDI - 4	income, IMR, total literacy
HDI - 5	income, IMR, male literacy
HDI - 6	income, IMR, female literacy

Income was adjusted by discounting values above a threshold level (to reflect the diminishing marginal utility of money).

The author uses two alternatives - one based on maximum and minimum values within the districts of Karnataka and another uses a normative maximum for literacy at 100% and IMR and life expectancy based on all districts of India. Tables 13 and 14 provides the six HDIS for alternative A and alternative B respectively. Ranking is done in table 15. We can see that the rank of Dakshina Kannada district is first followed by Bangalore. This shows that there is overall good development in Dakshina Kannada district based on the HDI developed by Vinod Vyasulu and Vani. We need to also look at the HDI figures being calculated by the government of Karnataka.

We now move from the present state of Dakshina Kannada district to look at natural resources.

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[2] IMR - Infant Mortality Rate

WATER RESOURCES

River system in Dakshina Kannada district.

There are several west flowing rivers covering both Uttara Kannada and Dakshina Kannada districts. They cover about 13% of the total drainage area and provide an average flow of 57000 m.cum.(table). The source is mainly from South West monsoon.

Netravati is the biggest river in the Dakshina Kannada district with a length of 96 km and a catchment area of 3355 sq.km. It takes its birth near Samse in Charmundi range of hills. The main tributaries are Neriyahole, Kumaradhara, Belthangadihole, and Shishilahole. It joins the Arabian sea near Mangalore.

Varahi river starts from Hosanagar taluk of shimoga district and joins the sea near Kundapur. Chakra river also passes through Dakshina Kannada district; it has a length of 72 km; it's waters are being diverted into Sharavathy valley to augment inflows into Linganamakki reservoir.

There are many other rivers like Shirvahole, Mulkihole, Payaswini, Baindoor hole, Swarna, Gurpur etc going through the district.

Tanks and Wells.

Dakshina Kannada district has very few tanks for irrigation - 167 in 1956, irrigating an area of 14700 acres as against 6000+ in Hassan, Shimoga districts and 3000+ in Kolar. The number of irrigation wells is over 30,000 (about 10% of the total in stake). There are no major reservoirs or irrigation projects in the district.

Rainfall.

Table 16. gives data pertaining to normal rainfall in different districts of Karnataka. (Source: Drought monitering cell). Rainfall is obtained for three seasons - premonsoon (January to May), monsoon (June to September) and post monsoon (October to December). We can see that Dakshina Kannada district gets the highest rainfall in the state of about 4000 mm per year.

The annual rainfall for the year 1996 - varied from 2878 for Kundapur, 2887 for Mangalore , 3963 for Puttur and 3691 for Sulya stations. This shows that the spatial variation is not high.

Ground Water

Measurements by central ground water board indicate that ground water levels in Dakshina Kannada district fell by 2 mts in an area of 6198 sq km out of a total area of 8441 sq km in the period May 95 to May 96; the fell in ground water level was between 2 to 4 mts for an area of 452 sq km for the same period. Careful observations are necessary to obtain a trend over a period of time before any conclutions can be obtained. The percent infilteration of rain water is only 3% in Dakshina Kannada district, a low value compared to 10% in Bider and 8% in several other districts. Estimates show that there is an available potential of 822 mmx3 in the Dakshina Kannada district against a utilisation of 23%. The perception amongst people in the district, especially in the coastal area, is that there is a scarcity for water during summer season. Hence the potential, utilisation, recharge factors for ground water should be estimated for each region.

Resources

Most of the activities use resources like land, water, air (oxygen, carbon dioxide, nitrogen etc) bio resources, fuels, minerals, food, fish etc. Resources are broadly classified as renewable and non renewable or depleting type. Non renewable resources like coal, petroleum oil, metallic ores etc. are stored resources and their usage reduces the total quantum available. Hence, it is desirable to minimise the use of nonrenewable resources

Renewable resources are those resources which are regenerated every year. Examples are water, wind, solar energy.

We can classify renewable resources as;

(i) Autonomous regenerative resources;

The regeneration of these resources depends on nature and natural effects like climate etc. The quantity of regeneration does not depend on human activities like agriculture, transport, industries and domestic activities. Examples are water, wind etc.

(ii) Consumption dependent renewable (regenerative) resources.

The quantity of regeneration depends on the usage of a resource. For example, the productivity of biomass depends on harvesting for use by people Large scale harvesting for fuel has led to deforestation. In these cases, there is an annual growth and if usage is less than or equal to the annual growth, the renewability is maintained. Otherwise, the available quantity of that resource decreases (equivalent to that of a non renewable resource).

Similar situations exist in the case of water flow in a river near a sea; greater consumption leads to a reduced flow resulting in a salt water ingression, thereby affecting the basic needs of people in that area Harvesting of fish also has similar problems. There is an upper bound on the quantity of harvesting. When we go on to harvest above this level, "seeds" decrease and productivity comes down.

There is now a sub classification on this category of renewable resource also. This is based on pollution (of water, soil, and air) Due to the addition of "waste" waters from municipalities and industries, the quality of this resource decreases resulting in a reduction in net availability in the neighbourhood and an increased incidence of health problems. In this case, though there is availability, the quality is less and this affects the growth and life of organisms in the short and long range. Preventive measures like introduction of pollution control units, tough implementation of laws, consciousness on the part of the polluting agencies, public involvement in handling pollution/control problems etc are required in a holistic manner to avoid this problem

These groups of resources depend on good planning and management policies for their sustainability - sustainable usage as renewable resources. We need to have limits on consumption and ensure control on consumption and quality.

The above grouping is based on regeneration of resources. We can classify resources based on consumption and production.

We know that spatial distribution of population is not uniform - it is highly skewed. Population density is a good illustrator of this fact Also with the higher concentration of other activities like services and industries, it is natural to expect that consumption of resources also exhibit a skewed spatial distribution. So each spatial region is no more a closed non- interactive system when we study resource consumptions. Each region may import or export resources. This leads to a classification of resources as local and non local

Local Resources

If there is a sufficient quantity of a resource available in the region and that region's consumption of that resource comes mostly from the available quanta, then the resource is called a local resource. Initially, many resources were local resources water was not pumped over long distances; people lived near rivers or lakes. But the situation has changed a lot. Still we have many regions for which water is a local resource. Water is definitely not a local resource for Bangalore city. Similarly, firewood was a local resource before we started transporting it over long distances.

Non Local Resources

If a resource needed by a region comes from another area, then we can classify that resource as a nonlocal one. Timber has been transported to different places from forests for a long time and hence it is a non local resource. Today many resources are becoming nonlocal resources.

Resources can be classified as primary or secondary ones based on the fact that they are naturally occurring or produced (engineered). Resources like water, air, minerals, fuels like coal and oil, biomass, grass, fish, organisms are naturally occurring and hence are primary resources. We can alter their rate of production through engineering, but marginal.

But resources like agricultural produce cereals, pulses,- electricity, etc are secondary resources as there is a considerable effort required in their production. There is always an energy efficiency associated with secondary resources due to conversions and losses. A good usage policy is to minimise use of secondary resources like electricity and reduce losses in production and wastage in usage in the case of essential secondary resources like food.

Resources can be further classified as simple and complex ones. Some resources can be identified and separated as a single one. Examples of simple resources are water, coal, fish, electricity, fertilisers, minerals etc.

Complex resources mean that there are several resources strongly intertwined and interacting that separation is not meaningful. Examples are soil, forest, coastal organisms, etc.

Resources can be classified as producing and absorbing based on the fact whether they are regenerated or they absorb various "wastes" produced by activities. Examples of generating resources are forests and coastal ecosystems. Example of absorbing resource is air. Air is also a complex resource, Soil has both generating and absorbing characteristics, but when it absorbs less that its quality is retained, it is a generating resource. But when absorption dominates, we get degraded soil. So depending on the quality of soil and its usage and the dumping of solid wastes, we can classify soils accordingly.

Resource Consumption

Whenever we want to plan for development of a region, or we want to find out the sustainability of resources in that region or we want to conduct carrying capacity studies, the basic aspect to be looked at is the consumption of various resources in the region. Sustainability and good ecology depend on the understanding of the consumption of resources and the development of proper strategies for usage based on the existing consumption pattern. Hence the first step in doing any of these studies or any modelling activities is to calculate and estimate consumption of resources.

A region can be viewed as one consisting of several activities needed by the living resources of that region. Each activity consumes some resources, produces some other resource and emits wastes.

As we said earlier resource consumption is normally because of conversions in activities. Different types of conversions are;

(1) Simple conversion producing a resource. Example; cooking stove (burning). Resource consumed is fire wood, the output is heat for cooking and production of carbon dioxide, a basic resource in air.

(2) Simple conversion with a recoverable waste. Example; washing. Resources consumed are water, and washing powder. Output is waste water.

(3) Cascaded usage. Example: Washing and agricultural irrigation. We use water for washing and the waste water is used for irrigation.

(4) Complex conversion. Example - agriculture. Resources used are land, water, energy, seeds, fertilizers, pesticides, etc. Outputs are cereals, agricultural residues, waste waters, soil degradation etc,

We need to not only study different activities, and resources utilization, but also set up norms for use of natural resources for each activity.

Types of Relevant Natural Resources

In order to look at sustainability of a region, we need to find out availabilities and consumptions of different resources Since many resources are used, we would like to look at major resources that are important for sustainability and cannot be engineered.

Major resources of relevance to Dakshina Kannada district are the following:

i) Water - rainfall, canals, wells, ground water - for several regions and seasons; quality of water.

ii) Land - landuse, land cover, quality of land - erosion due to sea.

iii) Air - desirable levels of oxygen, carbon and sulphur components. Diffusion/dispersion.

iv) Biomass - fire wood, coconut/arecanut residues, agricultural residues.

v) Biogas - from animal wastes, solid wastes, sewerages, industrial wastes etc,

vi) Food - from agriculture, imports

vii) Fish - from ocean, surface waters

viii) Forests

ix) Coastal system - micro organisms to fish

x) Soil - enrichment, leaching, quality,

Many resources are interactive. Forest productivity depends on atmospheric pollution Fish production depends on harvesting, micro organisms, pollution from rivers, canals and pipelines from industries. Water and metallic pollution affects land and soil. Solid wastes reduce soil quality and land availability

Animal resources like cattle, sheep, pigs etc are not considered as they are not relevant as inputs, but are relevant as consuming resources. They need land for grazing, and water for survival. They are considered for producing biogas.

Need for Carrying Capacity

Initially population was at a lower level Activities were not many - society was dependent on agriculture So the consumption of resources was at an acceptable level - mostly we used directly accessible, renewable resources.

But with the advent of industrialization and development of energy/power generating units, the needs increased. Consumption of resources also increased, We started tapping non renewable non regenerative resources also. The outputs from industries polluted water, air and land resources degrading some resources. Consumption of energy resources destroyed some resources - deforestation.

The effects of this are cumulative leading to a depletion of resources So it became necessary to carefully nurture and manage resources used in our activities.

Initially management of natural resources looked at alternative sources (like biomass in the place of coal, ethanol for petrol etc), and technological developments were initiated to improve efficiency of usage. Reuse and recycling of resources are being attempted now.

Still, the increasing need for resources due to increases in population and wants of people may stress an area or region Hence, it is desirable to conduct studies to obtain the limits on the availability of resources and their usage.

Since different regions of a state may not be developing at the same level, there is normally a skewed level of development. Utilisation of resources will not be uniform in all regions. Patterns of development (based on perception, availability of infrastructure) may vary But development is a continuous process Hence, carrying capacity studies for different regions will allow us to divide the state into regions of different classes - highly resource stressed regions, normally stressed regions, low - stressed regions - for different resources. This can help us to identify locations for future development and to generate development plans for each region.

Land Resources

For any region, land is the most important resource. It is basic resource used for agriculture, human settlements, industries, schools, communications like roads, storage reservoirs, trading establishments, service units, powerstations and most importantly forests. It is well known that a certain percentage of land is to be preserved as forests, in order to maintain the ecological balance of the region, state and country.

There is a lot of competition on the usage of land by various activities. Hence, a good optimal land use policy is necessary. This becomes more imperative in a country with a higher population density like India. As already stated, the population density of Dakshina Kannada district is higher than that of state, we should be carefull in the allocation of net available land to new activities.

We have land use land cover maps available for different land classifications. We remove from this map all areas in use - forests, agriculture, settlements, other essentials like schools, religious places, and existing industrial land use. This will give us land area available for future needs. From this, we subtract the additional needs of a growing population - settlements, agriculture and other needs for a period of 50 years We need per capita norms for these activities This gives us the net land availability.

L net = L total - L forests - L agri-
L settlements - L essential - L exist ind
- L future essentials - Lspare

where L total is the total land of the area
L forest - forest area
L agri - land used for agricultural purposes
L settlements - land for human needs like houses, trade, services etc,
L essentials - land for schools, religious purposes, storage reservoirs, parks, etc,
L exist ind - land used by existing industries
L future essentials - land needed by additional population = p * ne
where p - population (addition)
ne - norm (land required per capita)
L spare - spare for unforeseen

Now only L net (net land available for development) is to be made available for industries It is imperative that norms should be developed to establish land requirement for each class of industries We also note that L net includes land for industries and land required for additional needs that arise due to the setting up of industry (land required for transportation, services, settlement for employees etc.)

$$L\ net \geq \sum_{l=1}^{k} Li \quad mi\ .\ ci$$

where Li is the area required for ith group of industries
mi - multiplier factor
ci - capacity

If capacity is not a continuous variable, than we rewrite the inequality as

$$L_{net} \geq \sum_{l=1}^{k} \sum_{j=1}^{c} L_{ij} \cdot m_{ij} \cdot n_{ij}$$

where L_{ij} is the total area required by the ith group of industries for a capacity group j

m_{ij} is the multiplier factor

n_{ij} is the number of industries of group i for capacity group j

(capacity is grouped into C groups, each group with a particular value based on the existing capacity ranges - thereby making capacity a discrete variable, realistic with the existing situations).

The above land constraint states that the total requirement of land by different industry groups with different capacities should not exceed the net available value.

Actually the net available land area (given in hectares, say) is not a single contiguous value Hence we eliminate all industries needing larger contiguous areas for a capacity by the constraint.

$n_{ij} = o$ if

$L_{ij} m_{ij} > L_{cont.max}$

We divide L net into a set of land areas like (L_{c1}, L_{c2}, . L_{cn}) where L_{c1},L_{c2} are contiguous areas and

$L_{c1} + L_{c2} + \ldots + L_{cn} = L_{net}$

$L_{cont.max} = \max (L_{c1}, L_{c2}, \ldots L_{cn})$

Recall that this may not eliminate an industry group (i) in totality. It will only eliminate only industries of that group with very large capacities. This constraint is of theoretical importance today because technological improvements have reduced land requirements for most types of industries.

What is Carrying Capacity?

People and society consume various resources. There have been instances when societies have found shortages of some resources. We keep hearing about water shortages. Fortunately, with green revolution, better storages, buffer stocking and transportation facilities, it is now possible to handle food shortages in a region. But we do have grass and fodder shortages in different places during several periods. Ground water shortages exist in several places. Water usage has led to quarrels. From this, it was felt that the available resources can meet only a maximum level of population.

We ask questions like what is the maximum number of population that we can sustained in a particular region? It can be human population or animal population. The calculations are based on food producing capacity of that area, grass producing capacity of that area etc. Carrying capacity is calculated as

$$\text{Population that can be sustained} = \frac{\text{maximum food production}}{\text{food requirement for a person}}$$

Sometimes, it is based on two or more parameters like food, water etc. Then the carrying capacity is given by

$$C = \min(\text{Cfood}, \text{Cwater}, \text{------------})$$

The above depends on productivity of soil, technology used, acceptable comfort levels etc. Hence, it varies with time, with assumptions and with values used. So we should define carrying capacity as constrained by the current states of technology, of physical, chemical and biological environment, of social, political, economic institutions, of levels and styles of living and of values, preferences and moral judgements.

Some examples of carrying capacity are:

1) Food productivity in an area,
2) Biomass productivity in a forest area (sustainable),
3) Water availability in a river basin,
4) Grass productivity,
5) Fish productivity,
6) No. of vehicles on a road etc

These are secondary values based on which the primary values - like the number of people that can be sustained - are calculated. Since our task here is to find out the carrying capacity of Dakshina Kannada District from the point of view of industries, it is more focussed. so let us first define carrying capacity.

U.N (1980)

Carrying capacity is not given exogenously; it is determined endogenously i.e Development strategies, with a set of goals and policy measures, can make it possible to have a continuing expansion of carrying capacity.

KIRCHNER

Carrying capacity of a region is the maximum population of a given species that can be supported indefinitely, allowing for random and seasonal changes, without any degradation of the natural resource that would diminish this max-population in the future

VOGT

Man has moved into an untenable position by protracted and wholesale violation of certain natural laws.

CURRY LINDAHL

The fact that each area has a carrying capacity beyond which it cannot be utilised without causing damage, deterioration and decreased productivity, is an ecological rule that is almost always forgotten by those who plan and carryout land use development schemes.

Applied to mainly

Soil conservation ---------> usage (desertification)

inadequate mgmt of irrigated areas - salinity- loosing land

Pressure of population of humans ----------> biomass of cattle -----------> overgrazing

HOMEWOOD AND RODGERS

Concept of carrying capacity is not to areas with great annual variation in primary productivity and furthermore it can only be defined satisfactorily in terms of a given management aim.

HOGG

Judgment about carrying capacity is subjective.
We need data to assess longterm degradation of vegetation and/or desertification.

FEARNSIDE

Sustainable carrying capacity is the maximum number of persons that can be supported in perpetuity on an area, with a given technology and a set of consumptive habits, without causing environmental degradation.

Human Carrying capacity

$$\text{Population that can be fed} = \frac{\text{Food supply}}{\text{Individual food requirement}} = P1$$

$$\text{Population requirement for water} = \frac{\text{Water availability}}{\text{Individual water reqt.}} = P2$$

Population that can be fed and it's water needs met = min(P1,P2)

Carrying capacity ------>

(1) **Productivity.**

Primary Productivity

- Food Production in an area
- Biomass productivity in a forest ecosystem.
- Water availability (seasonal, average) in a river
- Average grass production (grazing).
- Maximum number of vehicals that can travel on a road.
- Fish productivity.

Acceptable burden

What is optimal/ acceptable productivity?

(biomass yield is 10 t/ha or 100t/ha)

Secondary Productivity

Soil Productivity

Population that can be supported by an area

Biodiversity

Coastal Productivity (of micro-organisms)

Productivity of land(overall)?

(minimal wastage of land?)

Carrying capacity not only depends on ecological concepts but also on human choices and technology.

So define a current (but varying) carrying capacity as constrained by the current states of technology;

Of physical , chemical and biological environment;

Of social, political, economic institutions;

Of levels and styles of living and moral judgments.

Tertiary level.

Maximum number of activities-domestic, agriculture, transport, industries that can be done/ supported without affecting

(1) Quality of life (pollution, traditional practices like gathering firewood, access to traditional resourcesand health)

(2) Balance of resources (is maintained).

(3) Sustainability.

(4) Existing systems(?)
(coastal erosion,salt water ingress)

Definition: Carrying Capacity

We can define carrying capacity as the maximum number of activities - like domestic, agriculture, transport, industries - that can be done continuously over a period of time without affecting

i) the existing quality of life (from the point of view of existing traditional practices, access to resources, health and pollution levels)

ii) the balance of resources (renewability/regeneration is maintained)

iii) the fact that activities can be done on a sustainable manner

iv) neighbouring systems

v) existing ecological systems like coastal systems, forests etc.

The above is a qualitative general definition. We redefine it for the purpose of industrialisation as an optimization problem with an objective function and constraints. The quantitative definition follows:

We define carrying capacity for industries as:

If there exist an excess of usable resources like land, water, biomass, minerals etc. after meeting the existing and essential - domestic, agricultural and other requirements of man for the next 50 years, then the carrying capacity for industries is defined as the maximum industrialisation that can come in that area subject to the following constraints:

i) the total requirements for each resource by industrialisation should be less than the net available quantity of that resource in that region

ii) total pollution load does not affect the needs and health of the people and maintain a desirable state of the region

iii) the forest and coastal ecosystems, large settlements, essential areas etc are not affected.

iv) usage of non renewables is discouraged

v) there are no permanent undesirable effects on the region

Let us now write the mathematical frame work for this problem of calculating the number of industries that can come up in that area - Dakshina Kannada district.

Mathematical Framework

The problem of industrialisation can be posed as an optimization problem. The objective function is industrialisation. What is industrialisation - number of industries - that may be the output we need from the solution. We can define industrialisation as the maximum employment that can be generated. It can also be the annual production. But I think employment is a better indicator and the framework should include small scale sector also - particularly those which use resources and produce pollution (like tile industry).

We can modify the objective function to include the risk factors also as a penalty. Similarly use of non renewables can also be treated as a penalty. The decision variables are: industries are grouped into several classes based on consumption and pollution.

ni - number of industries of class i that can be set up in that area

ni - is the decision variable

just like we group industries, we can also discretise production capacity into groups instead of treating it as a continuous variable. Then we get

nij- number of industries of class i with production capacity cj

The objective function can be chosen from:

1) Employment

$$\sum_i \sum_j eij\ nij$$

where eij is the number of employees required for industry of group i with capacity cj.

2) Employment and risk values

$$\sum_i \sum_j cij\ nij - \sum_i \sum_j rij\ nij$$

where cij is the cost towards employment rij is the cost due to risks for industries in group i for capacity cj.

3) Employment, risk and penalty on non renewables

$$\sum_i \sum_j cij\ nij - \sum_i \sum_j rij\ nij - \sum_k Pk\ Rkb$$

where Pk is a penalty factor, a fairly large value. Rkb is the amount of non renewable resource, k used by the industries in the solution. Rkb is obtained from the resource balance constraints.

The constraints are:

1) All decision variables are positive values

$$nij \geq 0$$

2) Resource balance constraint

a) water usage in every region for every period by all industries should be less than the net dependable water available in the region after meeting essential needs plus losses.

b) land requirement for industries (nij) should be less than net land available excluding forest, coastal, agricultural, settlements, grazing and other present and future requirements. We identify large patches of land available for industries.

c) skilled manpower required by industries preferably for each category of skills, should be less than or equal to the available manpower for each category.

d) energy requirements should be met

e) transportation requirements should be met

3) Pollution levels should be within limits. This needs to be done as a separate set of studies for water and air pollution and based on that we obtain maximum number of industries of each group in every region.

Then we get

$$nijr \leq nijrmax \text{ in each region}$$

where nijr is the number of industries of group i capacity cj in region r. nijrmax is obtained from separate studies. This is a simplified constraint. We can make it more realistic by the following constraint.

$$Plkrmax \geq \sum_i \sum_j nijr \cdot Plijk$$

Plk is the pollution load of type k (types can be BOD, COD, metallics, CO_2, SOx, NOx etc.).

Plkrmax is the maximum load of pollution type k permissible in region r.

plijk is the pollution of type k generated by industry group i with capacity cj

Activities

As seen before, a region's dynamics depends on several activities which consume resources. Examples of activities are domestic like cooking, lighting, use of water in cooking and drinking, agricultural activities like ploughing, irrigation, harvesting etc., transportation, cattle feeding, construction of buildings, industries etc.

Activities can be grouped as domestic, agricultural, industrial, transport and service oriented. Further grouping of industrial activities as manufacturing, mining, power generation, textiles, metallurgical, chemical, paper, sugar, food processing, etc. is also possible.

An activity can be modelled as a process with certain inputs of resources and certain outputs - both desirable land wastes - as well as losses to the system (which are not recoverable). Activities normally consume resources and produce outputs. Let us consider examples.

Consider agriculture. Inputs are land, soil, water, energy, fertilizer, pesticides etc Outputs are food produce (cereals, pulses etc.) and agricultural residues. In addition, there is a quality change in the pollution of water due to pesticides and of soil (due to water logging).

Similarly, a power generating unit consumes fuel (like coal), land, water for boiler, cooling water, land for storing fly ash, lubricant oils etc; it produces electrical energy; it also produces fly ash, and many carbon based gases like CO_2 and some sulphur based gases like SO_2 which go to the atmosphere. It also produces waste water. This activity also uses people for employment which is also a resource - human resource.

An activity can be modelled as

Qoi = fi (Q1,Q2,Q3,------------Qn)

where Q1, Q2, ---- are quantities of different resources
Qoi - is the ith output resource
fi - function of the output ith resource

So one of the aspects of modelling is to list all activities, estimate the required outputs of desired activities and calculate the needed input resources. The quanta of resources used and generated are used in the resource balance equation.

Resource Balance Constraint

We know that if we want to have a sustainable use of each resource, then the total yearly consumption of a resource in a region should be less than the regeneration of that resource. This is the resource balance constraint.

We can state that total generation of a resource for a time period in a region should meet the following:

i) consumption of the resource by each activity - essential and others
ii) conversion of the resource due to pollution

iii) losses in the resource in each activity
iv) minimum desirable quantity of the resource that should be left unused.
v) consumption of the resource by existing industries
vi) consumption needs for future
vii) balance (rbi)

We use only the balance quantum available for finding out additional industrialisation.

When we talk about resources, we use the balance equation for basic resources like water, land, air, biomass, electricity, skilled manpower etc. which are needed by industries to be set up The net availability is calculated after reducing from existing generated quantum the consumptions for existing and basic needs, future basic needs, losses and minimal residual quantity. It is this net available which is used in our carrying capacity model as a constraint

The net available quantity (balance) of a resource should be more than the requirements for different industries.

$$rbit > \sum_{j=1}^{n} \sum_{k=1}^{c} njk \cdot Qjkit \cdot \eta jki$$

where n is the number of industries of group j and capacity k;

Q is the quantity of resource i needed to produce a capacity k of industry group j during period t.

η is the efficiency of conversion for ith resource

Grouping of Industries

Industries have two effects on an ecosystem - one they consume many natural resources and second they pollute the atmosphere, water and soil. But all industries do not have the same effect on pollution and consumption. There is a large variation in these aspects.

Secondly, we cannot consider industries individually. That will make the model difficult to handle Hence, it is desirable to group industries based on the above aspects. A typical grouping is attempted below:

Group 1:

Industries that consume small quantity of resources like land and water and pollution outputs are negligible.

Examples are computer software units, hardware units, system integration units, electronic systems manufacturing, manufacturing of electrical machines and transformers, manufacturing of electrical and electronic control devices and systems, manufacturing of elevators, oxygen manufacture

Group 2:

This group deals with industries that need some natural resources and there is some water pollution, but negligible air pollution. Examples are textiles, large machine tools, food processing industries, tiles.

Group 3:

This group needs substantial natural resources like wood and there is water pollution, but air pollution is negligible.

Examples are paper manufacture, sugar, metallurgical industries (mining).

Group 4:

This group needs resources and results in water/air pollution.

Examples are chemicals, petrochemicals, polymers, battery manufacture.

Group 5:

This group needs natural resources and affects water, air, soil in a major way

Examples are thermal power plants, distilleries etc.

Group 6:

Deals with hazardous industries like nuclear (radioactive)

Since the requirements of group 1 are low, the effects are minimal and many industries belong to this category, this is an ideal group to look for from the point of view of carrying capacity, sustainability and acceptability. Hence, without delayed analysis and from first inspection itself, we can infer that many industries of this category may be set up without affecting ecology. But we may need to generate skills especially in the area of I.T industries and provide communication infrastructure.

Steps of Implementation

Step 1: From the land use land cover maps prepared, identify major areas of land available for development. This should exclude areas already mentioned.

Step 2: Conduct studies on water supply, and consumption by domestic, agriculture and industries. Project on future usage for essentials and establish surplus water availability for different seasons on a dependable basis. Suggest marginal storage units, if required, indicate the surplus availability areas on a map of Dakshina Kannada district.

Superimposition of the land availability map on water availability map will give us areas for group 3/4 industries.

Step 3: Conduct studies on the atmosphere; identify point sources based on the land use/water resources maps. Establish maximum allowable pollution load including existing industries, and road networks (point, line and volume sources). Establish the minimum distance between two industries based on air pollution. We can use data on highly polluting industries for this purpose and conduct diffusion/dispersion studies to arrive at the minimal distance. Use a factor of safety to arrive at a practical distance between two industries.

From the maps of water/land usage, we can calculate the number of industries of higher groups. We can get a set of values which become the feasible solutions.

Step 4: Check for soil and solid wastes. Calculate solid wastes that will be produced, identify a good management system for solid wastes. Based on solid wastes, adjust the feasible solutions.

Step 5: Calculate employment for various industry groups
Check the constraint for skill jobs ,
Adjust the number of industries
Obtain optional feasible solution.

Requirements for Success of the Study

1) We need a coordinating and monitoring committee that identifies persons/organizations, define the sub problems and deliverables from each sub problem. The committee should organize discussions with each group, monitor the progress and get the results

7. Estimation of necessary skilled manpower for each industry group and capacities; estimation of possible methods of generation of required skills in Dakshina Kannada district through establishment of training institutes, infrastructure development (like internet) etc

Agency: 1) Department of Management, Mangalore University
2) Prof. Vinod Vyasulu, CBPS, Bangalore
3) Dr. S Rajagopalan, TIDE
4) Dr. K.N. Krishnaswamy, IISc.

8. Studies on migration of people from Dakshina Kannada district, and to establish reasons for migration

Agency: Prof. K.M. Hegde, Prof. Hebbar, Prof. Moodithaya, NMAMIT Nitte

9. Studies on biodiversity, effect of industrialisation on biodiversity.

Agency: 1) Prof. Madhav Gadgil's group, IISc.
2) Biology Department, Mangalore University
3) Prof. Achar, Karkala

10. Studies on solid wastes - estimation of solid wastes, disposal methods, requirement of land, soil degradation etc.

Agency: Dr. Poornima Vyasulu, CBPS.

11. Simulation studies on transportation
- transportation requirements of industries,
- carrying capacity of existing roads,
- requirements of new industry groups

12. Studies on dispersion of fly ash during monsoon - due to heavy rains, effect on soils.

DATA SOURCES

1. Groundwater -	Central Groundwater Board, Govt. of India. Groundwater Cell, Dept. of Mines and Geology, Govt. of Karnataka.
2 Rainfall -	Public Health Dept. , Drought Monitering Cell, Govt. of Karnataka. Indian Meteorological Dept. , Govt of india
3. Water Resources -	WRDO, Govt. of Karnataka. Minor Irrigation Dept. Karnataka Power Corporation. Karnataka Urban Water Supply and Drainage Board, Agriculture Dept. , Govt. of Karnataka.

4. Industries -	Director of Industries and Commerce, Bureau of Economics and Statistics, Centre for Montering Indian Economy, Karnataka State Pollution Control Board, Central Pollution Control Board, Greater Mysore Chamber of Industries, Karnataka State Industries Infrastructure Corp., Dept. of Industries, Govt. of Karnataka, NEERI reports and publications, Dept. of Planning, Govt. of Karnataka, Tecsok, Govt. of Karnataka.
5. Transportation -	Transportation Dept., Govt. of Karnataka. PWD Dept., Govt of Karnataka. Ministry of Surface Transport, Govt. of India.
6. Power -	Karnataka Power Corp., Karnataka Electricty Board, Dept. of Energy, Govt. of Karnataka, Regional Power Survey Directorate, CEA, Govt. of India. Karnataka Pollution Control Board.
7. Fisheries -	Fisheries Dept., Reports of College of Fisheries.
8. Flora -	National Botanical Research Institute.
9. Maps -	Survey of India. Karnataka Remote Sensing Application Centre, NRDMS Centre, Dakshina Kannada District.
10. Forests -	Forest Department, Govt. of Karnataka.
11. Small Scale Industries-	KSSIDC, Small Scale Industries Service Inst.,
12. Ocean-	Nation Inst. of Oceanography. Dept. of Ocean Developement, Govt. of India, CAOS, IISc.
13. Wind -	Dept. of Non-conventional Energy, Govt. of India. IREDA, New Delhi, Centre for Renewable Energy Development, Karnataka, KSCST, Raman Research Institute.

Action Plans.

A list of activities that are to be initiated by the government is listed below. These activities are necessary for the successful completion of the carrying capacity studies. These activities are action plans

(1). **Clearance of projects:**

Scope of work has been written up and based on the scope, sub-problems like water resources, air, land, industry, energy etc. are identified. Projects proposals submitted by investigators, who were identified through discussions, were analysed. Hence, the first activity is to look at these project proposals, define sharply various factors like the scope, methodology and deliverable outputs, budget and duration through discussions with investigators, and approve proposals. This step is essential to initiate these projects. The government should also clear the budget proposal for each project at the earliest.

(2). **Setting up a co-ordination/ monitering committee:**

Since the whole program is a highly focussed one the outputs required from each project are needed for the final integration phase, there is a lot of interactions between these projects and there is a time criticality, it is necessary to set up a co-ordination/monitering committee which will review the progress of these projects at periodic intervals, suggest course correction, maintain a tight control on time budget, get the results reviewed by experts in each area, liase with government, obtain or help to obtain requisite data from government departments or others, get help from reputed scientists/ research organisations as and when required by any project co-ordinator, and do other activities as deemed fit.

This committee should conduct periodic review meeting with investigators of each project, sort out problems and suggest course corrections. A separate budget head should be created for handling the administrative expenses of this committee.

(3) **Creation of databases.**

As repeatedly stated, the projects will succeed if and only if the requisite data become available. The data should also be correct. The government should try to get the data from all sources. In the long term point of view, it is desirable that the Dept. of Ecology and Environment should set up a library of data and reports on the economic, social, ecological, developmental aspects preferably locating such a library at the Centre for Ecological Sciences,IISc. or at KSCST. In the short term, the government should get data required by project investigators with minimal delays.

(4) **Administration of Projects.**

There are several administrative aspects related to the projects. In some instanses, the project funding is given to the institutions and the respective institutions will handle all associated administrations; but in some instances, it is desirable to have an administrative support from outside. Similarly, the monitering committee also needs administrative support. As part of the overall program, it is desirable to conduct brainstroming sessions and workshops on the studies being conducted by the investigators of the projects, by inviting outside experts, local environmental groups, administrators and industrialists Hence, we need to find an agency for providing administrative support as well as accounting support.

Since, the district committee for science and technology is very active in the Dakshina Kannada district, it has several projects,it is implementing them successfully and it consists of several motivated persons, it is desirable to entrust the work to the DCST of Dakshina Kannadadistrict. They can provide support to investigators, support to the co-ordinating committee and organise brainstorming sessions. They can also liaise with state government agencies and district administration as well as obtain data from local sources and get cooperation from various local agencies.

Projects

Sl.no	ProjectActivity	Investigators and Agency	Duration
(1). *	Air pollution limits	Dr.G.Sriniketan Dr.M.B.Saidutta KREC, Surathkal	2 years
(2). *	Water Resources -Potentials,Usage and Quality.	Dr.Lakshman Nandagiri and others	2 years
(3). *	Solid wastes- area requirements Dispersion of fly ash	Dr.Gopal Mugeraya KREC,Surathkal	2 years
(4). *	Flaws of Resourses into activities.	Dr.S.Rajagopalan TIDE,Bangalore and others.	9 months

(5) *	Transportation	Dr A U Ravishankar KREC,Surathkal and others	2 years
(6) *	Migration in and out of the district	Dr K M Hegde NMAMIT, Niite	20 months
(7) *	Biomass production and estimation	Dr K S Jagadish, Dr Chanakya, Mr Somasekhar, ASTRA,IISc	2 years
(8) *	Landuse	Dr C R Bannur KSCST	1 year
(9) *	Industries	Dr T V Ramachandra CES, IISc	2 years
(10) *	Energy	Dr T V Ramachandra CES	2 years
(11) *	Fish productivity studies	Dr Mohan Joseph College of Fisheries	2 years
(12)	Shellfish Safety; Microorganisms of Public health significance	Dr I Karunasagar	2 years
(13) *	Microbial Diversity in coastal waters receiving industrial effluents	Dr I Karunasagar	2 years
(14) *	Human Resources	Dr T Mallikarjunappa University of Mangalore	1 year
(15)	Effects of marine pollution	Dr A V Hegde KREC	2 years

(16) *	Industries	Dr.Indira, Dr.Vinod	1 year
(17) *	People's perception of Carrying Capacity limits	Dr Kailash malhotra Dr Shoba Raguram and Okkoota	2 years

Second Stage

* System Integration(will start after 1.5 years)

NOTE: The asterik (*) mark indicates that these projects have objectives that are of the scope of work and are essential.

Budget

The estimated cost for the projects will be about Rs. 1.5 crores. The duration of work will be around 1.5 to 2 years.

Recommendations

From the study existing state of the district, we can make the following recommendations

1. Major industries which consume large quantities of resources and affect the environment can be identified for consideration only after the above mentioned studies are completed. The studies will tell us the type, number and capacity of different industries.
2. We need not wait for the studies to be conducted or completed, but it is possible to take up industries which do not consume resource and which do not affect our land, water, air, soil, forest and coastal environment. Examples of such industries are computer software, system integration, electronic device manufacture, etc.

Limitations of Carrying Capacity Limits

Carrying capacity limits are calculated for a region based on several assumptions on technology, social behaviour, developmental process and individual preferences. There are changes occuring in technologies available for resource utilization and intervention methods to improve environment. On the other hand, it does not include current management and operational inadequancies like the difficulties in meeting current water and wastewater systems in urban areas. (We assume that waste management systems are working well). Social change may also increase or decrease consumption of a resource for an activity due to reduced availability, or better education or new technological changes or consciousness of conservation.

Hence any limit evaluated for resources is only a guiding value. Because of various assumptions and factors, we may get several values for a parameter. The results of a carrying capacity study should be considered and analysed based on realistic factors to arrive at an acceptable value for the chosen resource. For example, if we state that available water in a place can meet the needs of 1000 persons, we can easily increase the limit to 2000 persons by reducing per capita water needs by half. These decisions on basic input parameters and standards are to be arrived at by persons in charge of development of a state.

But we can use the carrying capacity studies as a good decision support system for government policy planners and managers. It helps them in arriving at good decisions. They know the impact of their decision on the environment.

Annexure

Some Persons who Participated in Discussions (in random order)

1. Dr K.V. Rao Mangalore University.
2. Dr. Indrani Karunasagar, College of Fisheries.
3. Prof. P.N. Singh, Principal, KREC Suratkal.
4. Dr. S Srinikethan KREC.
5. Dr. M B. Saidutta, KREC.
6. Dr. Shreekumar, KREC.
7. Dr. K.N. Lokesh, KREC.
8. Dr. K.R.N. Setty, KREC.
9. Sri Srihari, KREC.
10. Dr A. Vittal Hegde, KREC.
11. Dr. B B. Hosetti, Mangalore University.
12. Dr Ravindranath Shanbag, Manipal
13. Dr. Ranjan Rao Yeradur, Guruvaranakere.
14. Mr. Shampa Daithotta, Okkoota
15. Mr. Murali Ballal, Economist.
16. Mr Somnath Naik, Okkoota
17. Mr. Upendra Hosabettu, Okkoota
18. Mrs. Celine Aranha, Okkoota.
19. Mrs. Vidya, Okkoota.
20. Mr Vittal Rao, Okkoota.
21. Dr. Ashok Kundapur, MGM College.
22. Mr. Mohammed Guthegar, Okkoota.
23. Prof. P.V Bhandari, Principal MIT Manipal.
24. Faculty members, MIT Manipal.
25. Faculty members, College of Fisheries.
26. Faculty, Mangalore University.
27. Dr. Lakshman Nandagiri, KREC
28. Dr. K.M. Hegde, NMAMIT, Nitte.
29. Dr. Moodithaya, Nitte.
30. Faculty member, Engineering College, Sulliya
31. Mr. S.M. Shivaprakash, College of Fisheries

32. Prof. NCLN Charyulu, KREC.
33. Mrs. Vijayamala Nair, Mangalore University.
34. Dr. Ramachandra Bhatta, College of Fisheries.
35. Dr. Mohan Joseph, College of Fisheries.
36. Dr. N. Vinay Kumar, College of Fisheries.
37. Dr. L.N. Srikar, College of Fisheries.
38. Dr. V. Hariharan, College of Fisheries.
39. Dr. R.J. Katti, College of Fisheries.

Persons with whom discussion were held at Bangalore

1. Prof. Madhav Gadgil, CES, IISc.
2. Fr. C.J. Saldanha, CTS.
3. Prof. R. Kumar, IISc.
4. Capt. S. Rajarao, Secretary Ecology and Environment.
5. Dr. Balakrishniah, Director (Technical) Ecology and Environment.
6. Dr. Shivalingiah, Chairman, Pollution Control Board.
7. Prof. Nadkarni, ISEC.
8. Mrs. Teresa Bhattacharya, Development Commissioner and ACS, Government of Karnataka.
9. Dr. Vinod Vyasulu, CBPS.
10. Dr. A. Indira, CBPS.
11. Dr. S. Rajagopalan, TIDE.
12. Mr. Sampath Kumar, TIDE.
13. Dr. Vishnu Kamath, Bangalore University
14. Mr. Y.B. Ramakrishna, Varthamana.
15. Students and faculty of CES, IISc.
16. Students and Faculty, Geology Department, Bangalore University.
17. Dr. C.R. Bannur, KSCST.
18. Dr. T.V. Ramachandra, CES, IISc.

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13. Mr. Somnath Naik for organising a meeting at St.Aloysius College, Mangalore with members of the Dakshina Kannada District Parisaraasakta Okkootta
14. Mrs. Ahalya Bhat, Director, Bureau of Economics and statistics for getting me data sources

Table 1: Population Growth rates (in percentage)

Sl.no	District	1961 - 1971	1971 - 1981	1981 - 1991
	BANGALORE DIVISION			
1	Bangalore	46.55	59.08	38.00
2	Bangalore (rural)	16.22	24.30	14.70
3	Chitradurga	27.71	27.20	22.51
4	Kolar	17.56	25.64	16.05
5	Shimoga	27.93	27.30	14.71
6	Tumkur	19.04	21.51	16.36
	BELGAUM DIVISION			
7	Belgaum	22.16	22.94	18.18
8	Bijapur	19.60	20.96	21.35
9	Dharwad	20.01	25.76	18.79
10	Uttara Kannada	23.14	26.38	13.49
	GULBARGA DIVISION			
11	Bellary	22.66	32.65	27.09
12	Bidar	24.26	20.83	25.65
13	Gulbarga	24.28	19.63	23.71
14	Raichur	28.75	26.00	29.33
	MYSORE DIVISION			
15	Chickmagalur	23.33	23.77	11.52
16	Dakshina Kannada	24.01	22.55	13.27
17	Hassan	23.05	23.10	15.43
18	Kodagu	17.18	22.10	5.05
19	Mandya	28.38	22.85	15.90
20	Mysore	24.28	24.97	21.58
	STATE	**24.22**	**26.75**	**20.69**

Table 2: Density of Population (persons per sq. km)

Sl.no	District	1961	1971	1981	1991
	BANGALORE DIVISION				
1	Bangalore }	314	421	1595	2210
2	Bangalore (rural) }			250	288
3	Chitradurga	101	129	164	201
4	Kolar	156	184	232	270
5	Shimoga	96	123	157	181
6	Tumkur	129	153	187	218
	BELGAUM DIVISION				
7	Belgaum	150	181	222	267
8	Bijapur	97	116	141	172
9	Dharwad	142	170	214	255
10	Uttara Kannada	67	83	104	119
	GULBARGA DIVISION				
11	Bellary	92	113	151	191
12	Bidar	122	151	183	231
13	Gulbarga	85	107	128	159
14	Raichur	78	101	127	165
	MYSORE DIVISION				
15	Chickmagalur	83	102	127	141
16	Dakshina Kannada	186	230	282	319
17	Hassan	131	162	199	230
18	Kodagu	78	92	113	119
19	Mandya	181	233	286	331
20	Mysore	140	174	217	265
	STATE	**123**	**153**	**194**	**235**

Table 3: Literary - Total (in percentage)

Sl.no	District	1961	1971	1981	1991
	BANGALORE DIVISION				
1	Bangalore }	34 34	42 72	51 32	76 27
2	Bangalore (rural) }				50 17
3	Chitradurga	25 09	31 45	38 25	55 48
4	Kolar	21 29	27 06	33 57	50 45
5	Shimoga	28 05	36.61	44 44	61 53
6	Tumkur	20 64	29 36	36 92	54 48
	BELGAUM DIVISION				
7	Belgaum	26 03	30.73	36 64	53 00
8	Bijapur	24 45	27 48	31 96	55 13
9	Dharwad	33 35	38 51	42 36	58 68
10	Uttara Kannada	33 44	40 65	48.35	66 73
	GULBARGA DIVISION				
11	Bellary	20.91	25 12	30 64	40 57
12	Bidar	14 49	20 02	26 44	45.11
13	Gulbarga	14.73	18.74	24.94	38.54
14	Raichur	15.66	20.20	24 72	35 96
	MYSORE DIVISION				
15	Chickmagalur	27.53	34 93	43 50	61.05
16	Dakshina Kannada	32 35	43.45	53 47	75 86
17	Hassan	24 34	30.56	37 49	56.85
18	Kodagu	36 27	44 30	50 15	68 35
19	Mandya	17 31	22.51	30 40	48 15
20	Mysore	21 30	25.62	31 34	47.32
	STATE	**25.40**	**31.52**	**38.46**	**56.04**

Table 4: Percentage of workers to total population

Sl.no	District	1961	1971	1981	1991
	BANGALORE DIVISION				
1	Bangalore }	39 65	31 58	31 92	33 81
2	Bangalore (rural) }				37.24
3	Chitradurga	50 95	37 17	38 86	38 70
4	Kolar	47 13	34 91	36 11	39.76
5	Shimoga	44 25	32 02	35 94	37.75
6	Tumkur	50 21	34 02	36 22	39 70
	BELGAUM DIVISION				
7	Belgaum	43 38	34 48	36 06	37 41
8	Bijapur	47 46	35 56	37 00	37.92
9	Dharwad	42 27	35 50	37 98	38 53
10	Uttara Kannada	44 97	33 68	34 02	35 13
	GULBARGA DIVISION				
11	Bellary	46.14	37 98	40 97	42 85
12	Bidar	46 72	33 02	26 81	37 16
13	Gulbarga	47.32	34.94	40.30	40.27
14	Raichur	46 51	37 22	41 07	42 04
	MYSORE DIVISION				
15	Chickmagalur	47 65	34 61	38 81	40 53
16	Dakshina Kannada	46 73	38 61	40.00	41 29
17	Hassan	47 30	31.75	35 20	37 56
18	Kodagu	46 92	40 40	45 18	45 09
19	Mandya	47.45	32 56	34 01	38 65
20	Mysore	43 31	33 61	35 16	37 38
	STATE	**45.48**	**34.74**	**36.76**	**38.45**

Table 5: Percentage of agricultural workers to total workers

Sl.no	District	1961	1971	1981	1991
	BANGALORE DIVISION				
1	Bangalore }	50 48	40 83	32.54	10 52
2	Bangalore (rural) }				70 96
3	Chitradurga	74 74	73 10	71 89	69 26
4	Kolar	78 70	76 05	75 52	72 73
5	Shimoga	61 58	70 39	72.29	72.76
6	Tumkur	79 96	77 87	79 17	75.78
	BELGAUM DIVISION				
7	Belgaum	77 04	72 88	71 15	70 27
8	Bijapur	75 50	71 78	72 81	74 67
9	Dharwad	72 71	68 55	66 81	69 09
10	Uttara Kannada	56 91	54 95	52 55	52 17
	GULBARGA DIVISION				
11	Bellary	72 06	72 73	72.56	74 31
12	Bidar	74 59	70 65	75 02	75 12
13	Gulbarga	71 99	70 70	71 03	74 77
14	Raichur	76 65	76 27	78 85	79 82
	MYSORE DIVISION				
15	Chickmagalur	60 03	56 67	58 90	60 65
16	Dakshina Kannada	64 82	54 16	44 43	35 79
17	Hassan	79 52	73 45	73 44	71 48
18	Kodagu	44 58	43 21	39 13	31 98
19	Mandya	43 87	81 11	80 60	78 18
20	Mysore	69 08	68 42	68 54	66 00
	STATE	**70.55**	**66.71**	**65.03**	**63.12**

Table 6: Distribution of workers in Dakshina Kannada District

Type	No.	Percentage
Cultivators	219324	19 50
Agricultural labourers	178879	15 90
Forestry fishery plantation	74196	6 66
Mining and quarring	4328	0 41
Manufacturing, processing, servicing, repairs	325131	28 91
Construction of buildings	34990	3 11
Trade and commerce	116089	10.32
Transport and communication	43232	3 84
Other services	115260	10 25
Marginal workers	50465	4 49
Nonworkers	1531350	
Total workers	1124449	100.00

Table 7: Landuse pattern in Dakshina Kannada District

Type	Area (hectares)	Percentage
Total area	833595	
Forest area	226783	27 20
Land put to non agricultural use	87238	10 47
Barren and uncultivable land	71886	8 62
Cultivable waste land	71535	8 58
Pastures	31529	8 78
Trees and groves	89713	10 76
Fallow land	34945	4 19
Net area sown	219966	26 39

Table 8: Percentage of net area sown to the total geographical area

Sl.no	District	1961	1971	1981	1991
	BANGALORE DIVISION				
1	Bangalore	52 12	48 85	45 10	43.30
2	Bangalore (rural)			50 92	54 10
3	Chitradurga	45 74	48 86	57 87	63 30
4	Kolar	38 58	39 32	47 83	49 30
5	Shimoga	29 25	29 07	30 69	33 20
6	Tumkur	46 17	46 30	52 34	56 60
	BELGAUM DIVISION				
7	Belgaum	67 73	67 06	66.72	67 60
8	Bijapur	83 46	68 21	79 17	79.00
9	Dharwad	80 90	80.22	70 53	79 80
10	Uttara Kannada	10 13	10 67	11 23	11 40
	GULBARGA DIVISION				
11	Bellary	62.98	49 27	64 67	59 50
12	Bidar	61 41	64 29	65.87	68 60
13	Gulbarga	75 36	73 17	71 94	74 60
14	Raichur	74 29	68 21	68 86	68 90
	MYSORE DIVISION				
15	Chickmagalur	31 52	35 01	39 32	40 00
16	Dakshina Kannada	22 33	23 05	26 27	26 60
17	Hassan	47 25	51 62	51 75	57 00
18	Kodagu	26 79	34 20	35 95	35 90
19	Mandya	54 28	48 62	48 33	50 10
20	Mysore	37 33	39 56	38 56	42 80
	STATE	**54.10**	**51.96**	**54.49**	**56.60**

Table 9: Percapita land available for cultivation (area in hectares)

Sl.no	District	1970-71	1980-81	1990-91
	BANGALORE DIVISION			
1	Bangalore }	0.13	0.09	0.21
2	Bangalore (rural) }			0.03
3	Chitradurga	0.51	0.40	0.34
4	Kolar	0.26	0.21	0.20
5	Shimoga	0.25	0.22	0.20
6	Tumkur	0.38	0.32	0.30
	BELGAUM DIVISION			
7	Belgaum	0.40	0.34	0.28
8	Bijapur	0.73	0.61	0.51
9	Dharwad	0.48	0.36	0.32
10	Uttara Kannada	0.17	0.14	0.12
	GULBARGA DIVISION			
11	Bellary	0.49	0.41	0.34
12	Bidar	0.58	0.46	0.37
13	Gulbarga	0.79	0.64	0.49
14	Raichur	0.73	0.65	0.54
	MYSORE DIVISION			
15	Chickmagalur	0.34	0.29	0.30
16	Dakshina Kannada	0.11	0.10	0.12
17	Hassan	0.33	0.29	0.28
18	Kodagu	0.36	0.38	0.35
19	Mandya	0.26	0.22	0.20
20	Mysore	0.25	0.21	0.19
	STATE	**0.39**	**0.32**	**0.27**

Table 10: Number of persons per registered factory

Sl.no	District	1971	1981	1991	1993-94
	BANGALORE DIVISION				
1	Bangalore }	2493	1109	1705	1691
2	Bangalore (rural) }				11424
3	Chitradurga	13700	7865	7331	7375
4	Kolar	20223	18322	18607	17758
5	Shimoga	18862	5959	11691	13682
6	Tumkur	31918	32965	13956	14982
	BELGAUM DIVISION				
7	Belgaum	7817	2471	18601	9653
8	Bijapur	14882	5560	11234	12485
9	Dharwad	6279	5009	5399	5761
10	Uttara Kannada	17690	8060	16359	16502
	GULBARGA DIVISION				
11	Bellary	7243	5772	7938	9190
12	Bidar	28414	19148	16428	21196
13	Gulbarga	17220	9678	16815	20886
14	Raichur	5224	5341	5886	7412
	MYSORE DIVISION				
15	Chickmagalur	20461	10602	1847	19500
16	Dakshina Kannada	5212	3225	5946	5491
17	Hassan	20415	23396	20451	21966
18	Kodagu	13511	4399	16120	14586
19	Mandya	22200	13636	20366	27362
20	Mysore	10598	5397	6714	7892
	STATE	**7682**	**3735**	**5836**	**6495**

Table 11: Number of establishments and employments

Sl.no.	District	No. of establishments as on March '94	Employment (%)	
			March 1993	March 1994
1	2	3	4	5
	BANGALORE DIVISION			
1	Bangalore }	3378	32 0	31 5
2	Bangalore (rural) }			
3	Chitradurga	855	1.5	3.3
4	Kolar	1283	3 6	3.5
5	Shimoga	741	3 4	3.3
6	Tumkur	691	3.0	2.5
	BELGAUM DIVISION			
7	Belgaum	1282	6 0	5 9
8	Bijapur	707	3 4	3.4
9	Dharwad	1273	8.2	8 2
10	Uttara Kannada	848	3 2	3 2
	GULBARGA DIVISION			
11	Bellary	674	3.2	3 2
12	Bidar	410	1.5	1.6
13	Gulbarga	942	3.8	3 8
14	Raichur	656	3 7	3.7
	MYSORE DIVISION			
15	Chickmagalur	599	2.2	2 2
16	Dakshina Kannada	1851	6 7	7 8
17	Hassan	692	2.4	2.4
18	Kodagu	450	1.4	1.5
19	Mandya	492	2.3	2 3
20	Mysore	1108	7.3	7 3
	STATE	**18274**	**100.0**	**100.0**
	Total employment	**(1501500)**		**(1530400)**

Source: Annual Employment Review - 1993-94

Table 12: Districtwise literacy rates, IMR, life expectancy and Real per capita income

Sl.No.	Districts	Literacy rates Males	Females	Total	IMR	Life expectancy at Birth	Per capita real income
1	Bangalore	77.59	60.86	69.64	51	64.72	3925
2	Belgaum	66.65	38.69	53.00	64	61.27	2560
3	Bellary	58.71	31.97	45.57	83	55.83	266
4	Bidar	58.97	30.53	45.11	67	60.27	1626
5	Bijapur	69.69	40.06	55.13	76	60.64	2030
6	Chikmagalur	70.56	51.31	61.05	67	60.44	2692
7	Chitradurga	66.88	43.36	55.48	71	59.94	2194
8	Dakshina Kannada	84.40	67.96	75.86	38	68.91	2617
9	Dharwad	71.37	45.20	55.68	71	59.94	1984
10	Gulbarga	52.08	24.49	38.54	67	59.94	2065
11	Hassan	68.87	44.90	56.85	64	61.27	2034
12	Kodagu	75.35	61.22	68.35	54	64.02	3678
13	Kolar	62.69	37.75	50.45	62	61.60	1583
14	Mandya	59.18	36.70	48.15	66	60.60	2204
15	Mysore	56.23	37.95	47.32	63	61.44	2399
16	Raichur	49.53	22.15	35.96	73	60.45	1753
17	Shimoga	71.34	51.42	61.53	66	60.60	2644
18	Tumkur	66.49	41.93	54.48	70	60.11	1859
19	Uttara Kannada	76.39	56.77	66.73	59	62.62	2042

IMR - Infant Mortality Rate

Table 13: Human development indices - Alternative A

Sl.No.	Districts	HDI-1	HDI-2	HDI-3	HDI-4	HDI-5	HDI-6
1	Bangalore	0.8349	0.8247	0.8330	0.8424	0.8321	0.8404
2	Belgaum	0.5894	0.6122	0.5667	0.5927	0.6154	0.5699
3	Bellary	0.2523	0.2606	0.2430	0.2523	0.2606	0.2430
4	Bidar	0.2065	0.2210	0.1906	0.2139	0.2284	0.1980
5	Bijapur	0.4637	0.4979	0.4331	0.3908	0.4250	0.3602
6	Chikmagalur	0.6379	0.6314	0.6387	0.6410	0.6346	0.6419
7	Chitradurga	0.5159	0.5203	0.5060	0.4961	0.5006	0.4863
8	Dakshina Kannada	0.9746	0.9780	0.9719	0.6746	0.9780	0.9719
9	Dharwad	0.4566	0.4475	0.4333	0.4368	0.4577	0.4136
10	Gulbarga	0.3232	0.3261	0.3185	0.3318	0.3347	0.3271
11	Hassan	0.4956	0.5077	0.4853	0.4989	0.5110	0.4886
12	Kodagu	0.8037	0.7827	0.8150	0.8079	0.7868	0.8191
13	Kolar	0.2670	0.2729	0.2586	0.2759	0.2818	0.2675
14	Mandya	0.4760	0.4674	0.4791	0.4822	0.4736	0.4853
15	Mysore	0.5415	0.5116	0.5604	0.5476	0.5177	0.5665
16	Raichur	0.1872	0.1871	0.1872	0.1404	0.1403	0.1404
17	Shimoga	0.6449	0.6410	0.6425	0.6511	0.6472	0.6487
18	Tumkur	0.3751	0.3840	0.3632	0.3581	0.3671	0.3462
19	Uttara Kannada	0.6151	0.6174	0.6079	0.6193	0.6216	0.6122

HDI - Human Development Index

Table 14: Human development indices - Alternative B

Sl.No.	Districts	HDI-1	HDI-2	HDI-3	HDI-4	HDI-5	HDI-6
1	Bangalore	0.6635	0.6735	0.6539	0.6864	0.6964	0.6768
2	Belgaum	0.4955	0.5198	0.4776	0.5093	0.5336	0.4914
3	Bellary	0.2228	0.2334	0.2148	0.2249	0.2355	0.2169
4	Bidar	0.1443	0.1590	0.1325	0.1596	0.1742	0.1478
5	Bijapur	0.3680	0.4014	0.3449	0.3225	0.3558	0.2993
6	Chikmagalur	0.5256	0.5339	0.5199	0.5379	0.5462	0.5322
7	Chitradurga	0.4245	0.4374	0.4137	0.4184	0.4314	0.4076
8	Dakshina Kannada	0.7520	0.7745	0.7404	0.7763	0.7989	0.7647
9	Dharwad	0.3553	0.3813	0.3358	0.3493	0.3752	0.3297
10	Gulbarga	0.2837	0.2870	0.2802	0.2993	0.3026	0.2958
11	Hassan	0.3898	0.4088	0.3785	0.4037	0.4226	0.3923
12	Kodagu	0.6416	0.6436	0.6403	0.6608	0.6627	0.6595
13	Kolar	0.1782	0.1897	0.1696	0.1969	0.2084	0.1883
14	Mandya	0.4020	0.4023	0.4008	0.4169	0.4172	0.4158
15	Mysore	0.4637	0.4488	0.4722	0.4799	0.4650	0.4884
16	Raichur	0.1517	0.1517	0.1517	0.1258	0.1257	0.1258
17	Shimoga	0.5299	0.5402	0.5221	0.5448	0.5551	0.5370
18	Tumkur	0.2854	0.3010	0.2737	0.2818	0.2974	0.2700
19	Uttara Kannada	0.4687	0.4858	0.4567	0.4855	0.5027	0.4736

HDI - Human Development Index

Table 15: Ranks of HDI

Sl.No.	Districts	Alternative - A					
		HDI-1	HDI-2	HDI-3	HDI-4	HDI-5	HDI-6
1	Bangalore	2	2	2	2	2	2
2	Belgaum	7	7	7	7	7	7
3	Bellary	17	17	17	17	17	17
4	Bidar	18	18	18	18	18	18
5	Bijapur	12	11	13	13	13	13
6	Chikmagalur	5	5	5	5	5	5
7	Chitradurga	9	8	9	10	10	10
8	Dakshina Kannada	1	1	1	1	1	1
9	Dharwad	13	12	12	12	12	12
10	Gulbarga	15	15	15	15	15	15
11	Hassan	10	10	10	9	9	9
12	Kodagu	3	3	3	3	3	3
13	Kolar	16	16	16	16	16	16
14	Mandya	11	13	11	11	11	11
15	Mysore	8	9	8	8	8	8
16	Raichur	19	19	19	19	19	19
17	Shimoga	4	4	4	4	4	4
18	Tumkur	14	14	14	14	14	14
19	Uttara Kannada	6	6	6	6	6	6

Sl.No.	Districts	Alternative - B					
		HDI-1	HDI-2	HDI-3	HDI-4	HDI-5	HDI-6
1	Bangalore	2	2	2	2	2	2
2	Belgaum	6	6	6	6	6	6
3	Bellary						
4	Bidar	19	18	19	18	18	18
5	Bijapur	12	12	12	13	13	13
6	Chikmagalur	5	5	5	5	5	5
7	Chitradurga	9	9	9	9	9	9
8	Dakshina Kannada	1	1	1	1	1	1
9	Dharwad	13	13	13	12	12	12
10	Gulbarga	15	15	14	14	14	14
11	Hassan	11	10	11	11	10	11
12	Kodagu	3	3	3	3	3	3
13	Kolar	17	17	17	17	17	17
14	Mandya	10	11	10	10	11	9
15	Mysore	8	8	7	8	8	7
16	Raichur	18	19	18	19	19	19
17	Shimoga	4	4	4	4	4	4
18	Tumkur	14	14	15	15	15	15
19	Uttara Kannada	7	7	8	7	7	8

HDI - Human Development Index

Table 16: Normal rainfall in Karnataka in mm

Sl.No.	Districts	Normal premonsoon (Jan-May)	Normal monsoon (Jun-Sep)	Normal postmonsoo (Oct-Dec)	Annual
1	Bangalore (u)	178	440	249	867
2	Bangalore (r)	68	415	234	817
3	Belgaum	109	541	159	808
4	Bellary	102	388	149	639
5	Bidar	65	693	90	847
6	Bijapur	75	366	127	569
7	Chikmagalur	173	1514	238	1925
8	Chitradurga	114	290	176	580
9	Kodagu	246	2173	300	2718
10	Dharwad	127	422	169	717
11	Gulbarga	68	607	102	777
12	Hassan	185	60	242	1031
13	Kolar	135	387	221	744
14	Mandya	189	264	246	700
15	Mysore	226	307	238	771
16	Uttara Kannada	138	2489	209	2836
17	Raichur	67	413	119	599
18	Shimoga	144	1227	198	1569
19	Dakshina Kannada	230	3448	352	4029
20	Tumkur	138	342	209	689

APPENDIX

Information on carrying capacity for Resources

1. Type of Resource Chosen :
   Water (rain,ground,tanks,river etc)/air/soil/biomass/wind/solar/bioresources/fish/agriculture produce/agriculture residues/Infrastructure like roads.

2. Types of usage of the resource :
   Agriculture/domestic/industry/general

3. How do we divide the district for the purposes of this study :
   based on revenue divisions/watersheds/others (explain)

4. What is the yearly potential of this resource ?
   (How do we compute it?) :

5. What is the yearly consumption? (Where do we get the data?)

6. What is the trend of consumption, trend of regeneration in the past few years according to your data/perception?

7. How do we calculate these values (consumption/regeneration/wastage etc)? What are the models available?

8. Based on the above, what is your perception of carrying capacity for the resource?

9. What are the effects on the chosen resource due to population, agricultural practices, industrialization Or other activities (like buildings, infrastructure creation)

10. What are the side effects of usage of the resource?
    (Waterlogging, Salinity, Pollution, Saltwater ingress, fish deaths etc)

11. What are the other resources affected by the use of this resource
    (Use of fertilizer/pesticide affects water supply)

12. What are the other resources used in conjunction with the chosen resource?

13. List the studies that are to be done for doing the carrying capacity studies?

14. Who are the people working/capable of doing projects in this area and the studies they can undertake

15. List data items, maps required for each study, Source for each data group, requirement of historial data (inluding time period) ? In case of data not available, suggest a methodology for data collection

APPENDIX

Verbal Definitions of Human Carrying Capacity

(in Chronological Order)

source	definition
House and Williams *(1975, pp 54-55)*	" . the carrying capacity theme becomes much more complex when applied to the evolution of human activities It seems clear that rather than defining carrying capacity as a certain level of population or some other point criterion, it must be defined in terms of a rather complicated function or set of functions, which would include a number of regional characteristics and economic parameters and would make explicit the possible trade-offs that are implicit in the definition. This requires a representation of the set of social trade-offs between the citizen's concept of environmental quality and the degree to which that society desires or needs to utilize the production and assimilation capabilities of the natural environment In examining the critical inter-relationships between human and economic activity, we must be concerned with a number of resource limits and environmental factors that may act as constraints or dampening forces in the dynamic interaction of population growth, related socio-economic activity, resource base and environment as an assimilator of waste [For] a closed system, carrying capacity would be seen as the ability of a system to produce desired outputs (goods and services) from a given resource base while, at the same time, maintaining desired quality levels. For an open system, the definition would further have to allow for import of both resources and goods and services and the export of output and residuals . . [There are] four relationships that are relevant to the overall measurement of carrying capacity. 1 Resource-production functions: the capacity of available resources to sustain rates of resource use in producing the system output. 2 Resource-residuals functions: the capacity of the environmental media to assimilate wastes and residuals from production and consumption . . at acceptable quality levels. 3. Infrastructure-congestion functions: the capacity of infrastructure, the distribution and delivery systems to handle the flow of goods and services and resources 4. Production-societal functions: the capacity of both resources and production outputs to provide acceptable quality of life levels Working from these four relationships, then, human carrying capacity is defined as the level of human activity that a region can sustain at acceptable 'quality of life' levels. "The high degree of interrelation among resources environmental media and desired quantity and quality states for human and associated socioeconomic activity underscores the fact that trade-offs must inevitably be made among desired production-consumption levels, resource uses, and a clean healthy and pleasant environment From this perspective carrying capacity must be interpreted as a variable socially determined within our understanding of economic social, and environmental values and their relative contribution in maintaining quality of life levels "

Whittaker and Likens *(1975, pp 311–15)*

Both the production by the biosphere and man's effects on it bear on what ought to be a guiding question for man's policy in occupying and using the world. This question is the world's carrying capacity for man: the size of the human population that can be supported on a long-term steady-state basis by the world's resources without detriment to the biosphere or exhaustion of non-renewable resources that are reasonably available . . . Neither for North America nor for the world can a carrying capacity be defined unless a standard of living and a role of technology are first specified If the role of technology is large, a time scale for exhaustion of resources may need to be part of the definition; but this time scale itself is (given the uncertainties of substitution and feasible use of low-grade resources) almost indeterminable."

United Nations *(1980, reprinted in Ghosh 1984, p 74)*

'The carrying capacity, however, is not given exogenously; it is determined endogenously This implies that development strategies, encompassing interrelated sets of goals and policy measures, can make it possible to have a continuing expansion of carrying capacity."

Simon and Kahn *(1984, p 45)*

Because of increases in knowledge, the earth's 'carrying capacity' has been increasing throughout the decades and centuries and millennia to such an extent that the term carrying capacity' has by now no useful meaning These trends strongly suggest a progressive improvement and enrichment of the earth's natural resource base, and of mankind's lot on earth "

Muscat *(1985, p 20)*

'In sum, the closer a low-income agricultural region or country is to having no trade, only marginal technological improvements available for adoption, no effective institutional base for spreading such improvements as are known and warranted, no vent for surplus [population] in the face of declining marginal returns to incremental arable land, and population growth more rapid than productivity growth, the closer it is to the simple model of a country approaching its carrying capacity ceiling . . . [T]he key is the speed with which the constraints are pushed back "

Kirchner et al *(1985, p 45)*

The *carrying capacity* of a particular region is the maximum population of a given species that can be supported indefinitely, allowing for seasonal and random changes without any degradation of the natural resource base that would diminish this maximum population in the future. The concept of carrying capacity is familiar to biologists and wildlife managers, who devised it to express the capacity of natural areas (ecosystems) to support animal life. With modifications, it is also an important measure of the ability of regions to support human populations. Carrying capacity is therefore an important concept for the work of development economists, planners, and political decision makers." Kirchner et al. pointed out that it is necessary to allow for seasonal and random changes. Fearnside put this observation to work in 1986.

Thurow *(1986, p 22)*

If the world's population had the productivity of the Swiss the consumption habits of the Chinese, the egalitarian instincts of the Swedes, and the social discipline of the Japanese then the planet could support many times its current population without privation for anyone On the other hand, if the world's population had the productivity of Chad the consumption habits of the United States the inegalitarian instincts of India and the social discipline of Argentina, then the planet could not support anywhere near its current numbers "

Thurow s four dimensions are productivity consumption habits egalitarianism and social discipline.

Gever et al *(1986)*

(p 7) Human survival except in the most primitive societies, is now contingent on the ability to obtain energy for our nonliving support systems. The best way to estimate the bounds on what people can and cannot do—that is, the carrying capacity for humans—is to examine the amount of energy available to human populations and the ways in which that energy is used "

(pp 15–16) "The key to reconciling the use of nonrenewable resources with the concept of carrying capacity lies in the rapid adaptability of humans We would say that *a population, human or otherwise, is exceeding its carrying capacity if severe hardships and / or population contraction become inevitable.* history is full of examples in which humans adjusted quickly to the absence of a particular resource by finding substitutes and averted substantial hardship

In short, simply because we are using certain resources faster than they are replenished does not necessarily mean that we are exceeding our carrying capacity and have doomed ourselves to a population collapse. But, on the other hand the longer we use resources unsustainably, the closer we come to the edge of our carrying capacity and the more difficult it will be to back away from it "

Hardin
(1986, p 603)

"When dealing with human beings there is no unique figure for carrying capacity. So when a pronatalist asserts (Revelle 1974) that the world can easily support 40 to 50 billion people—some ten times the present population—he need not be contradicted. . . The naive question, 'What is the human carrying capacity of the earth?' evokes a reply that is of no human use. No thoughtful person is willing to assume that mere animal survival is acceptable when the animal is *Homo sapiens*. We want to know what the environment will carry in the way of cultural amenities, where the word culture is taken in the anthropological sense to include all of the artifacts of human existence: institutions, buildings, customs, inventions knowledge. Energy consumption is a crude measure of the involvement of culture. It may not be the best measure possible, but it will do for a first approach When dealing with human problems, I propose that we abandon the term *carrying capacity* in favor of *cultural carrying capacity* or, more briefly *cultural capacity* As defined, the cultural capacity of a territory will always be less than its carrying capacity (in the simple animal sense). Cultural capacity is inversely related to the (material) quality of life presumed Arguments about the proper cultural capacity revolve around our expectations for the quality of life. Given fixed resources and well-defined values cultural capacity, like its parent carrying capacity is a conservative concept "

Fearnside *(1986, p 73)*

"The basic definition of sustainable carrying capacity . is: *the maximum number of persons that can be supported in perpetuity on an area with a given technology and set of consumptive habits without causing environmental degradation.*"

King
(1987, p 7)

In its simplest form, carrying capacity can be expressed as the size of population which may be sustained by a given territory at a given physical standard of living The concept is, of course, an extension of the biological definition, but when applied to human societies it becomes infinitely more complex, infinitely more subtle. Not only do cultural economic and political factors come into play; human societies have the possibility of expanding their carrying capacity through the deliberate selection and pursuit of development options which allow for the enhancement and sustainable use of physical resources while ensuring that economic growth is not surpassed by population growth and the material demands of individuals. It is not of course, a matter of physical resources alone, for development potential is determined also by a host of other factors: technology, education, agricultural management and land tenure systems, trading opportunities with the outside world, legal and incentive systems or political will "

World Commission on Environment and Development *(1987, p 8)*

Humanity has the ability to make development sustainable—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs The concept of sustainable development does imply limits—not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth The Commission believes that widespread poverty is no longer inevitable '

Srinivasan in Lee et al. *(1988, p 13)*

. the concept of population-carrying capacity: the maximum population that can be sustained indefinitely into the future '

Demeny *(1988, pp 215–16)*

As applied to human populations the concept of carrying capacity is obviously a slippery one Man is a toolmaking animal capable of squeezing out of his environment more than undisturbed nature would provide for his needs. . in contrast to the case of animal ecology, the capacity of a given environment to support human populations can expand relatively rapidly On the other hand . . for humans a physical definition of needs may be irrelevant Human needs and aspirations are culturally determined.

Gilbert and Braat *(1991, pp 3–4)*

'Human carrying capacity may be defined (Unesco and FAO, 1985) as the number of people sharing a given area or territory who can for the foreseeable future, sustain the existing standard of living [through the utilisation of] energy land water, skill and organisation' Quantification of carrying capacity in general is difficult; the given environment is not a constant. Quantification of human carrying capacity is even more difficult because of the interplay between economic and social factors in the human environment and the subjective elements within standard of living'

Davis, in Davis and Bernstam *(1991 pp. 7–8)*

Obviously if a country has certain advantages in nonfood trade it can use these to buy food A policy of self-sufficiency in food makes no sense for . any country that has access to international trade The Earth is becoming one large trading system; and so the carrying capacity' must refer not just to what food could be raised within national borders but to the total of what could be gained in all ways

In short, the notion is false that each region has a carrying capacity that can be calculated and used in making projections and formulating policies. This idea is more applicable to cattle grazing in a pasture than to human beings '

Hillel *(1991 pp 191–93)*

' in international development agencies[a] term much bandied about . . . is a region's carrying capacity It is a rather nebulous term, intended to characterize the amount of biological matter an ecosystem—or rather an agro-ecosystem—can yield for consumption by animals or humans without being degraded More simply put, it is a measure of how many people and / or animals an area can support on a sustained basis Obviously, the productive yield obtainable from an area—and hence the number of people deriving their livelihood from it, at whatever standard of life—depends on how the area is being used; it is a function of technology . .

The more intensive forms of utilization also involve inputs of capital, energy and materials, such as fertilizers and pesticides, that come from outside the region itself but enhance its productivity It is therefore highly doubtful that any given region can be assigned an intrinsic and objectively quantifiable property called carrying capacity '

. the carrying capacity of a region depends on how it is managed, and all that can be said in a given situation is that the particular region is either well-managed or over-exploited under the present mode of utilization which may or may not allow realization of the region's sustainable potential '

Biegman *(1992, p 9)*

Because we are talking about human communities and not animal populations there are no direct, clearcut links to be drawn between population and environment Human culture mediates between man and the environment. Man is continually recreating his natural environment, making the problem all the more complex The phrase the carrying capacity of the environment has been borrowed from the ecologists to describe the relationship between human communities and their natural environment, but the analogy is limited If we wish to use this concept to identify and remedy environmental problems at [the] local level, the local technology, social organization, traditional knowledge and skills, and other social and cultural variables will have to be mapped out "

Myers *(1992, pp 18–19)*

Carrying capacity can be defined as 'the number of people that the planet can support without irreversibly reducing its capacity to support people in the future'. While this is a global-level definition it applies at [the] national level too albeit with many qualifications as concerns international relationships of trade, investment, etc. In fact it is a highly complex affair, reflecting food and energy supplies, ecosystem services human capital people's lifestyles cultural constraints, social institutions, political structures, and above all public policies among many other factors all of which interact with each other Particularly important are two points: that carrying capacity is ultimately determined by the component that yields the lowest carrying capacity [Myers here assumes Liebig's law of the minimum]; and that human communities must learn to live off the interest of environmental resources rather than off their princip[al]' "

Meadows et al *(1992, p. 261)*

The carrying capacity is the size of population that can be sustained by the environment indefinitely. The concept of carrying capacity was originally defined for relatively simple population / resource systems, such as the number of cattle or sheep that could be maintained on a defined piece of grazing land without degrading the land For human populations the term carrying capacity' is much more complex because of the many kinds of resources people take from the environment the many kinds of wastes they return and the great variability in technology, institutions and lifestyles Carrying capacity is a dynamic concept A carrying capacity is not constant; it is always changing with weather and other external changes and with the pressure exerted by the species being carried ' (How are the first and last

Thurow's four dimensions are productivity consumption habits, egalitarianism and social discipline

Gever et al *(1986)*

(p 7) "Human survival except in the most primitive societies, is now contingent on the ability to obtain energy for our nonliving support systems The best way to estimate the bounds on what people can and cannot do—that is, the carrying capacity for humans—is to examine the amount of energy available to human populations and the ways in which that energy is used "

(pp 15–16) "The key to reconciling the use of nonrenewable resources with the concept of carrying capacity lies in the rapid adaptability of humans We would say that *a population, human or otherwise, is exceeding its carrying capacity if severe hardships and / or population contraction become inevitable.* history is full of examples in which humans adjusted quickly to the absence of a particular resource by finding substitutes and averted substantial hardship

In short, simply because we are using certain resources faster than they are replenished does not necessarily mean that we are exceeding our carrying capacity and have doomed ourselves to a population collapse But, on the other hand, the longer we use resources unsustainably, the closer we come to the edge of our carrying capacity and the more difficult it will be to back away from it "

Hardin *(1986, p 603)*

"When dealing with human beings there is no unique figure for carrying capacity. So when a pronatalist asserts (Revelle 1974) that the world can easily support 40 to 50 billion people—some ten times the present population—he need not be contradicted The naive question, 'What is the human carrying capacity of the earth?' evokes a reply that is of no human use. No thoughtful person is willing to assume that mere animal survival is acceptable when the animal is *Homo sapiens* We want to know what the environment will carry in the way of cultural amenities, where the word culture is taken in the anthropological sense to include all of the artifacts of human existence: institutions, buildings, customs, inventions knowledge Energy consumption is a crude measure of the involvement of culture It may not be the best measure possible but it will do for a first approach When dealing with human problems, I propose that we abandon the term *carrying capacity* in favor of *cultural carrying capacity* or, more briefly *cultural capacity* As defined, the cultural capacity of a territory will always be less than its carrying capacity (in the simple animal sense). Cultural capacity is inversely related to the (material) quality of life presumed Arguments about the proper cultural capacity revolve around our expectations for the quality of life Given fixed resources and well-defined values, cultural capacity like its parent carrying capacity, is a conservative concept "

Fearnside *(1986, p 73)*

"The basic definition of sustainable carrying capacity is: *the maximum number of persons that can be supported in perpetuity on an area, with a given technology and set of consumptive habits without causing environmental degradation.*"

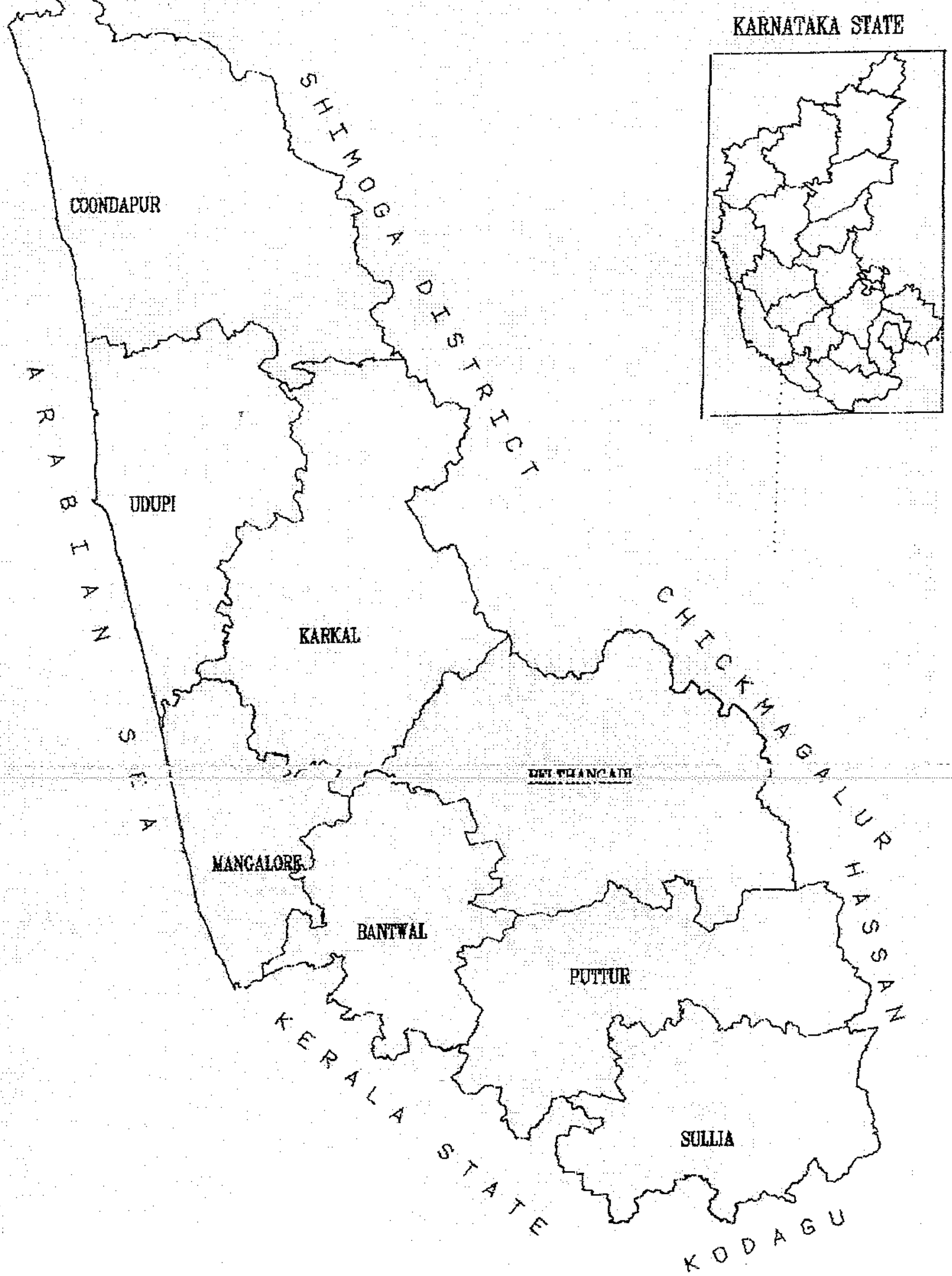
King *(1987, p 7)*

"In its simplest form carrying capacity can be expressed as the size of population which may be sustained by a given territory at a given physical standard of living The concept is, of course, an extension of the biological definition, but when applied to human societies, it becomes infinitely more complex, infinitely more subtle. Not only do cultural economic and political factors come into play; human societies have the possibility of expanding their carrying capacity through sentences of this definition to be reconciled: the size of population that can be sustained . indefinitely" versus 'A carrying capacity is not constant; it is always changing . . '?)

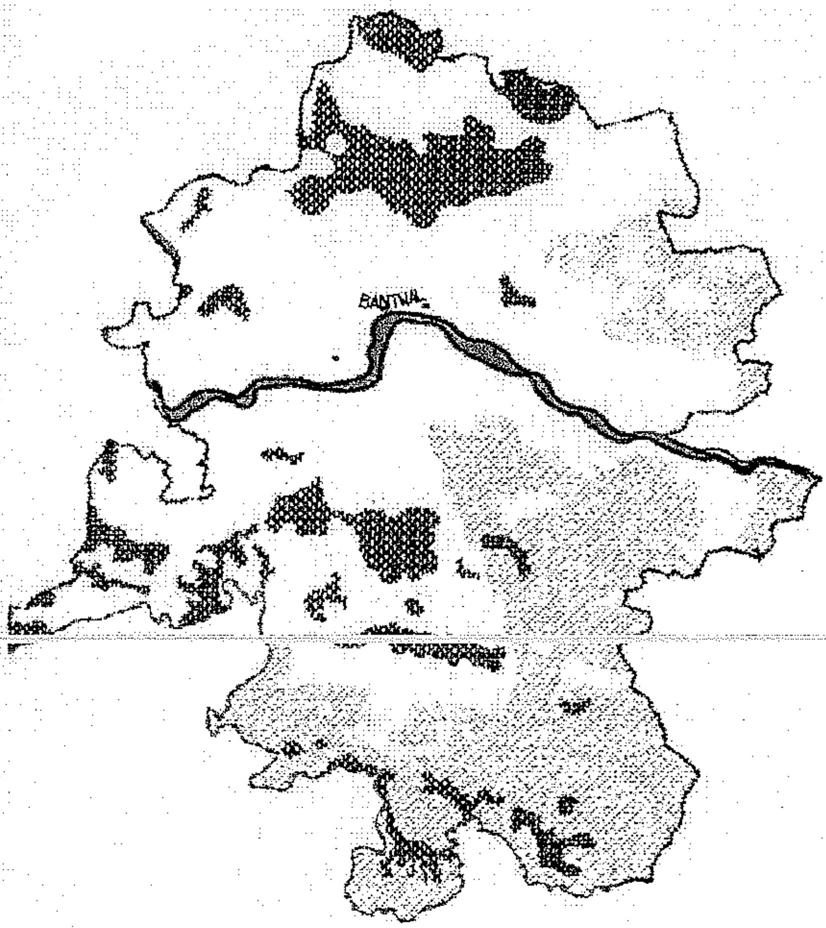
Miller *(1992, p. 81)*	'Carrying capacity refers to the number of individuals who can be supported in a given land area over the long term without degrading the physical, ecological, cultural and social environment . . . Although the advent of technology permits humans to exceed natural carrying capacity limits in some respects, the ultimate size of any human population is still constrained by amounts of arable land potable water, and other resources The unique limiting factor of energy is also on any modern society's list of required assets. 'Human carrying capacity is not determined exclusively by land, energy and water constraints Dr Garrett Hardin of the University of California Santa Barbara was the first to use the term 'cultural carrying capacity' to explain the role that human choice plays in determining optimum population The more clean air fresh water wilderness solitude and biodiversity that humans deem necessary the more population will need to be reduced Increased levels of material consumption ultimately reduce the carrying capacity of any ecosystem Individual freedom deteriorates as human numbers increase and social problems become more intractable"
Carrying Capacity Network *Focus (winter 1992, p. 1)*	'Carrying capacity refers to the number of individuals who can be supported without degrading the physical, ecological, cultural and social environment. i e without reducing the ability of the environment to sustain the desired quality of life over the long term.'
Daily and Ehrlich *(1992)*	(pp. 762–63) 'For human beings the matter [of carrying capacity] is complicated by two factors: substantial individual differences in types and quantities of resources consumed and rapid cultural (including technological) evolution of the types and quantities of resources supplying each unit of consumption Thus carrying capacity varies markedly with culture and level of economic development ' We therefore distinguish between biophysical carrying capacity the maximal population size that could be sustained biophysically under given technological capabilities, and social carrying capacities, the maxima that could be sustained under various social systems (and, especially, the associated patterns of resource consumption) At any level of technological development, social carrying capacities are necessarily less than biophysical carrying capacity, because the latter implies a human factory-farm lifestyle that would be not only universally undesirable but also unattainable because of inefficiencies inherent in social resource distribution systems [reference omitted]. Human ingenuity has enabled dramatic increases in both biophysical and social carrying capacities for *H. sapiens*, and potential exists for further increases ' (p. 769) ' . . central determinants of social carrying capacity lie in the domain of interactions among resources, among sociopolitical and economic factors and between biophysical and social constraints However the complexity of these interactions makes it unlikely that they will be sufficiently well evaluated in the next several decades to allow firm calculations of any carrying capacity. From a policy perspective the current great uncertainty in future social carrying capacity is irrelevant because the human population is likely to remain above that carrying capacity for decades at least '

King *(1993, p 23)*	"The carrying capacity of an ecosystem is the maximum number of a given species that it can support indefinitely without causing environmental degradation In the case of human populations, 2 important qualifications have to be added: with a given technology and consumption patterns A population can, however, exceed the carrying capacity of its ecosystem temporarily, but as it does so it consumes its ecosystem's biological resource base so that the carrying capacity of the ecosystem falls even as the population it supports rises Since this cannot go on for ever, there comes a time when the ecosystem collapses so that people either die or migrate. The point at which they do this is their Malthusian ceiling, but they usually start migrating well before they reach it "
Heilig *(1994, p 255)*	"The carrying capacity of the earth is not a natural constant—it is a dynamic equilibrium essentially determined by human action
Postel *(1994 pp 3–4)*	"Carrying capacity is the largest number of any given species that a habitat can support indefinitely. . . The earth's capacity to support humans is determined not just by our most basic food requirements but also by our levels of consumption of a whole range of resources, by the amount of waste we generate, by the technologies we choose for our varied activities and by our success at mobilizing to deal with major threats."

DAKSHINA KANNADA DISTRICT



AREAS SUITABLE FOR INDUSTRIES AT BANTWAL TALUK



Fallow agriculture lands

Land with or without Scrub and Barren areas

Scrub land with mixed plants

Coastal Regulation zone (No development zone)

State/District Boundary

Taluk Boundary

Rivers

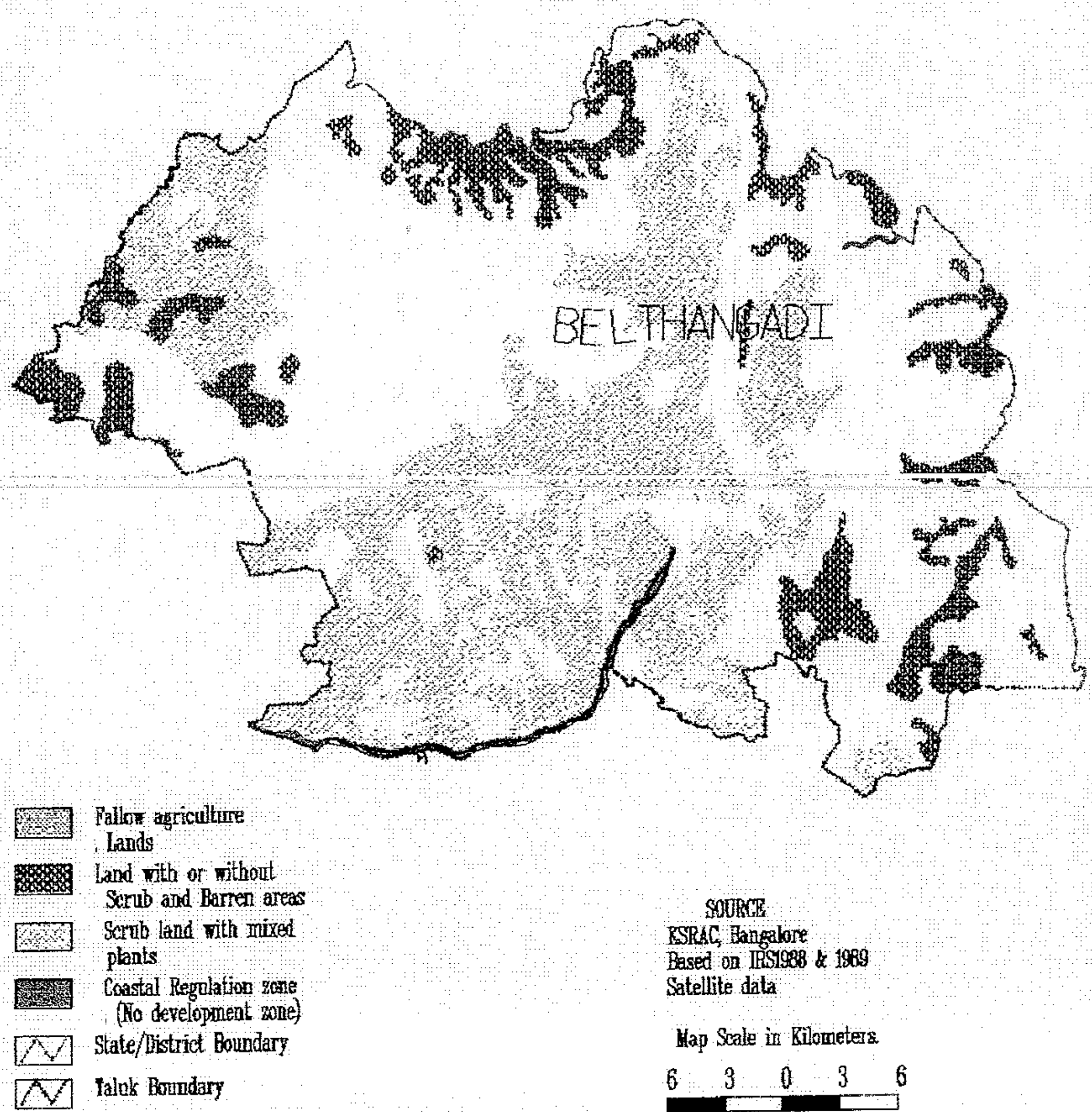
SOURCE
KSRAC, Bangalore
Based on IRS1988 & 1989
Satellite data

Map Scale in Kilometers

5.6 2.8 0 2.8 5.6

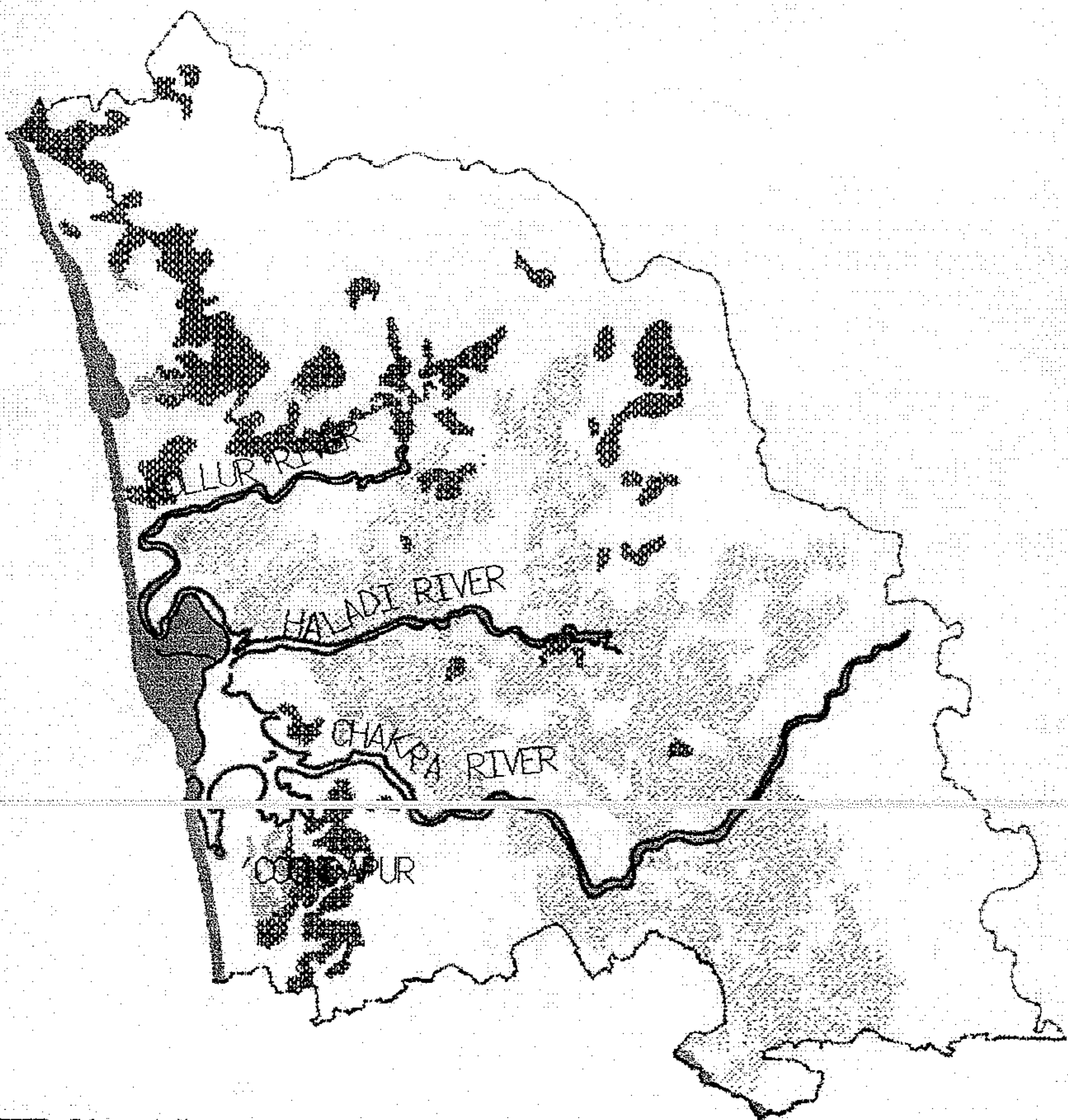
DIGITAL DATABASE AT:- NRDMS STATE CENTRE, KSCST, IISc BANGALORE

AREAS SUITABLE FOR INDUSTRIES AT BELTHANGADI TALUK



DIGITAL DATABASE AT:- NRDMS STATE CENTRE, KSCST, IISc BANGALORE

AREAS SUITABLE FOR INDUSTRIES AT COONDAPUR TALUK



- Fallow agriculture Lands
- Land with or without Scrub and Barren areas
- Scrub land with mixed plants
- Coastal Regulation zone (No development zone)
- State/District Boundary
- Taluk Boundary
- Rivers

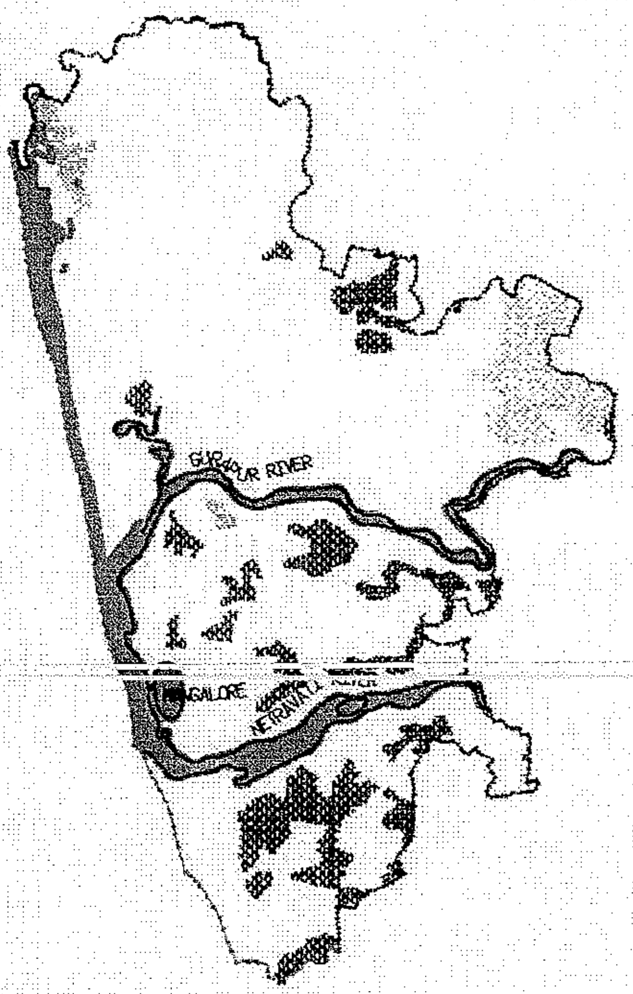
SOURCE
KSRAC, Bangalore
Based on IRS1988 & 1989
Satellite data

Map Scale in Kilometers

5.62.80 2.85.6

DIGITAL DATABASE AT:- NRDMS STATE CENTRE, KSCST, IISc BANGALORE

AREAS SUITABLE FOR INDUSTRIES AT MANGALORE TALUK



- Fallow agriculture Lands
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- Coastal Regulation zone (No development zone)
- State/District Boundary
- Taluk Boundary
- Rivers

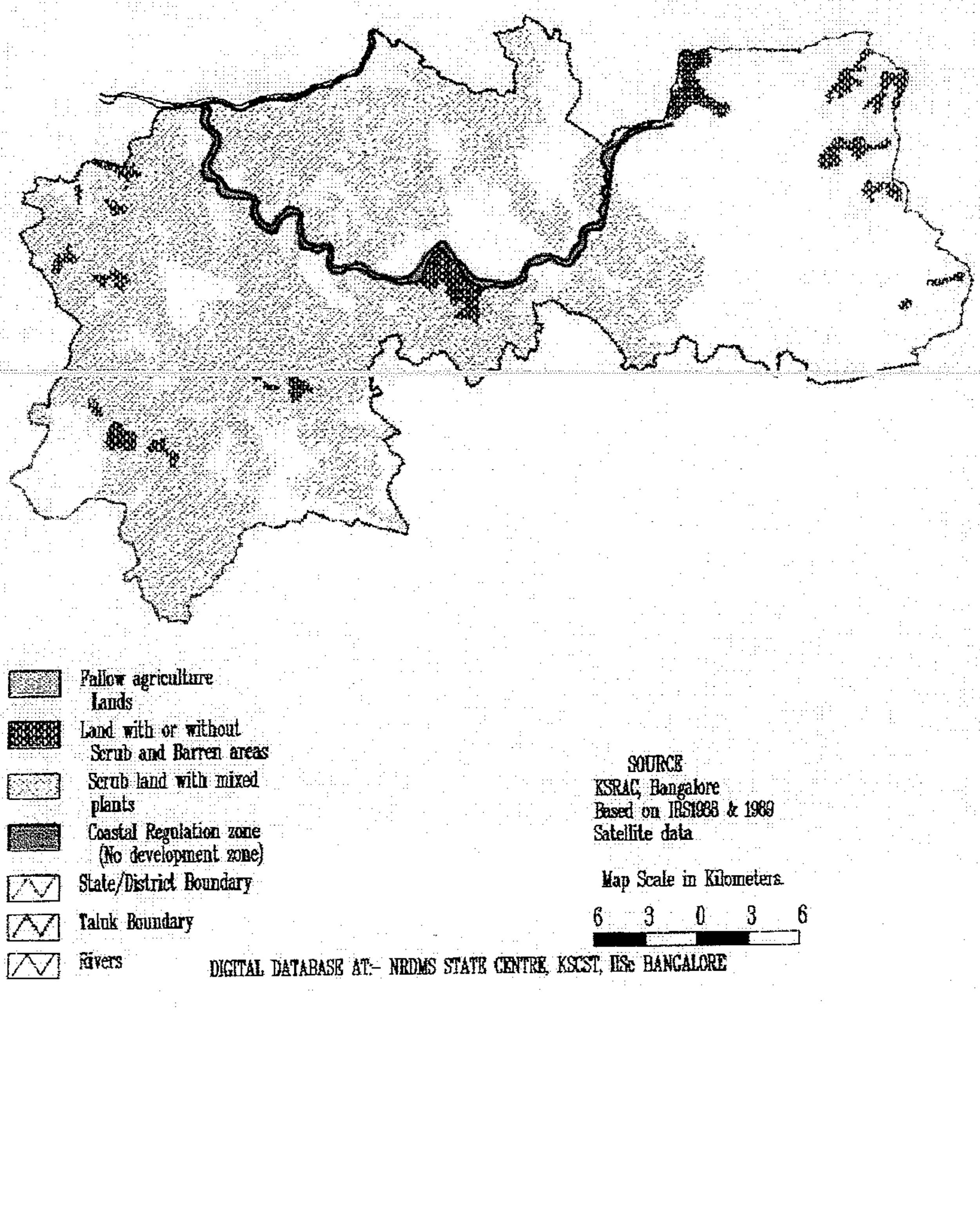
SOURCE
KSRAC, Bangalore
Based on IRS1988 & 1989
Satellite data

Map Scale in Kilometers.

5.6 2.8 0 2.8 5.6

DIGITAL DATABASE AT:- NRDMS STATE CENTRE, KSCST, IISc BANGALORE

AREAS SUITABLE FOR INDUSTRIES AT PUTTUR TALUK



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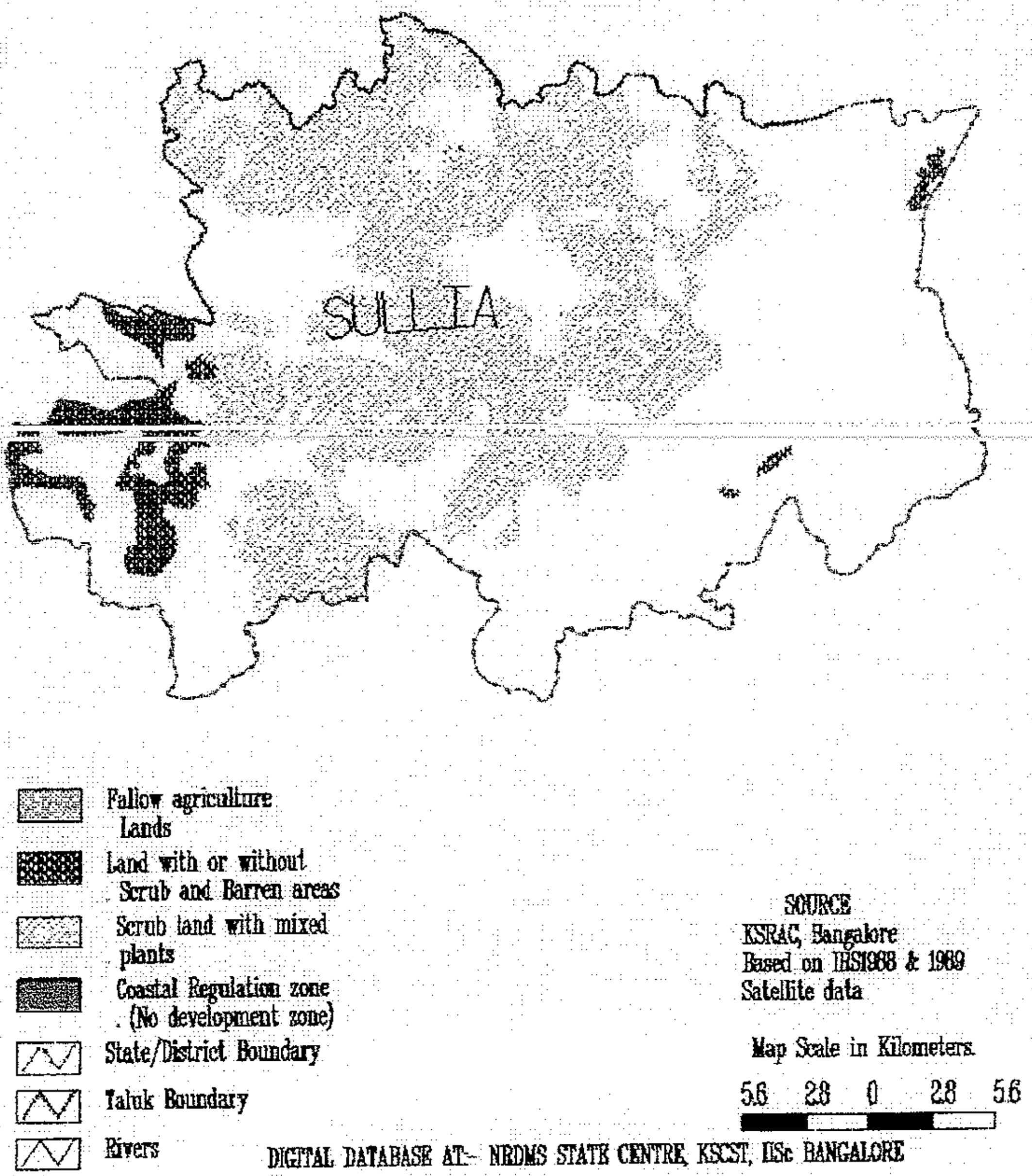
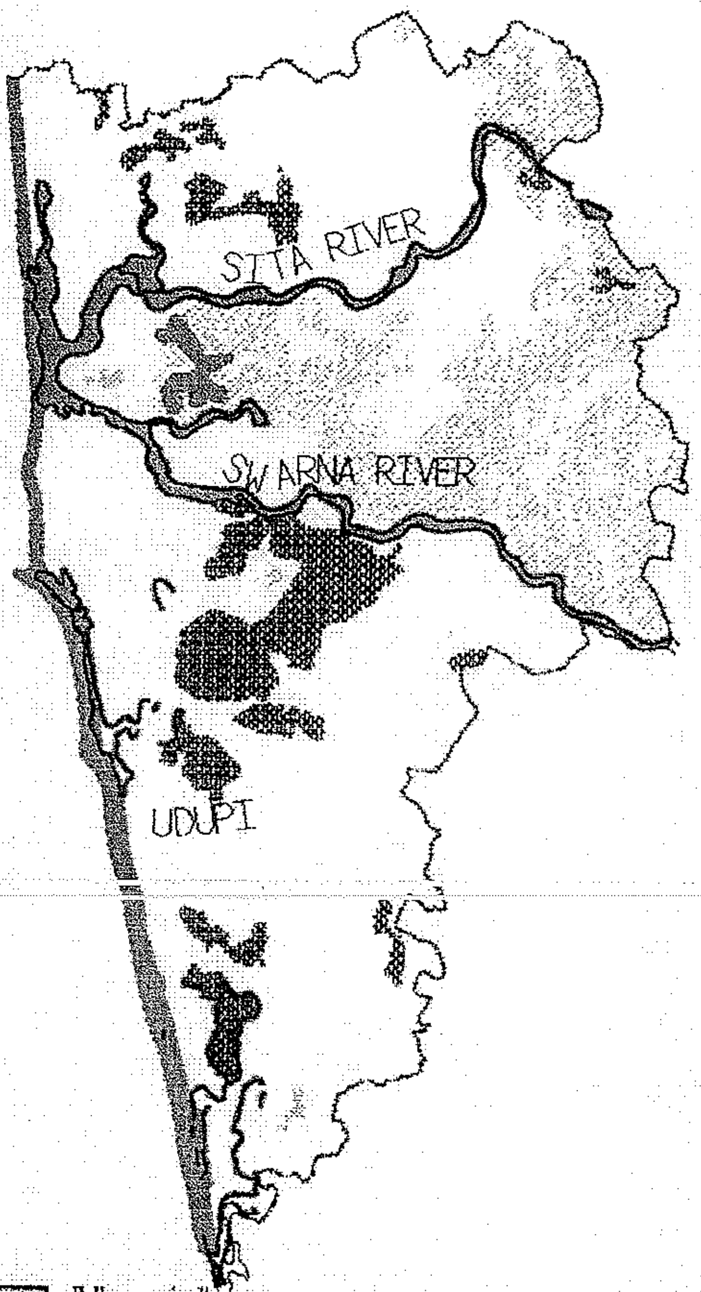


AREAS SUITABLE FOR INDUSTRIES AT UDUPI TALUK



Fallow agriculture lands
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KSRAC, Bangalore
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5.6 2.8 0 2.8 5.6

DIGITAL DATABASE AT:- NRDMS STATE CENTRE, KSCST, IISc BANGALORE