PERFORMANCE OF MINOR IRRIGATION IN KRISHNA BASIN OF KARNATAKA-AN ECONOMIC PERSPECTIVE

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I. INTRODUCTION

Water, the most precious natural resource covers almost three-fourths of earth's surface. Its abundance as well as scarcity has been greatly instrumental in shaping the life style and culture of the people inhabiting the earth. Early civilizations developed and flourished on the shores of major rivers like Tigris and the Eupharates in Mesopotamia, the Nile in Egypt, the Huang-Ho in China and Indus valley in India. For all types of agriculture such as geoponic, aeroponic and hydroponic water is a basic component.

Irrigation has acquired increasing importance in agriculture the world over. From just eight m. ha in 1800, irrigated area across the world increased five fold to 40 m. ha (13.4 m. ha in India) in 1900, to 100 m. ha in 1950 and to just over 255 m. ha in 1995. With almost one fifth of that area (50.1 m. ha net irrigated area), India has the highest irrigated land in the world today (Postel and Sandra, 1999). During the last two decades, irrigation's steady boom has begun to wane. Between 1970 and 1982, global irrigated area grew at an average rate of two per cent per year. But between 1982 and 1994, this rate dropped to an annual rate of 1.3 per cent. Even by optimistic estimates, the global irrigation base is unlikely to grow faster than 0.6 per cent a year over the next 25 years. Since 1980, per capita irrigated area has declined, leading to stagnation in per capita cereal production and thus adding a new dimension to world food security. India, with a geographical area of 3.3 million square kilometers, experiences extremes of climate. Annual average rainfall in the country is of the order of 1,170 mm, which is equivalent to nearly 4,000 cubic Km of water. However, the rainfall varies from 100 mm in Western Rajasthan to over 8,000 mm at Cheerapunji in Meghalaya, considered as wettest spot on earth.

India's irrigation development this century and particularly after independence, has seen large number of big storage based systems, all by the government effort and money. However, in pre British period in India, there were practically no large reservoir projects in India. Even in-British period, a few storage structures were built only in the beginning of this century. Post-independence India, however, has seen more than 60 per cent of irrigation budgets going for major and medium projects.

India's irrigated agriculture sector has been fundamental to India's economic development and poverty alleviation. Agriculture accounts for 28 per cent of India's Gross Domestic Product (GDP) and 67 per cent of employment. Agriculture is the primary source of livelihood in rural areas, which accounts for 75 per cent of India's population and 80 per cent of its poor. And, in turn, irrigation is the base for about 56 per cent, possibly more of total agricultural output. The rapid expansion of irrigation and drainage infrastructure has been one of India's major achievements. From 1951 to 1997, gross irrigated area (includes double cropping) expanded four - fold, from 23 m. ha to 90 m. ha. Increase in irrigation intensity has contributed to the growth in the overall cropping intensity, which increased from 111.07 per cent in 1950-51 to 131.19 per cent in 1993-94. As a result, India has moved from the spectre and actuality of food imports and periodic famines to self sufficiency since the early 1970s, food exports and progressively more diversified production. (Thakkar, 1999)

Ultimate irrigation potential of the country, as on 2000-01, has been estimated to be at 139.9 m. ha from all the sources. Of which, major and medium irrigation sector contributes to the tune of 58.5 m. ha accounting for 41.81 per cent and minor irrigation sector accounts for 58.19 per cent. ha. Out of the total ultimate irrigation potential created in minor irrigation sector, 62.4 m. ha of irrigation potential is created through ground water schemes and 11.9 m. ha through Surface water schemes.

Out of this ultimate irrigation potential in minor irrigation sector, created potential through both ground water and surface water schemes has been estimated at 74.34 m. ha and only about 51.96 million hectare of this created potential has been gainfully harnessed.

Karnataka is the eighth largest state in the country and is located in the deccan plateau. Geographical area of Karnataka is 190.49 sq.km accounting for 5.81 per cent of the total geographical area of the country. Agriculture being the main occupation of the state, irrigation plays significant part in obtaining increased yields from the land. The development of irrigation in the state was slow and unsystematic during the pre-independence era. However, there were some notable irrigation works undertaken and completed during the pre-

independence, such as Krishnaraja Sagar (which was the only major project completed prior to independence), Vijayanagar canals, Cauvery anicut channels, Gokak canal, Vanivilasa Sagar, Markonahalli and Anjanapura dams. Though major projects like Tungabhadra, Bhadra and Ghataprabha stage-I were commenced prior to the plan period, their progress was slow and they got impetus only after their inclusion in the first five year plan. There were more than 25,000 tanks scattered over the erstwhile Mysore state. But, in Bombay Karnataka and Hyderabad Karnataka areas, the number of such minor irrigation works are low.

The average annual yield of the rivers of the Karnataka has been roughly estimated at 98,406 m. cum. (3475 TMC). However, the economically utilisable water potential for irrigation is about 48,000 m. cum (1695 TMC). There are seven river systems in the state, Godavari, Krishna, Cauvery, North Pennar, South Pennar, Palar and West flowing rivers with a drainage area of 4.43 sq.km, 111.74 sq.km, 34.27 sq.km, 6.94 sq.km, 3.76 sq.km, 2.97 sq.km and 26.39 sq. km, respectively totaling to 190.50 sq.km.

Third minor irrigation census (2000-01) revealed that 9, 51,505 minor irrigation schemes are there in the state, out of which 91,142 (10 per cent) are surface water schemes and 8, 60,363 (90 per cent) are ground water schemes. The ultimate irrigation potential created by the state, including all the sources, has been estimated to be at 5.97 m. ha, of which, contribution by minor irrigation schemes as a whole is estimated to be at 3.47 m. ha and 2.5 m. ha from major/medium irrigation schemes. Of this total ultimate irrigation potential from minor irrigation sector, 2.57 m. ha are from surface water schemes and 0.90 m. ha area is from ground water schemes (Anonymous, 2001). The total investment up-to the end of March 2000 on irrigation in the state is Rs. 14,267 crores comprising Rs.13,399 crores on major & medium irrigation and Rs. 868 crores on minor irrigation (using surface waters). This does not include the investment on irrigation prior to the plan period. Krishna basin extends over an area of 258,948 km^2 which is nearly eight per cent of total geographical area of the country. It is the second largest river in peninsular India. The basin lies in the states of Karnataka (113,271 km^2), Andhra Pradesh (76,252 km^2) and Maharashtra (69,425 km^2). Krishna river rises in the western ghats at an elevation of about 1,337 m just north of Mahabaleshwar, about 64 km from the Arabian sea and flows for about 1,400 km and falls into the Bay of Bengal. The principal tributaries joining Krishna are Ghataprabha, Malaprabha, Bhima, Tungabhadra and Musi. An average annual surface water potential of 78.1 km^3 has been assessed in this basin. Out of this, 58.0 km^3 is utilisable water. Culturable area in the basin is about 20.3 million ha, which is 10.4 per cent of the total culturable area of the country.

Present use of surface water in the basin is 50.0 km^3. Live storage capacity in the basin has increased significantly since independence. From just about 3.2 km^3 in the pre-

plan period, the total live storage capacity of the completed projects has increased to 34.5 km^3. In addition, a substantial storage quantity of over 4.9 km^3 would be created on completion of projects under construction. An additional storage to the tune of over 0.1 km^3 would become available on execution of projects under consideration.

In the Krishna river basin of Karnataka, as per the minor irrigation statistics, up to the end of March 2006 total number of minor irrigation schemes accounted for 2,634. Of which 2,195 are tanks, 285 are lift irrigation schemes and remaining 404 schemes include anicuts, pickups, bandharas, barrages etc., Total potential created by these schemes in the basin accounts for 9,69,334 ha. Despite huge amounts of investments and management by public bodies only about 57.26 per cent of the created potential has been utilised efficiently (Minor Irrigation Department, Bangalore and Bijapur).

Krishna water dispute

India is witness to many water conflicts both during pre and post-independence periods. One such conflict has been revolving around the Krishna basin. With the states reorganization in 1956, Krishna basin came under the jurisdiction of the Maharashtra, erstwhile Mysore and Andra Pradesh. In July 1951, a memorandum of agreement was signed for apportioning available supply of Krishna water for 25 years. But, with the increased pace of irrigation development, demand for more water supplies were also raised by the concerned

states. These were the initial signs of inter state water conflicts. In 1969, central government constituted the First Krishna Water Dispute Tribunal headed by justice Bachawat and tribunal delivered its award in may 1976 and allocated the dependable flow of 2,060 TMC to Maharashtra (560 TMC), Karnataka (700 TMC) and Andra Pradesh (800 TMC). Upon the expiry of the of tribunal award in 2001, the Government of India constituted the second Krishna Water Dispute Tribunal on April 2004, headed by justice Brijesh Kumar as the chairman. In this context, a technical cell has been constituted by the state government to prepare techno-economic data base for effectively arguing before tribunal in support of the state's claims.

There are many studies on the individual components of minor irrigation system irrigation viz., tanks, lift irrigation schemes, bore wells, barrages etc., but no studies have been taken up on the minor irrigation systems and river basin as a whole. Present study focuses on the various minor irrigation schemes in the entire Krishna river basin of Karnataka. The findings of the study can serve as a data base which can be utilised by a body like Technical Advisory Cell constituted by Government of Karnataka to assist in putting the right facts about states irrigation before the Brijesh Kumar Tribunal.

Therefore, this study was taken up to document the different aspects of minor irrigation which has been neglected compared to major irrigation and to make a comprehensive evaluation of the minor irrigation schemes and to identify the constraints which these schemes fall in achieving the targets.

SPECIFIC OBJECTIVES

Specific objectives of the study were,

1. To study the growth of minor irrigation in study area
2. To analyze the trend and pattern of investment in minor irrigation development in the study area
3. To study the potential created and utilization of irrigation.
4. To evaluate the performance of selected minor irrigation schemes.
5. To identify the constraints for the development of minor irrigation in the study area.

HYPOTHESES:

1. Growth of minor irrigation in the study area declined over the years.
2. Investment in the minor irrigation sector in the study area is declining over the years.
3. Minor irrigation potential created is not fully utilized.
4. Performance of minor irrigation projects is not satisfactory.
5. Development of minor irrigation in Krishna river valley of Karnataka is beset with constraints.

PRESENTATION OF THE STUDY

The study has been presented in seven chapters. In Chapter-I, the nature and importance of the research problem, specific objectives of the study have been depicted.

Chapter-II deals with the review of the relevant past studies related to the study.

Chapter-III gives an over view of the study area, the nature and sources from where relevant data have been collected, the analytical tools employed for evaluating the objectives and interpreting the results and various concepts used in the study.

The results of the study and their analysis have been presented through a variety of tables in the Chapter-IV.

A critical discussion on the results obtained has been made in the chapter-V. It emphasizes on interpretation of the results and attempts to establish the relationships between certain variables and their outcomes.

A brief summary of the overall results and the main findings of the study have been presented in the Chapter-VI along with the policy implications that emerged from the findings of the study.

Chapter-VII includes the list of the referred books and journals in the study.

LIMITATIONS OF THE STUDY

Since the study was mainly based on the secondary data, the inherent lacunae associated with this type of enquiry have crept into the study.

The major lacuna was non availability of uniform data set for both south and north Karnataka of Krishna river basin. 14 year data was available for north Karnataka with respect to number, potential created and utilization of irrigation. Whereas, 26 year data was available with respect to number and potential created. With respect to utilization of the potential only 9 year data was available for all the minor irrigation components as a whole. So, it is not appropriate to compare the results of south Karnataka with north Karnataka, as any comparison needs an uniform data set with respect to period and variables considered.

II. REVIEW OF LITERATURE

In this chapter a review of past research in the field has been compiled to enable better understanding of the problems concerned to the study. The review of literature is presented in this chapter under the following headings.

2.1 Growth of minor irrigation

2.2 Investment, irrigation potential created and utilised

2.3 Evaluation of irrigation projects

2.4 Constraints

2.5 Tools and techniques employed

2.1 Growth of minor irrigation

Dhawan (1979) in his study on trends in tube well irrigation observed that tube wells in India increased in number from 3,000 in 1951 to 1.75 million in 1978. Area irrigated by tube wells increased from about 0.25 million hectares to about 5.5 million hectares. The factors that vitally impinged on the economics of tube well irrigation were progress in land. Proportion of tube wells to the net irrigated area of Uttar Pradesh has increased from 21 to 52 percent during 1966-67 to 1980-81. Whereas, the proportion of wells, (32 to 9.69 per cent), tanks (5.5 to 1.96 per cent) and other sources (3.7 to 3.4 per cent) to the net irrigated area came down during this period. However, the area irrigated by the canals went up from 22.68 lakh hectares to 30-33 lakh hectares.

Sethu *et al*, (1989) in their study on water resource management reported that at the commencement of the first plan, there were only five reservoirs in Tamil Nadu, by 1984, the number of reservoirs constructed in the state increased to 37, accounting for about 90 per cent of the total capacity. With the limited scope for additional projects, the available tank resources that abound in the state, supplemented by irrigation wells, are the only alternatives. Irrigation wells have progressively increased by over three and a half times from 79,000 in first phase to 2.87 millions by the end of fifth plan and accounted for 40 per cent of the irrigated area.

Reddy *et al,* (1993) compared the changes that took place in sources of irrigation in particular well irrigation with the decline in tank irrigation system in Andhra Pradesh between 1959 and 1989. Percentage of tank fed area declined in all drought prone districts from a range 23 to 53 per cent during 1959-62 to the range of 9 to 33 percent in 1986-89. During the same period area under well irrigation grew from 8 to 29 per cent to the range of 19 to 69 per cent. It was observed that after 1965, the well irrigation over took all the other sources of irrigation in succession. Simple growth rate analysis showed that the growth of tanks was negative while the same for the wells was uniformly and highly positive.

Nagaraj and Chandrakanth (1995) evaluated the economic feasibility of investment on borewell irrigation using standard discounting cash flow techniques in different ground water zones. The IRR varied among different ground water zones from 39 per cent in grey zones to 50 per cent in white zones. The IRR for dark zone was around 44 per cent. The BCR worked out at 14 per cent discount rate was 1.23, 1.26 and 1.28 in dark, grey and white ground water zones respectively. The NPW is positive in all the ground water zones with Rs. 72, 607 in dark, Rs. 62, 643 in grey zone and Rs. 75, 707 in white zone. The pay back period was found to be 2.9, 3.0 and 2.7 years in dark, grey and white ground water zones, respectively.

Gireesh *et al* (1997) in their study on rehabilitation of irrigation tanks in eastern zone of Karnataka reported that one of the irrigation tanks was desilted by the Department of Minor Irrigation (Muttur) in 1993 and the other by a voluntary organization (Kasaraghatta). Costs and benefits associated with tank rehabilitation and the financial feasibility of investment in tank rehabilitation were calculated. The selected farmers were classified according to those who applied silt and those who did not. The internal rate of return was 14 per cent for an investment of Rs 37,00, 000 in the rehabilitation of Muttur tank and 29 per cent for Kasraghatta tank for an investment of Rs 196 000, based on a rehabilitation life of 20 years.

The discounted benefit-cost ratio at 10 per cent was 1.13 and 1.7 for Muttur and Kasraghatta, respectively. Thus the analysis indicates that investment in tank desilting is economically viable. Desilting improved the groundwater recharge and also provided silt as manure.

Hiremath (1998) documented the growth in the different sources of irrigation in Karnataka during 1970-71 to 1993-94. Growth in the number of tanks during the study period for the state as a whole was negative (-5.69 per cent) where as growth in number of dug wells for the state was 1.98 per cent and significant. High growth rates were observed in all the districts and for the state as a whole in case of both bore well and lift irrigation schemes and it was 48.90 and 43.57 per cent per annum, respectively.

Anonymous (2006) reported that the ultimate irrigation potential of minor schemes in India was 14.06 million hectares in 1951 which increased to 59.38 million hectares upto the end of 1999-2000 showing an increase of 322 per cent during last 49 years. At the end of IX five year plan, as per the third minor irrigation census 2000-2001, ultimate potential created through minor irrigation is 81.4 million hectares out of which contribution of groundwater schemes is 64.1 million hectares and 17.3 million hectares from surface water.

Narayanamurthy (2006) assessed the state wise tank irrigated area in India from 1962-63 to 2002-03. Results revealed that during period-I (1962-63) area under tank irrigation system in India was 4.65 million hectare, which dropped to 3.14 million hectares during period-II (1982-83). Further, during period-III (2002-03) area under tank irrigation declined to 2.261 million hectares. Study revealed that tank irrigation system has registered a declining trend in almost all the states. On the contrary Maharashtra registered an increasing trend in tank irrigation system. Area under tank irrigation system in the state during period-I was 0.193 million hectares which rose to 0.27 million hectares during period-II and to 0.36 million hectares during period-III.

2.2 Investment, irrigation potential created and utilised

Hiremath and Chetty (1988) reported that, the total investment for irrigation development in Karnataka during the period 1950-85 was of the order of Rs. 1,458 crores, out of which 85 percent was on major and medium irrigation projects and only 15 percent was on minor irrigation. The irrigation potential has gone up from 7.99 lakh hectares to 26 lakh hectares during the same period. Out of the 16-lakh hectares additional potential created since 1950-51, the share of major and medium projects is to the tune of 53 per cent, minor irrigation surface accounted for about quarter and the rest was from ground water irrigation. During the entire period (1950-85) about 52,000 hectares have been added on an average per year, out of which well irrigation share was 12,000 hectares through public efforts (major and medium projects).

Sisodia (1992) conducted study in Chambal command area of Madhya Pradesh which directed towards the determining whether an investment on the project was likely to contribute significantly to the development of the economy as a whole. In Madhya Pradesh, introduction of the Warabandi system of irrigation was made from 1982-83 in two districts of Chambal command area. Main implementing agency was Minor Irrigation Department. Between 1982-83 and 1986-87 an amount of Rs. 2.14 lakhs was spent on this programme and about Rs. 54.76 lakhs have been spent by the end of 1990-91. The average cost of four year of implementation of the programme worked out to Rs. 220.66 per hectare of irrigated land. The total actual unit cost of the programme increased by 37 per cent as compared to norms established by the government. Hence the study suggested effective mechanism for financial management.

Manjunath (1993) made an economic evaluation of investment on ground water irrigation in Tumkur district of Karnataka. The results of evaluation in terms of PBP, NPV, BCR and IRR indicated high level of profitability of investment in irrigation .The PBP of the project was 2.17 years for the ground water irrigation as a whole (including bore wells and open wells). The NPVs at 15 per cent discount rate were about Rs. 64, 959, Rs. 63, 299 and Rs. 66,621, for groundwater irrigation as a whole and for open well and borewell, respectively. The study reported high levels of IRR at 45.8 per cent, 50.25 per cent and 41.20 per cent for investment in ground water irrigation as a whole and in irrigation from open well and bore well, respectively. The BCR of investment in irrigation for ground water was 2.17 while that for open well and bore well was 2.56 and 2.14, respectively.

Hiremath (1998) studied the actual investment for drilling borewell, installing irrigation pumpset, pipelines etc., in Khanapur and Ranebennur taluks of Karnataka. Cost of drilling a borewell was Rs. 11,200 in Khanapur and s. 17,750 in Ranebennur taluk. The cost of irrigation pumpset and other accessories was Rs. 26,500 and Rs. 31,550 in Khanapur and Ranebennur, respectively. The other costs which included pipeline repair and pumpset etc., accounted to 16.59 per cent and 11.65 per cent of total investment. To get one ready bore well, the total investment was around Rs. 45, 200 in Khanapur and Rs. 55,800 in Ranebennur taluk. The feasibility measures viz., NPW, BCR, IRR and PBP indicated the viability of investment on bore well in both the taluks.

Kumar (2001) in his study on lift irrigation scheme over Krishna river found that total investment on lift irrigation structures amounted to Rs. 1.08 lakh per respondent in the study area. He also found that, at 12 per cent of discount rate, the NPV of the investment was Rs. 3, 49,414.76, the BC ratio, the IRR and pay back period were 1.51, 78 per cent and 3.01 years, respectively. The investment on the lift irrigation project in the study area was found financially feasible.

Roy and Pal (2002) made a state level analysis on investment, agricultural productivity and rural poverty in India. Public investment in the country as a whole registered a declining trend. It was 6.06 per cent during 1965-73, rose to 9.36 per cent during 1974-86 and declined to 5.13 per cent during 1987-99. Where as study noticed an impressive growth in private investment. Results revealed that public investment in agriculture largely consisting of investment in minor irrigation. Though irrigation projects continue to remain as the most important item of public sector investment in agriculture, the focus shifted away from major and medium irrigation projects towards minor irrigation.

Anonymous (2003) anticipated the expenditure to be made and potential to be created during the year 2002-03 in Karnataka. According to the report, revised estimates of expenditure on major and minor irrigation projects were Rs. 2296.21 crores and Rs. 173.87 crores under projects pending approval in 2001-02. Expenditure anticipated in 2002-03 was Rs. 2631.00 crores for plan projects and Rs.108.16 crores for projects pending approval. Expenditure on flood control anti-sea erosion projects in that year was anticipated at Rs. 6.00 crore.

Singhal (2003) reported that the working group on major and minor irrigation programmes for the Tenth Plan proposed an outlay of Rs. 1, 09,025 crores. Of this Rs. 1,07,327 crores were under state plan and Rs. 1,698 crores under the central plan. In the state plan provisions were made for repairs in existing irrigation systems, dam safety measures, improved water management and new water development activities including surveys and investigations, R&D and training, etc. The working group worked out the Tenth Plan target for creation of new potential based on availability of funds. In case full funds are made available, a potential of 11.14 million hectares could be created. With 75 and 60 per cent funds available, the target of creation of potential could be 8.35 million hectares and 6.68 million hectares, respectively.

Anonymous (2006) reported that the Government of Karnataka decided to take up minor irrigation projects in the Cauvery Basin at a cost of Rs. 56 crore in 2006 to irrigate 1.34 lakh hectares. The Government decided to rejuvenate 700 tanks at a cost of Rs. 180 crores under the community-based tank management project this year in the state. The Jala Samvardhane Yojana Sangha (JSYS) was established in 2002 as the nodal agency to implement the project. It was undertaking the rejuvenation of 2,005 tanks in nine districts with World Bank assistance. Under the centrally sponsored scheme, the state received Rs. 87 crore for rejuvenation of 289 tanks in Bangalore rural and Gulbarga districts in 2006.

Sud (2006) reported that, a pilot scheme to be implemented in the 10 th plan with an estimated cost of Rs. 300 crore for the repair, renovation and restoration of tanks and other water bodies, which was envisaged in 2004-05 budget. The union water resource ministry had approved projects in 23 districts of 13 states involving a total cost of Rs. 262.91 crore till April 2006. In addition to this, about one million hectares of irrigation potential is planned to be created by way of minor irrigation schemes by using surface flows. Another one million hectares potential is proposed to be made available through renovation, repairs, extension and moderation of minor irrigation schemes in next four years i.e., 2005-06 to 2008-09.

2.3 Evaluation of irrigation projects

Sisodia (1992) evaluated the impact of warabandi programme on land use, cropping pattern, cropping intensity and yield levels of principal crops in two selected districts of Madhya Pradesh during 1982-83 to 1986-87. As a result of introduction of the programme, irrigation ratio has increased from 40.19 per cent in 1981-82 (before warabandi) to 87.39 per cent in 1986-87. The intensity of cropping showed a modest increase from 104.75 per cent in 1981-82 to 108.93 per cent in 1986-87. After enforcing warabandi, kharif crops as a proportion of net area sown rose to 10.32 per cent, which was worked out to 4.99 per cent earlier, and the cropping pattern tilled towards non-food grains, which are more remunerative. The yield rates of bajra, wheat, gram and sugarcane were increased by 174 per cent, 41.94 per cent, 46.87 per cent and 20.83 per cent, respectively.

Atibudhi (1997) investigated the effects of major irrigation projects in creating water logging problems in coastal districts of Orissa. In the coastal delta of Cuttack, Puri and Balasore for every 100 hectares that were under irrigation eight hectares have gone out of cultivation due to water logging. The resource use in the problem area is seriously affected. Policy measures suggested to tackle the problem included conjunctive use of water in command area, drainage and supply of rotational irrigation water, changing the cropping pattern and more light duty crops.

D'Souza *et al*. (1998) in their study on evaluation of multipurpose river valley projects namely Hirakud, Ukai and Indira Gandhi Nahar project in India, observed that voices in the world over have been raised against the construction of multipurpose river valley projects (MRVPs). Notably the agitations against the three Gorges dam in China, Arun III dam in Nepal and against Narmada, Suvarnarekha, Koel karo, Tehri, Indravati, Poyamkutty and Sharavathi projects have substantially undermined in the blind belief that MRVPs were panacea for many of our problems and were to be judged vis-à-vis the costs of rehabilitation, deforestation, top soil erosion, reservoir induced seismocity and social consequences.

Karunakaran and Palanisami (1998) presented the impact of irrigation particularly different sources of irrigation on cropping intensity with a view to evaluate investment pattern in major and minor irrigation projects and maximizing the benefits of the available resources. Results revealed definite evidence of close relationship between irrigation development and intensity of cropping at the state level. Besides canal and tank irrigation, dug well irrigation also showed significant positive impact on the cropping intensity up to 1979-80. After that tube well and dug well irrigation had more impact on cropping intensity. In spite of a declining trend in tank-irrigated area, it has significant positive impact on cropping intensity. The minor irrigation (tube well and dug well), which showed desirable impact on intensity of cropping, needed more investment in subsequent plans.

Chakraborty (1998) studied the productivity impact of minor irrigation projects in north Bengal of India and reported that project area exhibited substantially higher growth of crop output (Rs 1,16,500 per hectare at farm gate prices) with productive use of inputs vis-à-vis the non-project area that produces Rs.9, 067 per hectare at farm gate prices in the same block. There were significant variations in net return per farm as well as per hectare between the two areas.

Tanwar (1998) reported that the development and utilization of groundwater resources in India had lead to the indiscriminate growth of open-wells; bore wells and shallow tube-wells - due predominantly to the activities of the private sector. Conflicts have arisen due to excessive depletion of the water table and difficulties of showing electrical energy fairly. He suggests that different types of conflict - about resources, environment, construction standards, and planning - require different methods of solution that involve legislation at federal level, state level, and river-basin level.

Poddar, *et al* (2001) evaluated a farmer managed small scale irrigation project in India, i.e., Chikkapadasalagi barrage across Krishna river during 1987-89 focused on the participatory organization for the construction and maintenance of the barrage; and the benefits and costs of the project. The outstanding feature of the project's organizational set up was that farmers on their own initiative without state's support constructed it. Investment analysis revealed a short payback period, positive benefit cost ratio, high net present value, and high internal rate of return, indicating that the investments in the project were worthwhile.

Angeli *et al* (2003) considered the Lachguef lake in Zaghouan province of Tunisia and assessed the impacts on agricultural production systems and on associated economic results. The estimated capacity of the dam was 1, 08,000 m^3. The dam would provide irrigation water for 36 m ha of agricultural land, to be used for market gardening and plantation of olive trees. Analysis of the potential impacts of the scheme involved modelling the economic effects of the project, taking into account the implications of changes in the farming systems used, as well as a cost: benefit analysis of the financial investment associated with this project. This analysis included both construction costs and the costs involved with the ongoing maintenance of the dam after construction. The importance of fully involving the local population in the planning and implementation of this project was stressed, given the role that they will play in maintaining the dam.

Pavlov *et al,* (2006) conducted an economic performance assessment of irrigated agriculture for the north Crimea canal irrigation system in Crimea, Ukraine. A spatial analysis was required, because in the remote parts of north Crimea canal water had to be lifted several times before it reached the field and costs of water delivery consequently vary. The analysis showed that (i) irrigated agriculture was profitable under a market economy although costs vary considerably (due to water lifting and irrigation technology used); (ii) the irrigation costs could be recovered by farmers and could be reduced substantially at distribution and farm level.

2.4 Constraints

Sisodia (1992) in his study conducted in Chambal command area of Madhya Pradesh, identified the constraints in utilization of created irrigation potential. Out of 237 hectares of potential created under the warabandi system, about 49 hectares of land could not be brought under irrigation in spite of advance operational planning. Insufficient time given in warabandi, fixing of outlets above the full supply level of minor and poor condition of water courses and field channels were the main reasons for non-utilisation of created potential. Tail-end cultivators were in a more disadvantageous position with regard to utilization of irrigation potential created.

Reddy *et al.* (1993) in their study attributed the inadequacy of institutional and financial support by the government as the major contributing factor for disastrous decay in the tank irrigation system in Andhra Pradesh. The total expenditure on major and medium irrigation projects in the state between 1959-60 and 1982-83 amounted to over Rs. 1186 crores where as minor irrigation received Rs. 92 crores, with which even the maintenance of the tank irrigation works were very hard to come by. The maintenance expenditure of the tanks remained at Rs. 1.50 per acre until July 1966. But the deteriorating state of tanks forced the government to raise it to Rs. 3.50 per acre and ultimately to Rs. 20 per acre in 1984. But the much of this raise was hardly adequate to meet the establishing charges. More important was that tank irrigation system, which was subjected to neglect for such a long time, lost all the supporting institutional structure and the magnitude of neglect was so huge that any thin spread of the resources may not have any impact.

Palanisami and Balasubramaniam (1998) in their study on well density and tank performance pointed out that the increasing number of wells poses a serious threat to the sustainability of as a direct source of irrigation. Study observed that where the well density exceeded one well per hectare of tank command area, tanks became totally defunct. They suggested that government authorities should take a decisive turn towards the sustainable management of tanks so as to discourage the growth of private wells in the tank commands.

Kumar (2001) in his studied lift irrigation in Krishna river belt and identified the constraints that were encountered by both adopter and non-adopter respondents in the study area. Constraints faced by the adopters of lift irrigation system were- heavy investment, power cut/supply, submerge of field during flood, motor burning due to voltage fluctuation, drainage problem, breaking of pipes, soil salinity and non availability of electrician. Similarly, constraints faced by the non-adopters were- distance of the field from river, small holding, heavy investment, costly labour, cumbersome loan procedure and high rate of interest.

Nanda (2003) presented a perspective of India's irrigated agriculture in the 21st century and considered the significance of minor irrigation projects and their financing. Technical as well as financial and credit-related constraints to minor irrigation were outlined.

Possible strategies and solutions for boosting institutional investments in minor irrigation were presented.

Dorsan *et al* (2004) in their study, performance evaluation of transferred irrigation schemes of Lower Gediz Basin of Turkey and evaluated some physical, economic and institutional performance criteria for the pre- and post-transfer periods. According to the performance evaluations most concrete and positive changes occurred in the collection of irrigation fee. Some other criteria also improved after management transfer to user associations.

Anonymous (2005) reported that out of 9.11 lakh irrigation schemes that were functioning in Karnataka, in as many as 4.38 lakh schemes (48 per cent) the potential utilised was less than the potential created and this shortfall was attributed to various constraints. Out of total minor irrigation schemes about 1, 89,517 (43.3 per cent) schemes were beset with inadequate water, 97,219 (22.2 per cent) schemes with less water discharge, about 11,769 (2.7 per cent) schemes were bounded with break down of channels. As far as 8,000 (1.8 per cent) and 2,532 (0.6 per cent) minor irrigation schemes faced constraints like non-filling of storage and siltation, respectively.

Anonymous (2006) identified the constraints for dismal performance of agriculture in north costal Andhra Pradesh. Rural poverty was high in this region with predominance of tank irrigation has been stagnating despite huge investments in Vishkapatnam city. No major irrigation schemes were initiated in this region since independence. Institutional constraints, sharp fall in public expenditure; low irrigation intensity and frequent crop failure were the main constraints for the poor performance of agriculture. The expansion of ground water irrigation was so slow in high rainfall north costal Andhra Pradesh. Only 9.8 per cent of area was irrigated by wells where as the corresponding percentage for the state was 43.3 per cent. The low utilisation of ground water source is mainly associated with domination of small fragmented land holding and their weak economic viability.

Dasaratharamaiah (2006) identified the significance and causes for declining trend of tank irrigation in India. Tank irrigation, which contributed 6.06 per cent of net irrigated area in 1996-97 declined to 4.61 per cent in 2000-2001. Encroachment, poor management and deforestation in catchment area, encroachment of tanks by local bodies for the purpose of summer storage tanks and poor management of tanks by gram panchayats without adequate financial support by government were the important causes for this declining trend in tank irrigation system. Study suggested government intervention on the lines of checking encroachment and regular maintenance of tanks.

Sud (2006) identified some of the bottlenecks in the development and growth of tanks. India has about 1.5 million tanks dotting the countryside in all the states. But many of these tanks suffer from lack of maintenance. The growing siltation, over the years, reduced their irrigation capacity. The study also identified that while in the 1960's an area of about 4.8 million hectares estimated to be irrigated through tanks, this acreage was now reckoned to have dropped by 1.7 million hectares due to drying up of the tanks, reduced rainfall or other reasons.

2.5 Compound growth rate

Kumar and Rosegrant (1994) worked out the annual compound growth rates of area, production and yield of rice at regional and all India level between the period 1969 to 1990 and different sub periods while assessing the total factor productivity growth in different regions of India. The study highlighted the spatial disparities in agricultural growth in the country. The northern region registered an annual compound growth rate of production of rice at 7.1 per cent as compared to 1.5 per cent in the eastern region for the entire period. But between 1982 and 1990, the eastern region registered an impressive growth rate of 6.8 per cent, most of which was productivity led, as against 5.2 per cent in the northern region and 4.7 per cent at the all India level.

Dhindsa and Sharma (1997) calculated the growth rate of area, production and yield of various pulse crops *viz.,* gram, massar, mash and moong and total pulses. The study was conducted in three agro-climatic regions of Punjab for the period from 1966-67 to 1991-92 by fitting the exponential function of the form $Y=AB^t$. Growth rates of area and production were

found to be negative and significant for all the pulse crops with the exception of moong for which it was positive and significant.

Hiremath, (1998) calculated the annual compound growth rates in the net area irrigated by canals, tanks, wells, other sources, lift irrigation and bore wells in Karnataka during 1950-60 to 1970-94. During period –I (1950-60) the growth in the net irrigated area by canals, tanks and other sources was to the extent of 3.95, 2.33 and 12.75 per cent, respectively. The growth in well area was negative but non-significant. During period-II (1960-70) growth of canal and well irrigated area increased respectively by 7.89 and 9.07 per cent annually, while the growth in tank and other sources was negative. During period-III (1970-94) except the growth rate of tank-irrigated area, positive significant growth rates were observed in remaining sources.

Subhashini (2001) used compound growth rate of the form $Y=AB^t$ to analyse the growth in area, production and yield of groundnut during the period 1950-51 to 1998-99 in India, Tamil Nadu and South Arcot district. The growth rates were positive for the whole period for area, production and yield of oil seed crops in India and the chow test confirmed that there was significant difference among the period in growth rates.

Goswami *et al.* (2003) studied the dynamics of land use in Mizoram. They employed compound growth rates to analyse the changes in land use categories in Mizoram. The results indicated that the area under miscellaneous tree crops and groves and permanent posture and other grazing land achieved a significant high growth rate of 198.77 per cent and 181.41 per cent during the period 1992-93 to 2000-01. Area under current fallow was increasing at a significantly high growth rate of 40.90 per cent. Where as fallow land other than current fallow was declining at a significant rate of 3.17 per cent.

Mohan (2005) documented the growth rates with respect to gross and net irrigated area by different sources of irrigation in Karnataka during 1980-81 to 2000-01. Growth rate with respect to gross irrigated area by canals was found to be positive and significant with 2.58 per cent annually but non-significant and positive in case of net irrigated area with 3.40 per cent. Growth rates with respect to tanks were significantly declined both in case of gross irrigated area (-1.21 per cent) and net irrigated area (-1.23 per cent). With respect to well irrigated area growth rates were found to be positive in both the cases, it was 31.36 per cent and 32.63 per cent in case of net and gross irrigated area by borewell and with respect to gross and net irrigated area by lift irrigation schemes, growth rates were 4.68 per cent and 4.67 per cent, respectively.

III. METHODOLOGY

This chapter deals with the description of the study area, sampling procedure adopted, method of survey, nature and sources of data, techniques employed for analysing the data in evaluating the results. At the end of the chapter, the terms and concepts used in the study are also defined to facilitate a clear understanding of the important issues with which the present study is concerned. The chapter is presented under following heads.

3.1 Description of the study area

3.2 Sampling procedure

3.3 Nature and sources of data

3.4 Analytical techniques

3.5 Concepts used in the study

3.1 Description of The study area

3.1.1 Geographical location

The river Krishna rises in the Western Ghats at an altitude of 1,337 m north of Mahabaleshwar, about 64 km from the Arabian sea and flows from west to east through Maharashtra, Karnataka and Andhra Pradesh to join the Bay of Bengal. Total length of the river from source to its outfall into Bay of Bengal is about 1,400 km of which 305 km is in Maharashtra, 483 km is in Karnataka and 612 km is in Andhra Pradesh.

Major tributaries joining the Krishna are Ghataprabha, Malaprabha, Bhima, Tungabhdra, Musi, Palleru and Muneru. Krishna basin extends over an area of 2, 58,948 km^2, which is nearly eight per cent of the total geographical area of the country. Basin lies in the states of Karnataka (1, 13,272 km^2), Andra Pradesh (76,252 km^2) and Maharashtra (69,425 km^2)

In the north, Krishna basin is bounded by common ridge separating it from the Godavari basin, on the south and east by Eastern Ghats and on the west by the Western Ghats. The basin is approximately triangular in shape with its base along the Western Ghats, the apex at Vijayawada and the river Krishna itself forming the median.

Of the total 190.50 sq. km drainage area of Karnataka about 111.74 sq. k m (58 per cent) is drained by river Krishna (Table 3.1). Annual yield of the river has been estimated at 969.44 TMC i.e., 27.9 per cent of the average annual yield of all the rivers in the state.

In Karnataka, Krishna basin spreads in 18 districts, from Bidar in the north to Hassan in the south. Total basin area of the river in the state accounts for 113,272 sq. km. Bijapur, Bagalkot, Chitradurga, Raichur, Koppal, Haveri, Gadag, Gulbarga and Davanagere districts have hundred percent area under Krishna basin.

3.1.2 Topography

The interior of the Krishna basin is a Plateau, the greater part of which is at an elevation of 300-600 m. Its general slope is eastwards. Great undulating plains divided from other by flat-topped ranges of hills are the chief characteristics of the Plateau. The hill sides are marked by conspicuous wide terraces except in the Southern part of the plateau where the hills are frequently crowned with great ‘tors’ or rounded hummocks of bare rocks as the result of the constant weathering.

3.1.3 Basin characteristics

Krishna basin receives the major portion of its rainfall during South-West monsoon. During this period, the basin receives about 80 per cent of its total annual rainfall. Annual rainfall in the Krishna basin varies from 600 mm 3048 mm. Krishna basin has a tropical climate. The mean annual surface temperature in the Western Ghats is about 24ºC. It increases gradually towards the east and attains a maximum of 29.4º C on the east coast.

Table: 3.1 State-wise drainage area of Krishna basin

Sl. No	Name of the state	Drainage area (km^2)	Percentage to the total basin drainage area
1.	Maharashtra	69,425	26.8
2.	Karnataka	1,13,272	43.8
3.	Andhra Pradesh	76,251	29.4
	Total	2,58,948	100.00

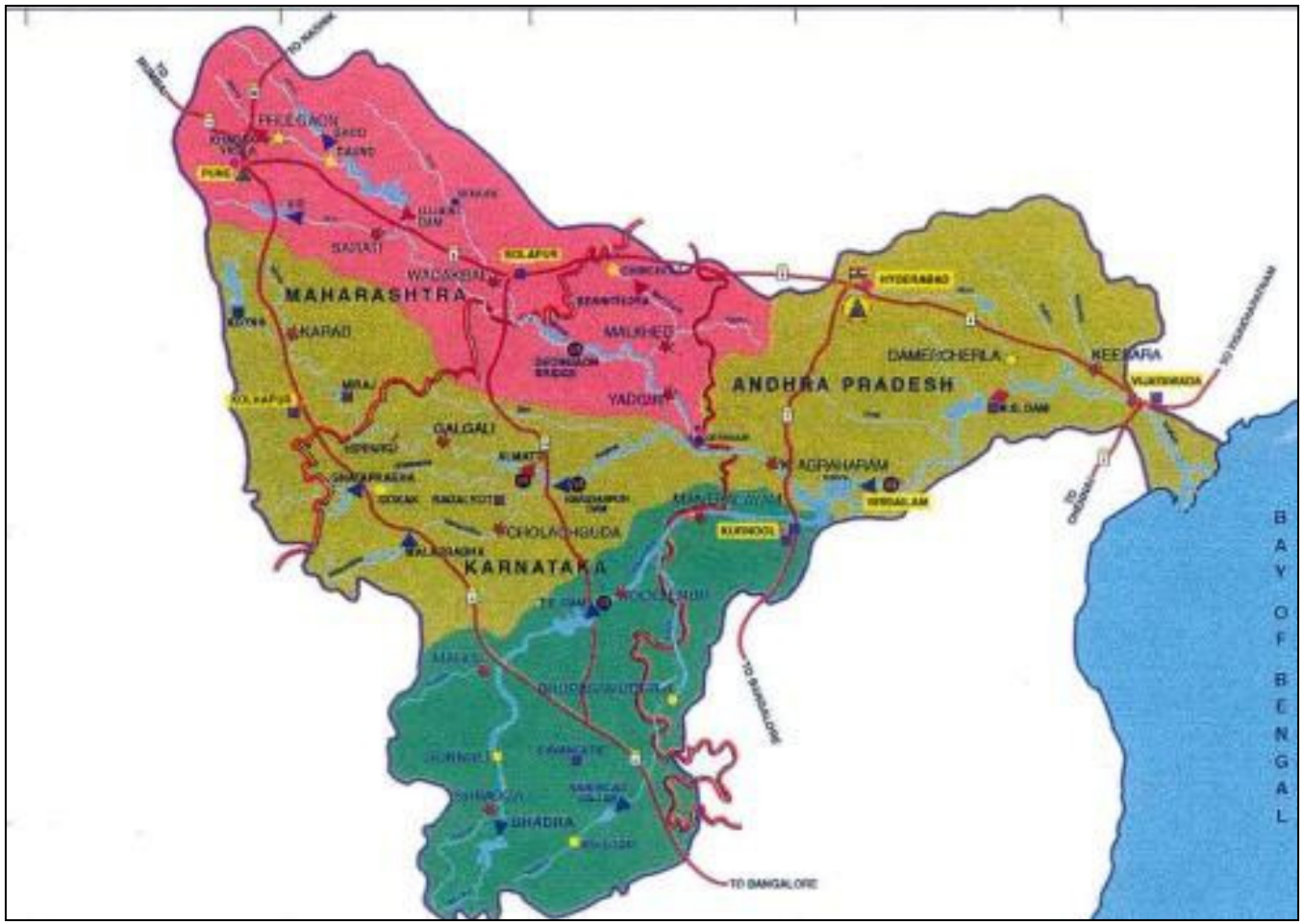


Fig1 : Map showing Krishna Basin in India

Table 3.2 Drainage area and the average annual yield of the rivers of the Karnataka

Sl. No.	River systems	Drainage area		Estimated average yield in		
		Sq. km	Percentage	m.cum	TMC	Percentage
1	Godavari	4.43	2.33	1,415	49.97	1.44
2	Krishna	111.74	58.66	27,451	969.44	27.90
3	Cauvery	34.27	17.99	12,034	425.00	12.23
4	North Pennar	6.94	3.64	906	32.00	0.92
5	South Pennar	3.76	1.97	906	32.00	0.92
6	Palar	2.97	1.56			
7	West flowing rivers	26.39	13.85	56,600	1998.83	57.51
	Total	190.50	100	98406	3475.24	100

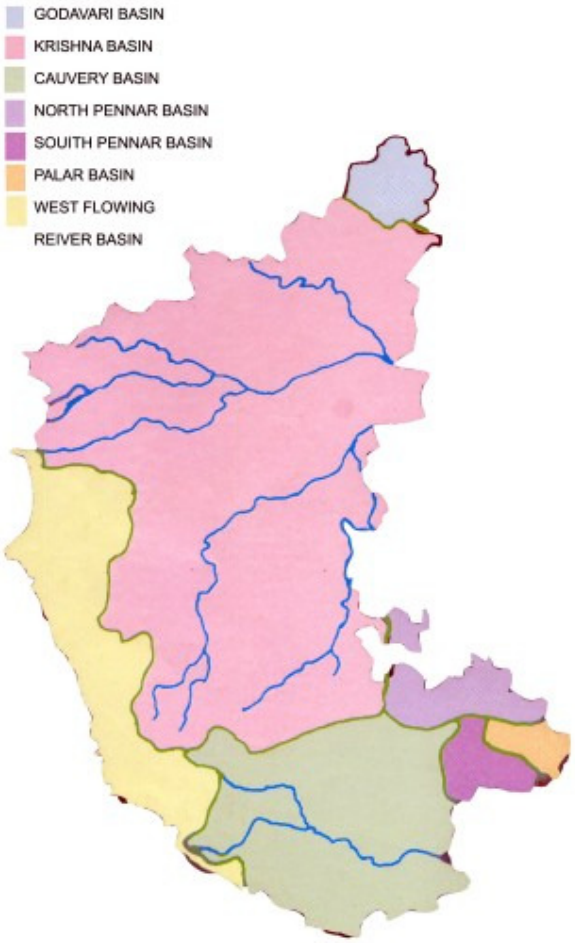


Fig 2: Map showing Krishna basin in Karnataka

During January the mean daily minimum temperature increases from west to east from 15º C in the western ghats to about 18º C in the east coast; the mean daily maximum temperature generally exceeds 30º C in the western part of the Krishna basin and is only slightly less than 30º C in the eastern part.

Population of the basin based on 2001 census was 64.78 millions, out of which 66 per cent live in rural and remaining 34% in urban areas. The density of population is around 250 persons per km^2.

3.1.4 Soils

Important soil types found in the Krishna basin can be broadly classified into ten main groups (1) Deep black soil, (2) Medium black soil, (3) Coarse shallow soil, (4) Mixed red and black soil, (5) Red earth, (6) Red loamy soil, (7) Red sandy soil, (8) Reddish brown soil, (9) Lateritic soil and (10) Forest loam soil.

3.2 Sampling procedure

Since the main objective of the study was to evaluate the temporal performance of the minor irrigation schemes in the Krishna river basin of the state, all the 18 districts under Krishna river basin were selected for the study.

To study the performance of minor irrigation schemes in the basin a total of twenty four functioning schemes, eight functioning schemes under each component- tanks, lift irrigation schemes and barrages/pick-ups; were selected randomly from the districts of northern Karnataka. Three schemes under each component were selected from Haveri and Ranebennur taluks, one scheme each from Dharwad and Bailhongala.

To evaluate the performance of bore wells in the study area, data was collected randomly from thirty borewell farmers.

3.3 Nature and sources of data

The required data for evaluating the objectives of the study were collected from both primary and secondary sources.

Secondary data

District wise secondary data pertaining to growth of minor irrigation schemes in the basin, pattern of investment, potential created and utilised were collected from Department of Minor irrigation (South) Bangalore, Department of Minor irrigation (North) Bijapur, Directorate of Economics and Statistics Bangalore, Executive Engineer Minor Irrigation Department Dharwad, Belgaum and Assistant Executive Engineer, Minor irrigation Department Ranebennur division.

District wise 14 years secondary data on growth of minor irrigation schemes, potential created, utilization and pattern of investment were collected for the period from 1992-93 to 2005-06 from offices of Minor Irrigation (North), Bijapur for North Karnataka.

In the case of Minor Irrigation (South), for six districts under Krishna river basin, district wise 26 year data were collected on growth and potential created through different minor irrigation schemes for the period from 1980-81 to 2005-06. This data from 1980-81 to 1996-97 also included those minor irrigation schemes with a cultural command area between zero to 40 hectares (tanks and other schemes except lift irrigation schemes) which were maintained by Zilla Panchayats. But, from 1997-98 onward, minor irrigation department stopped considering these schemes in its census and only those schemes maintained by the department were included. District wise utilisation data were collected for all the minor irrigation schemes as a whole for the period from 1996-97 to 2005-06.

Fourteen years investment data on minor irrigation works were available for the zone as a whole in the Minor Irrigation Department (southern zone) for the period from 1992-93 to 2005-06. Investment on minor irrigation schemes in Krishna basin was computed taking the per cent area under Krishna river basin to the total area of the zone.

In order to obtain precise and clear information on the pattern of investment on minor irrigation works in the basin, total investment was categorized into six different headings. These heads included,

A	:	Construction of new tanks, pick-ups, lift irrigation schemes, diversion schemes, world bank aided tank projects and restoration of tanks
B	:	Rejuvenation and rehabilitation of tanks and lift irrigation schemes
C	:	Maintenance and repairs of minor irrigation schemes
D	:	Land acquisition charges
E	:	Flood control works
F	:	Miscellaneous expenditures includes: survey works, extension and improvements, other lump sum works.

In 1996-97, districts in the state were reorganized and seven new districts were formed. In order to overcome the computational errors and to avoid the discrimination and exaggeration in the results all the newly formed districts were merged with the erstwhile districts. Data pertaining to Haveri and Gadag districts were merged with Dharwad district; those pertaining to Koppal district were merged with Raichur and that of Bagalkot with Bijapur district.

Primary data

The required data for evaluating the performance of selected minor irrigation schemes were collected with the help of structured schedules from assistant engineers, village accountants and farmers under respective minor irrigation schemes.

Number of indicators was developed in analysing the performance of selected minor irrigation schemes in the basin. These included,

a. Area of the project
b. Number of irrigation
c. Number of farmers
d. Type of farmer beneficiaries
e. Cropping intensity in commands
f. Cropping pattern in commands
g. Proportion of high value crops
h. Size and capacities of schemes
i. Physical condition of schemes
j. Tanks: silt and extent of siltation
k. Lift irrigation: Number of working hours per day and Days in a year
l. Command area development

To analyse the performance of Borewells, primary data were collected regarding cropping pattern, investment details of borewells, input requirements of different crops grown

under borewell irrigation from selected thirty farmers for the agricultural year 2005-06. Structured schedules were prepared to achieve the purpose.

To identify constraints in the way of minor irrigation development in the study area, an opinion survey was conducted with the help of structured questionnaire. Data were generated from thirty stake holders including irrigation experts, workers, activists and officials in the organizational set up of state minor irrigation department.

3.4 Analytical Techniques

For the purpose of achieving the objectives of the study, data were analysed using ratios, percentages compound growth rate etc.

3.4.1 Tabular analysis

Tabular analysis was used for estimating the proportion of area under Department of Minor Irrigation (south zone); number of small, medium and large farmers, cropping pattern, water discharge capacity and cost of construction of minor irrigation schemes; cropping pattern, cropping intensity, cost, returns and profits of crops grown under tube well irrigation and average income from crop enterprise.

3.4.2 Compound growth rate analysis

Growth of any variable indicates its past performance. The analysis of growth is usually used in economic studies to find out the trend of a particular variable over a period of time. It clearly indicates the performance of the variable under consideration and hence it can be very well used for making policy decisions.

In order to analyse the growth of different minor irrigation schemes, potential created and utilization, pattern of investment on minor irrigation works in each district and the basin as a whole, compound growth rate was employed using the exponential function of the form:

$$Y_t = AB^t U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

Y_t = Dependent variable for which growth rate was estimated (numbers, investment, potential created and utilisation)

A = Intercept indicating Y in the base period (t=0)

B = 1+ g

t_i = Years which takes values 1, 2 …… n

U_t = Error term

g = Average compound growth rate

Equation (1) was converted into logarithmic form in order to facilitate the use of linear regression. Taking logarithms on both sides we obtain,

$$\text{Ln } Y_t = \text{Ln } A + t (\text{Ln } B) + \text{Ln } U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Or

$$Y = a + bx_t + U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,

$Y = \text{Ln } Y_t$
$a = \text{Ln } A$
$b = \text{Ln } B$
$t = x_t$
$U_t = \text{Ln } U_t$

The linear regression of the above forms was run separately for numbers, investment, potential created and utilisation by minor irrigation schemes, gross and net irrigated area by bore wells in each district and the basin as whole. The values of ‘a’ and ‘b’ were estimated by using ordinary least square technique.

Value of 'g' was obtained as,

$$\text{Ln } B = b$$
$$B = \text{antilog } b$$
$$B = 1 + g$$
$$g = B - 1$$

To obtain the percentage of annual compound rate of growth the value of 'g' is multiplied by 100.

$$g = (\text{Antilog of Ln } b - 1) * 100$$

So equation (3) is our estimating equation for compound growth rates using time series data.

The significance of regression coefficient was tested using the students't' test which was defined as

$$t = \frac{b_i}{Se\,(b_i)}$$

Where,

b_i = Regression coefficient

se (b_i) = Standard error of the coefficient

3.5 DEFINITIONS OF TERMS AND CONCEPTS USED

a. Minor Irrigation (M.I.) Scheme:

A scheme having culturable command area up to 2,000 hectares individually is classified as minor irrigation scheme.

b. Irrigation Potential Created

The total gross area proposed to be irrigated under different crops during a year by a scheme. The area proposed to be irrigated under more than one crop during the same year is counted as many times as the number of crops grown and irrigated.

c. Irrigation Potential Utilised

The gross area actually irrigated during reference year out of the gross proposed area to be irrigated by the scheme during the year.

d. Lift irrigation schemes

In regions where the topography does not permit direct flow irrigation from rivers and streams, water has to be lifted into irrigation channels by using pumps. Such schemes are referred to as lift irrigation sources.

e. Culturable command area

It is the area, which can be physically irrigated from a scheme and is fit for irrigation.

f. Cropping pattern

The proportion of the area under various crops at a point of time (Kharif, rabi and bi-season) represented the cropping pattern.

g. Small farmer

Farmer having an irrigated area of up to two hectares of land falls under this category.

h. Medium farmer

Farmer having an irrigated area between two and four hectares of land falls under this category.

i. Large farmer

Farmer having an irrigated area of above 4 hectares of land falls under this category.

j. Cropping intensity (CI)

Cropping intensity was computed as the ratio of the gross cropped area to the net sown area and expressed in percentage.

$$\text{Cropping Intensity} = \frac{\text{Gross cropped area}}{\text{Net cropped area}} \times 100$$

IV. RESULTS

The findings of the study are presented in this chapter under the following headings in consonance with the objectives of the study.

4.1 Growth in different minor irrigation schemes

4.2 Investment on minor irrigation schemes

4.3 Potential created and utilization by minor irrigation schemes

4.4 Performance of minor irrigation schemes

4.5 Constraints in development of minor irrigation schemes

4.1 Growth in different minor irrigation schemes

The role of irrigation in increasing agricultural production has been well recognized. Consequently, the increasing emphasis has been given by the public as well as private to increase the area under irrigation. Minor irrigation structures are most important in efficient utilization of the potential created and thereby increasing the net area under irrigation. So, it is important to study the status and growth in these irrigation structures over the time and space in order to know their relative importance in different locations of Krishna basin.

4.1.1 Status of minor irrigation schemes in Krishna river basin

From Table 4.1 it is clear that, total number of minor irrigation schemes in Krishna river basin of Karnataka was 2, 90,074. Of which about 60 per cent (1, 33,810) of the schemes were located in Northern part of the state and about 40 per cent (86,264) were located in southern part of the state.

Borewells hold a unique position in the irrigation scenario of the basin with 98.68 per cent of the total minor irrigation schemes followed by tanks (0.99 per cent), barrages/pick-ups and other schemes (0.18 per cent) and lift irrigation schemes (0.12 per cent). Maximum number of borewells, barrages and lift irrigation schemes were observed in North Karnataka with 60.91, 64.85 and 62.10 per cent, respectively. Where as maximum number of tanks were found in southern part of the basin with 51.57 per cent of them being located there.

4.1.2 District wise growth in different minor irrigation schemes in North Karnataka

From Table 4.2 it is clear that minor irrigation schemes grew at a rate of 9.10 per cent annually in the Northern Karnataka. Among districts high growth was observed in Belgaum with 13.14 per cent annually and it was significant, followed by Dharwad (11.24 per cent) and Bidar (11 per cent). Positive groth was observed in all the districts of the region.

Tanks

Construction of tanks is a good old practice since time immemorial in order to give protective irrigation as well as for domestic supply. From the results presented in Table 4.2 it is clear that growth in number of tanks during the period 1992-93 to 2005-06 for the Krishna basin of North Karnataka was positive (11.35 per cent) and significant. Among the districts, highest growth was observed in Belgaum district with 14.37 per cent and the lowest growth was observed in Bellary i.e., 8.30 per cent. Positive growth was observed in all the seven districts of the Krishna valley.

Lift irrigation schemes

There was a negative growth with respect to lift irrigation schemes with growth of 0.02 per cent per annum for the region as a whole. Among the districts, positive and significant growth was observed in Belgaum (1.77 per cent), Gulbarga (1.06 per cent) and Raichur (0.82 per cent). Negative growth of the lift irrigation schemes was observed in Bellary and Bijapur districts. Where no growth was recorded in Bidar district.

Table 4.1: Number of minor irrigation schemes in Krishna basin of Karnataka

	Number of units				
	Tanks	Lift irrigation works	Barrages/Pick-ups and others	Borewells	Total
North Karnataka	1063 (48.42)	177 (62.10)	262 (64.85)	1,32,308 (60.91)	1,33,810 (60.80)
South Karnataka	1132 (51.57)	108 (27.89)	142 (35.14)	84,882 (39.08)	86,264 (39.19)
Basin	2195 (0.99)	285 (0.12)	404 (0.18)	2,17,190 (98.68)	2,20,074 (100)

Note: Figures in parentheses are percentages to total number of units

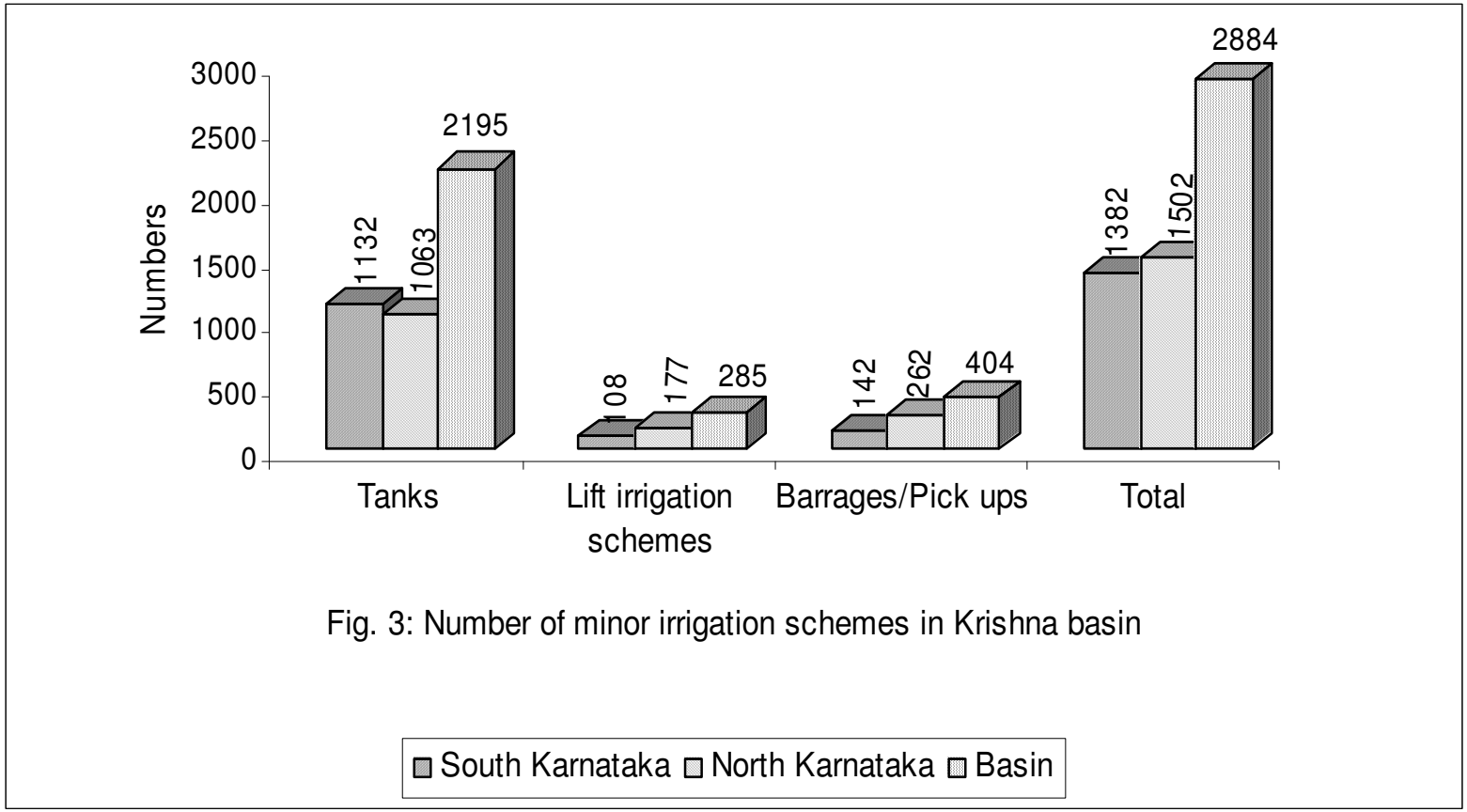


Fig. 3: Number of minor irrigation schemes in Krishna basin

Fg3: Number of minor irrigation schemes in Krishna basin

Barrages/pick up and other schemes

Barrages, pick-ups and other minor irrigation structures (check dams, feeder channels, planking arrangements etc.,) have been constructed across the rivers in order to harness the water for irrigation. Growth in number of schemes for the northern part of the state showed significant growth (40.35 per cent). Among the districts, all the districts registered positive growth except Bidar, where number of barrages and pick ups registered zero growth. Belgaum had the highest growth rate of 38.70 per cent.

4.1.3 District wise growth in minor irrigation schemes in south Karnataka during period – **I**

From Table 4.3 it is observed that minor irrigation schemes grew at a rate of 4.17 per cent per annum in the south Karnataka region during period-I (1980-81 to 1996-97). Among the districts, highest positive and significant growth was observed in Davangere with 8.5 per cent per annum, followed by Hassan with 6.10 per cent and 3.59 per cent in Chikmagalur. Lowest growth was observed in Chitrdurga with 0.86 per cent and it was significant.

Tanks

Positive growth rate was observed (3.72 per cent) in Krishna river valley of South Karnataka for period I. Among the districts, highest growth rate was observed in Hassan with 6.10 per cent. Here again all six districts recorded positive and significant growth rates while lowest growth was recorded in Chitradurga at 0.31 per cent.

Lift irrigation scheme

Lift irrigation schemes recorded positive but non significant growth at 0.36 per cent per annum for the region as a whole. Among the districts, negative growth was observed in Tumkur and Chitradurga with -5.13 per cent and -0.06 per cent, respectively. Highest growth was observed in Chikmagalur (6.10 per cent) followed by Hassan (4.21 per cent).

Barrages/pick up and other schemes

For southern region of the state, growth rate with respect to number of barrages/pick ups was 2.22 per cent and significant. Among the districts, positive and significant growth was observed in four districts namely Tumkur, Chitradurga, Shimoga and Chikmagalur with 2.40, 3.74, 1.79 and 2.46 per cent per annum, respectively. In Davanagere and Hassan, growth was observed to be positive but non significant.

4.1.4 District wise growth in minor irrigation schemes in South Karnataka during period – II

From the results presented in Table 4.4 it is clear that growth of the minor irrigation schemes in south Karnataka during period-II (1997-98 to 2005-06) was negative with -0.48 per cent per annum. Among the districts, positive and non significant growth was observed in three districts namely, Tumkur (0.45 per cent), Chitradurga (0.20 per cent) and Davangere (0.16 per cent). Growth was found to be negative in other three districts of the region.

Tanks

Growth in number of tanks registered significant negative growth of -0.70 per cent. Highest growth rate was observed in Tumkur district with 0.54 per cent and negative growth rate was observed in two districts namely Shimoga and Hassan with -3.05 per cent and -0.15 per cent, respectively.

Lift irrigation schemes

Growth in the number of lift irrigation schemes for the period-II was found to be negative and non-significant at -0.42 per cent. Among the districts positive but non-significant growth of lift irrigation schemes was observed in Shimoga and zero growth rate was observed in two districts namely Chitradurga and Davanagere and negative growth rate was observed in the remaining three districts.

Table 4.2 District wise compound growth rates for different minor irrigation schemes in Krishna river basin of North Karnataka (1992-93 to 2005-06)
(in per cent)

Sl No	Districts	Tanks	Lift irrigation schemes	Barrages/pickups and others	Total
1	Belgaum	14.37**	1.77**	38.70**	13.14**
2	Bellary	8.30*	-1.74*	26.59*	1.76
3	Gulbarga	9.81**	1.06*	27.68**	7.94**
4	Bijapur	8.73**	-1.98	33.44**	8.33**
5	Raichur	10.20**	0.82*	11.06**	7.21**
6	Dharwad	13.72**	0.09	28.23**	11.24**
7	Bidar	11.00**	0	0	11.00**
	North Total	**11.35***	**-0.02**	**40.35****	**9.10****

Note: ** and * indicate significant at 1 and 5 per cent respectively

Table 4.3: District wise compound growth rates different minor irrigation schemes in Krishna river basin of south Karnataka during period-I (1980-81 to 1996-97)

(in per cent)

Sl. No	Districts	Tanks	LIS	Barrages/pickups and others	Total
1	Tumkur	2.06**	-5.13**	2.40**	2.07**
2	Chitrdurga	0.31**	-0.06	3.74**	0.86**
3	Davangere	1.64**	0.59*	0.90	8.50**
4	Shimogga	3.60**	2.55*	1.79**	2.06*
5	Hassan	6.10**	4.21**	0.26	6.10**
6	Chikmagalur	3.74**	6.10**	2.46**	3.59**
	Total	3.72**	0.36	2.22**	4.17**

Note: ** and * indicate significant at 1 and 5 per cent respectively

Table 4.4: District wise compound growth rates of different minor irrigation schemes in Krishna river basin of South Karnataka during period-II (1997-98 to 2005-06)

(in per cent)

Sl No	Districts	Tanks	LIS	Barrages/pickups and others	Total
1	Tumkur	0.54**	-5.78	-0.44	0.45**
2	Chitradurga	0.09**	0	1.88**	0.20**
3	Davangere	0.16**	0	0	0.16**
4	Shimoga	-3.05**	2.7	5.65**	-2.19
5	Hassan	-0.15**	-4.62*	0	-0.33**
6	Chikmagalur	0.26	-5.45	0.16	-0.01
	Total	**-0.70****	**-0.42**	**1.46****	**-0.48***

Note: ** and * indicate significant at 1 and 5 per cent respectively

Barrages/pick up and other schemes

Growth rate with respect to barrages/ pick-ups schemes was observed to be 1.46 per cent and significant. Highest growth rate was observed in Shimoga (5.65 per cent) and lowest in Tumkur (-0.44 per cent).

4.1.5 District wise compound growth rates for borewells in Krishna basin

Growth rate of borewells in north Karnataka, south Karnataka and basin were computed and are presented in Table 4.5.

Borewells form another important source of irrigation in recent days in view of the frequent drought and commercial farming involving use of high yielding varieties. High growth rate was observed for the basin as a whole at 10.58 per cent per annum and was significant. Northern region of the state registered higher rate of growth (11.21 per cent) compared to southern part (9.67 per cent). Borewells owned by individual farmers' registered high significant growth of 11.63 per cent as against 1.50 per cent growth of borewells dug by Government sector. Privately owned borewells recorded high growth of 11.23 per cent in northern part of the basin whereas growth of the government dug borewells was 1.55 per cent in southern part. Growth rate was found to be higher than the basin average in eight districts namely Bijapur, Bellary, Gulbarga, Raichur, Shimoga, Hassan, Chikmagalur and Tumkur. Though the growth rate was less than the basin average in three districts, the magnitude was more than 50 per cent except for Chitradurga.

In the case of public borewells zero growth rate was observed in five districts namely Bijapur, Hassan, Chikmagalur, Tumkur and Raichur. Negative growth rate was observed in Bellary, it was -1.84 per cent. Highest growth rate was observed in Gulbarga i.e., 15.74 per cent and it was significant.

In the case of borewells owned by private individuals, growth rate was found to be higher than the basin average in eight districts except for Belgaum, Dharwad and Chitradurga. Highest growth rate was observed in Raichur (20.85 per cent) in northern region of Krishna valley and 18.76 per cent growth in Shimoga district of Southern region.

4.2 Investment on minor irrigation works

The data on the investment made on the irrigation works (except borewell) in the North Karnataka, South Karnataka and the Krishna basin as a whole is presented in Table 4.6.

Total investment made on the minor irrigation works in the basin during 2005-06 was to the tune of Rs. 10,521.28 lakhs. Investment on different minor irrigation works was higher in Northern Karnataka at Rs. 8101lakhs than South Karnataka which was Rs. 2420.38 lakhs.

Among different minor irrigation works, maximum investment was made on the construction of new minor irrigation schemes with Rs. 5414.07 lakh (51.45 per cent), followed by maintenance and repairs of minor irrigation works with Rs. 3053.16 lakhs (29.01 per cent) and rejuvenation and rehabilitation of minor irrigation works (7.95 per cent). Investment on the miscellaneous expenses with 1.88 per cent of the total investment.

4.2.1 District wise compound growth rates for investment on minor irrigation works in Krishna basin of Karnataka

Growth rates with respect to investment made on the minor irrigation works in the Krishna basin were computed and are presented in Table 4.7.

A positive and significant growth of 10.14 per cent per annum was observed for the Krishna basin as a whole with respect to investment made on different minor irrigation works. Comparison of southern and northern regions of the valley showed that growth rate in northern region was found to be higher than the basin average. In the case of northern region it was 10.27 per cent and significant. For the southern region growth rate was found to be 9.76 per cent and significant.

Table 4.5: District wise compound growth rates for borewell in Krishna basin (1992-93 to 2005-06) (in per cent)

Sl. No	Districts	Government	Private	Total
1	Belgaum	11.19**	6.71**	6.71**
2	Bijapur	0	20.14**	20.14**
3	Bellary	-1.84**	14.33**	14.29**
4	Dharwad	0.80	5.80**	5.79**
5	Gulbarga	15.74**	14.35**	14.36**
6	Raichur	0	20.85**	20.85**
	North total	1.34	11.23**	11.21**
1	Chitradurga	0.87*	5.19**	5.16**
2	Shimoga	12.63**	18.76**	18.72**
3	Hassan	0	11.76**	11.76**
4	Chikmagalur	0	12.40**	12.40**
5	Tumkur	0	13.03**	13.03**
	South total	1.55**	9.71**	9.67**
	Basin total	1.50**	10.61**	10.58**

Note: ** and * indicate significant at 1 and 5 per cent respectively

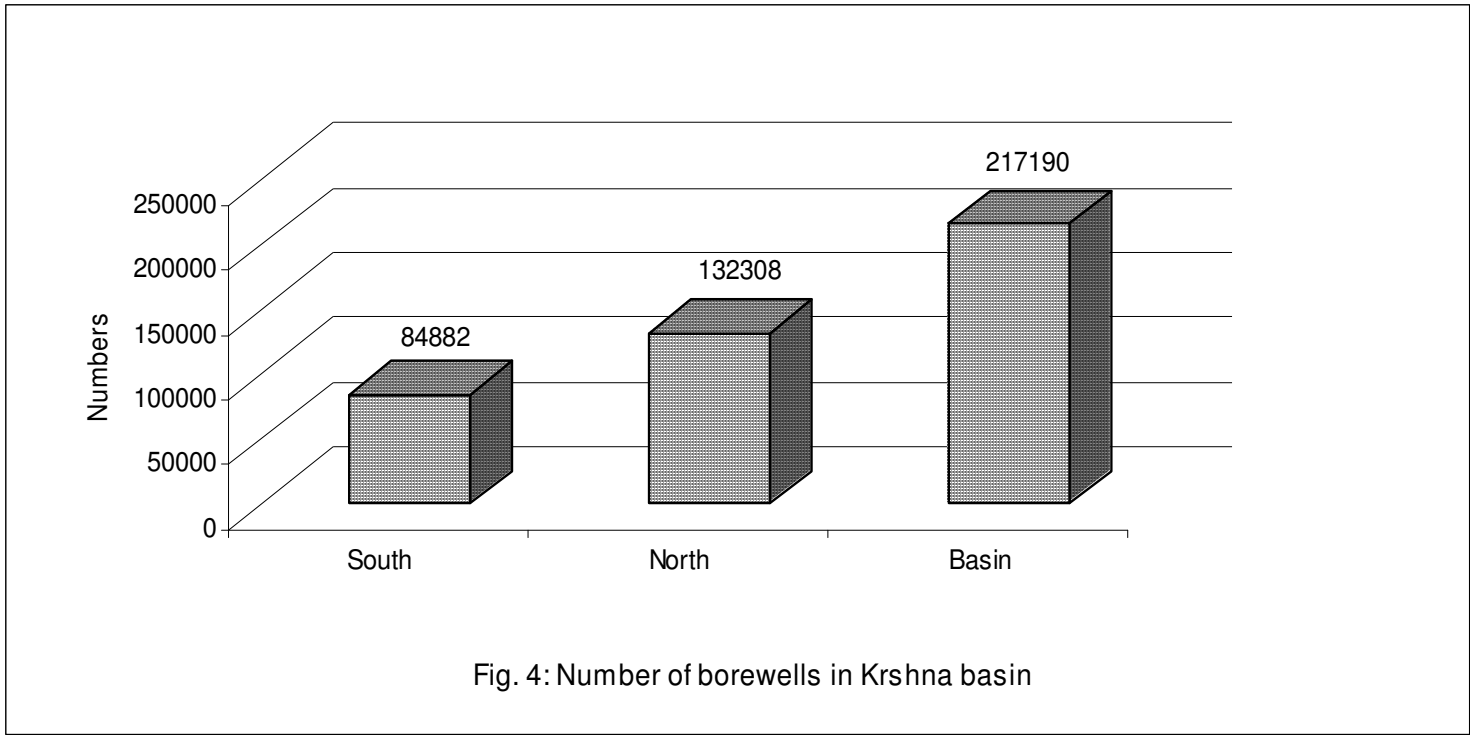


Fig. 4: Number of borewells in Krshna basin

Fig 4: Number of borewells in Krishna basin

Table 4.6: Investment on minor irrigation works in Krishna river basin (2005-06)

(Rs. In lakhs)

	Works						
	A	B	C	D	E	F	Total investment
North Karnataka	4388.02	484.11	2192.41	711.99	130.75	193.62	8100.90
	(54.16)	(5.9)	(27.06)	(8.78)	(1.61)	(2.39)	(100)
South Karnataka	1026.05	352.84	860.75	24.00	151.71	5.03	2420.38
	(42.39)	(14.57)	(35.56)	(0.99)	(6.27)	(0.20)	(100)
Basin total	5414.07	836.95	3053.16	735.99	282.46	198.65	10521.28
	(51.45)	(7.95)	(29.01)	(6.99)	(2.65)	(1.88)	(100)

A= Construction of new tanks, pick ups, lift irrigation schemes, diversion schemes world bank aided tank projects and restoration of tanks

B= Rejuvenation and rehabilitation of tanks and lift irrigation schemes

C= Maintenance and repairs of MI schemes

D= Land acquisition charges

E= Flood control works

F= Miscellaneous expenses

Note: Figures in the parentheses are percentages to total investment

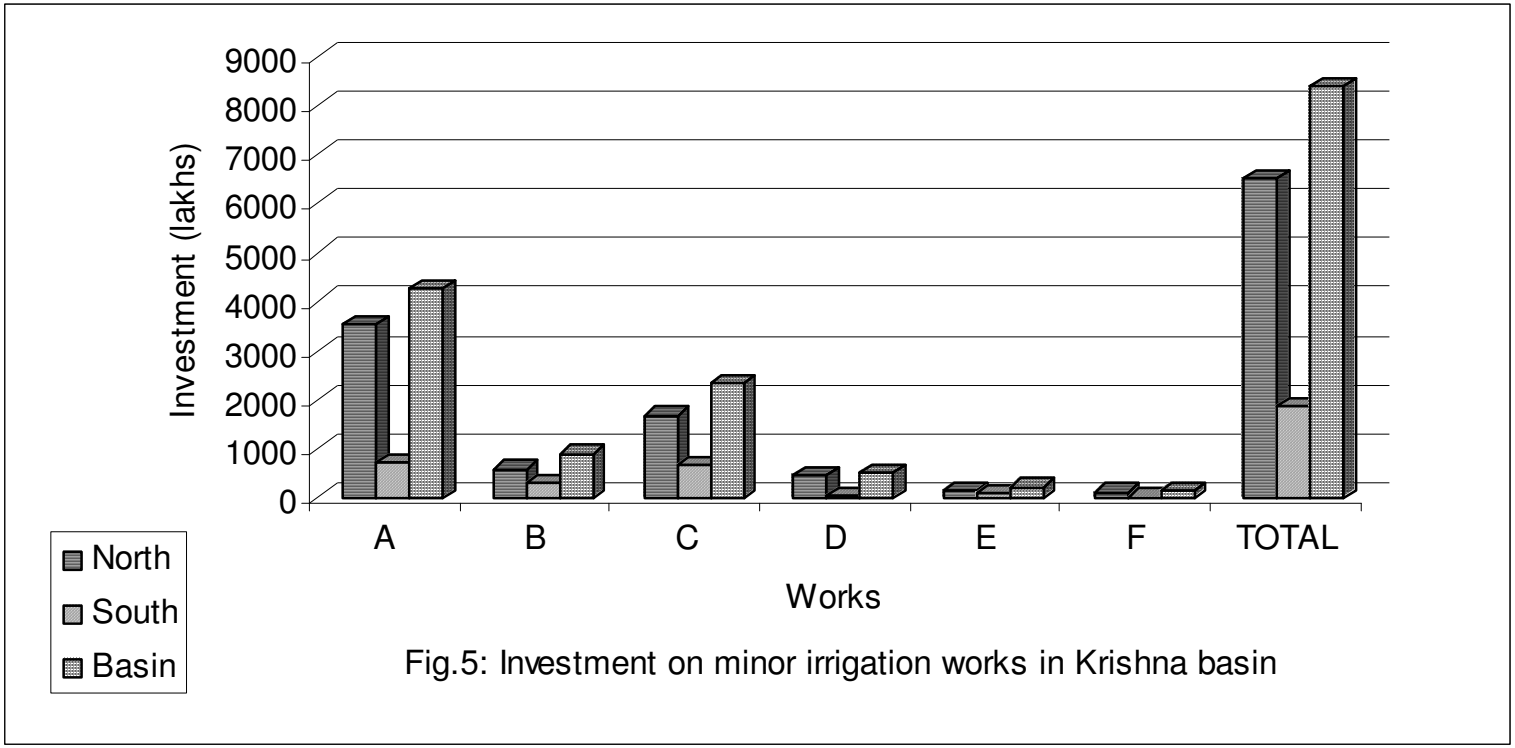


Fig.5: Investment on minor irrigation works in Krishna basin

Fig5: Investment on minor irrigation works in Krishna basin

Table 4.7: District wise compound growth rates for investment on minor irrigation works in Krishna river basin of Karnataka (1992-93 to 2005-06)

(in per cent)

Note: ** and * indicate significant at 1 and 5 per cent respectively

Sl No	Particulars	North Karnataka	South Karnataka	Basin total
1	Construction of new MI schemes	11.30**	6.67	10.77**
2	Rejuvenation and rehabilitation of MI schemes	16.51*	17.20**	15.61*
3	Maintenance and repair of MI schemes	9.01**	11.61**	9.51**
4	Land acquisition charges	6.64	2.35	6.63
5	Flood control works	0.86	9.03*	2.80
6	Miscellaneous expenses	31.40	-12.14*	18.13
	Total	10.27**	9.76**	10.14**

(in per cent)

Note: ** and * indicate significant at 1 and 5 per cent respectively

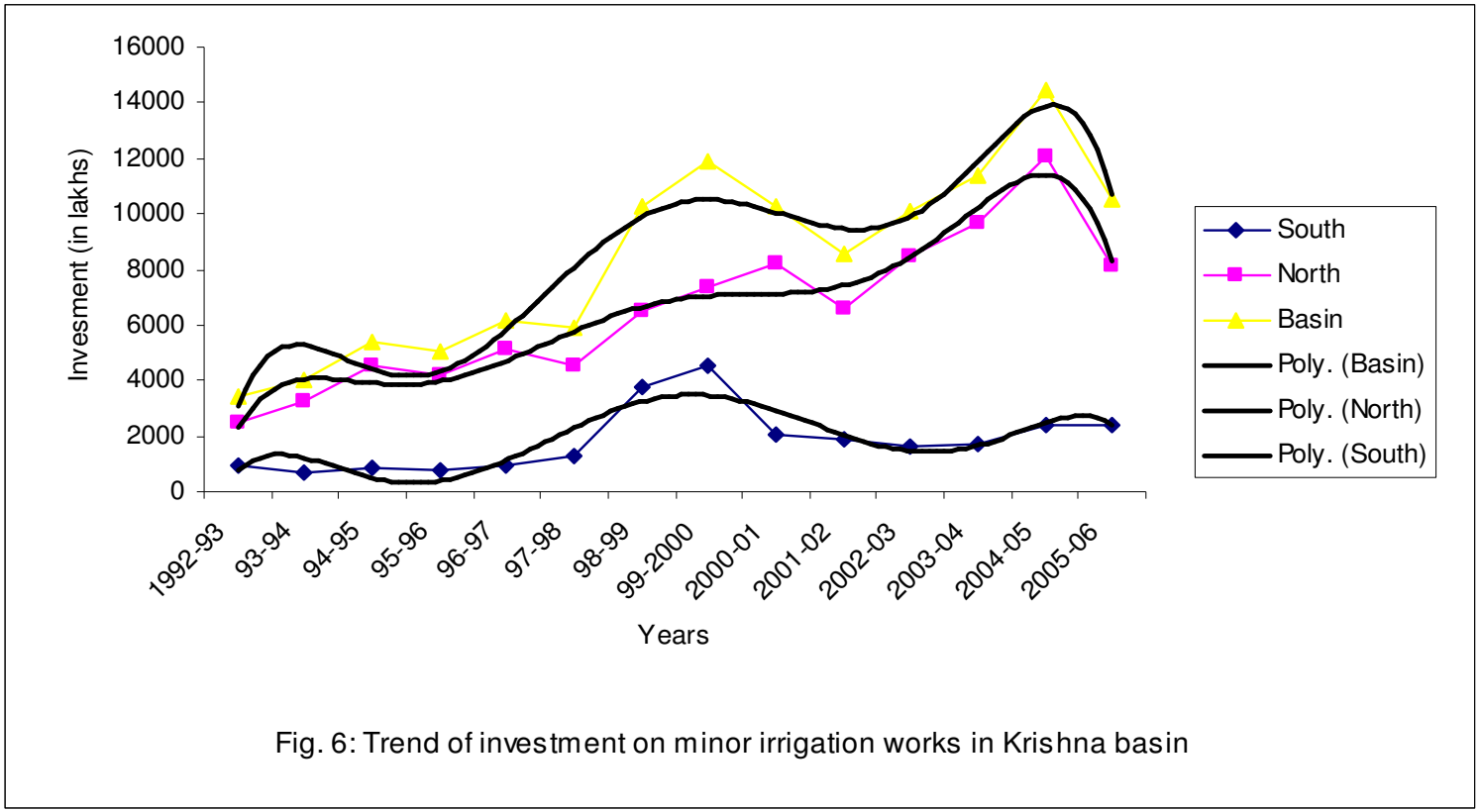


Fig. 6: Trend of investment on minor irrigation works in Krishna basin

Fig6: Trend of investment on minor irrigation works in Krishna basin

Different components of total investment are discussed below.

With respect to construction of new minor irrigation schemes a positive and significant growth of 10.77 per cent was observed for the basin as a whole. A growth rate of 11.30 per cent was observed for the northern Karnataka, whereas positive but non-significant growth of 6.67 per cent was recorded in South Karnataka.

In the case of rejuvenation and rehabilitation of minor irrigation schemes, growth rate observed was 15.61 per cent and it was significant. Growth rate in this expenditure was slightly higher at 17.20 per cent for South Karnataka when compared to northern region which was 16.51 per cent. In both the cases, growth rate was found to be significant. With respect to maintenance and repairs of minor irrigation works, growth rate observed for the Krishna basin as a whole was 9.51 per cent and it was significant. A positive and significant growth rate of 9.01 and 11.61 per cent per annum was registered for north and south Karnataka, respectively. With respect to land acquisition charges, positive but non-significant growth was recorded for both north and southern parts and also for Krishna basin as a whole. It was 6.63 per cent for the basin as a whole, 6.64 per cent for north Karnataka and 2.35 for South Karnataka. In case of flood control works growth rate observed was 2.80 per cent for the basin as a whole and it was non-significant. For the south, growth rate observed was 9.03 per cent and significant. For the north Karnataka, growth rate was 0.86 per cent and non-significant. With respect to miscellaneous expenses, non-significant growth rate of 18.13 per cent per annum was observed for the Krishna basin as a whole. Negative but significant growth of -12.14 per cent was observed in southern region, whereas positive but non-significant growth was observed in the case of southern region (31.40 per cent).

4.3 Potential created and utilization through different minor irrigation sources

4.3.1 Gap between potential created and utilization in Krishna river basin

Table 4.8 depicts the potential created, utilization and percentage gap between the irrigation potential and utilization in Krishna basin. It was observed that total potential created by minor irrigation schemes in Krishna basin was 9, 69,334 ha and utilisation was only 5, 55,077 ha with a gap of 42.73 per cent. Potential created in the northern region was 6, 03,353 ha with the utilisation level of 3, 28,173 ha. With regard to southern region of the basin potential created was 3, 65,981 ha and the utilisation of the created potential was2, 26,904 ha. Percentage gap in the utilisation of potential was found to be higher in northern region of the basin with 45.60 per cent and in case of southern region it was found to be 38 per cent.

4.3.2 District wise growth potential created and utilisation in northern Karnataka

Potential created and utilization of the created potential through minor irrigation sources in the Krishna river basin is presented in Table 4.9.

Growth rate with respect to potential created through all minor irrigation sources in Krishna basin in the North as a whole was found to be 4.36 per cent per annum and was significant. With respect to utilization of potential by all the minor irrigation sources in the basin, growth rate observed was 1.29 per cent and non-significant.

Among the districts, highest growth in potential was observed in Bidar, it was 12.80 per cent and was significant. Positive and significant growth was observed in all the six districts of North Karnataka except for the Bellary where growth rate was very small (1.76 per cent). With respect to utilization, positive and significant growth rate of 9.43 per cent per annum was recorded in Belgaum district. In three districts namely Bijapur, Dharwad and Bidar growth rate was found to be positive but non-significant. In Bellary, growth rate for potential created by minor irrigation sources was found to be -11.86 per cent per annum and it was significant. Negative growth rate was also found in Gulbarga (-1.54 per cent) and Raichur (-0.18 per cent) but was found non-significant.

Table 4.8: Percentage gap between potential created and utilisation in Krishna basin

(Area in ha)

	Potential created	Utilisation	Percent gap
North Karnataka	6,03,353	3,28,173	45.60
South Karnataka	3,65,981	2,26,904	38.00
Basin	9,69,334	5,55,077	42.73

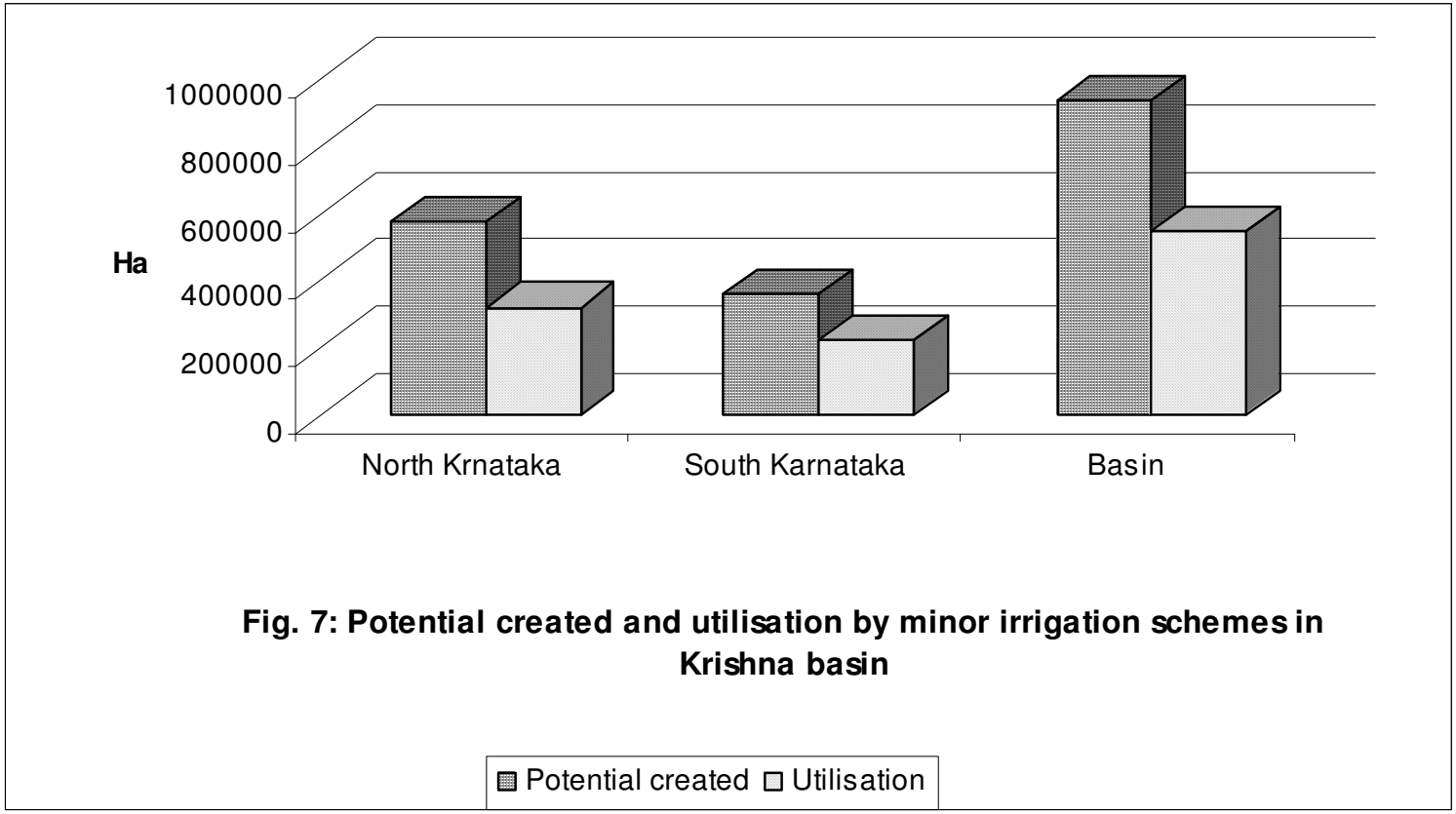


Fig. 7: Potential created and utilisation by minor irrigation schemes in Krishna basin

Fig.7: Potential createdand utilization by minor irrigation schemes in Krishna basin

Tanks

Growth rate with respect to potential created by tanks in the Krishna basin as a whole was found to be 4.63 per cent and significant and on par with basin growth rate. As far as, the utilization was concerned growth was negative (-3.53 per cent) and was non-significant.

Among the districts, growth rate was found to be higher than the region average in four districts namely Bidar (12.80 per cent), Bellary (8.77 per cent), Belgaum (7.15 per cent) and Gulbarga (5.18 per cent). Non-significant growth was observed in Dharwad, at 63.19 per cent. In remaining two districts, Bijapur and Raichur, though growth rate was less than the region average, the magnitude was more than 75 per cent.

As per the utilization of the potential created through tank irrigation system, negative and non-significant growth of -3.53 per cent was observed for the northern Karnataka as a whole. Among districts, positive non-significant growth of 10.42 and 11.21 per cent was observed in Dharwad and Bidar districts, respectively. Negative and non-significant growth was observed in Bellary (-15.23), Gulbarga (-3.08 per cent), Bijapur (-9.16 per cent) and Raichur (-4.29 per cent). In the case of Belgaum, growth rate was -4.30 per cent and significant.

Barrages/pick ups and others

Growth rate with respect to potential created and utilization through barrages/pick ups and other schemes for the north Karnataka as a whole was found to be 30.53 per cent and 35.61 per cent per annum, respectively. In both the cases, growth rate was found to be significant reflecting upon the priority of the state in irrigation development.

Among the districts, with respect to potential creation positive and significant growth was observed in all districts except Bidar, where growth rate observed was zero. Highest growth rate was found to be in Bijapur (92.49 per cent) followed by Dharwad (85.18 per cent), Bellary (62.10 per cent), Belgaum (26.32 per cent) and Gulbarga (22.68 per cent).

With respect to utilization of potential created by barrages and pick-ups, highest growth was observed in Bijapur i.e., 51.56 per cent and significant followed by Belgaum, where growth rate was found to be 34.99 per cent. Zero growth rates were observed in Bellary and Bidar.

Lift irrigation schemes

Positive and non-significant growth of 0.64 per cent per annum was observed in the case of north Karnataka with respect to potential created by these schemes with respect to utilization of the potential created growth rate observed was -4.85 and significant.

Among districts, highest growth rate was observed in Dharwad (1.96 per cent) followed by Raichur (1.89 per cent) with respect to potential created by lift irrigation schemes. Negative but significant growth was observed in Bellary (-1.88 per cent), zero growth rate was observed in Bidar district. No significant growth was observed in rest of the districts. With respect to utilization, highest growth observed was 83.93 per cent in Dharwad district followed by Bijapur (23.85 per cent). Negative but significant growth was observed in Belgaum (-11.72 per cent). Zero growth rate was observed in Bidar district.

Total potential created and utilization

It was observed from Table 4.9 that growth rate for the potential created in the northern region as a whole was observed to be 4.36 per cent and was significant. Among the districts, positive growth rate was observed in all the districts except Bellary where it was found to be non significant. High growth rate was observed in Bidar with 12.80 per cent per annum followed by Belgaum with 7.53 per cent, Bijapur (4.60 per cent) and Gulbarga (4.46 per cent).

With respect to utilisation of the potential growth rate for the region was observed to be 1.29 per cent and was non-significant. Among the districts high growth was observed in Dharwad (14.89 per cent), followed by Bidar (11.21 per cent) and Belgaum (9.43 per cent). Negative growth was observed in three districts namely Bellary (-11.86 per cent), Gulbarga (-1.54 per cent) and Raichur (-0.18 per cent).

Table 4.9: District wise growth rates for potential created and utilization through minor irrigation schemes in Krishna river basin of North Karnataka (1992-93 to 2005-06)

(in per cent)

Sl. No	Districts	Tanks		Barrages/pick-ups and others		Lift irrigation schemes		Total	
		Potential	Utilisation	Potential	Utilisation	Potential	Utilisation	Potential	Utilisation
1	Belgaum	7.15**	-4.39*	26.32**	34.99**	1.25	-11.72**	7.53**	9.43
2	Bellary	8.77**	-15.23	26.59**	62.16**	-1.88**	-12.91**	1.76	-11.86**
3	Gulbarga	5.18**	-3.08	22.14**	30.40	0.81	2.19	4.46**	-1.54
4	Bijapur	3.51*	-9.16	92.49**	51.55**	0.28	23.85**	4.60**	0.23
5	Raichur	3.57**	-4.29	51.95**	-2.34	1.89**	3.12	2.98**	-0.18
6	Dharwad	3.19	10.42	85.18**	16.24	1.96**	83.93**	3.68*	14.89
7	Bidar	12.80**	11.21	0	0	0	0	12.80**	11.21
	Total	4.36**	-3.53	30.57**	35.61**	0.64	-4.83**	4.36**	1.29

Note: ** and * indicate significant at 1 and 5 per cent respectively

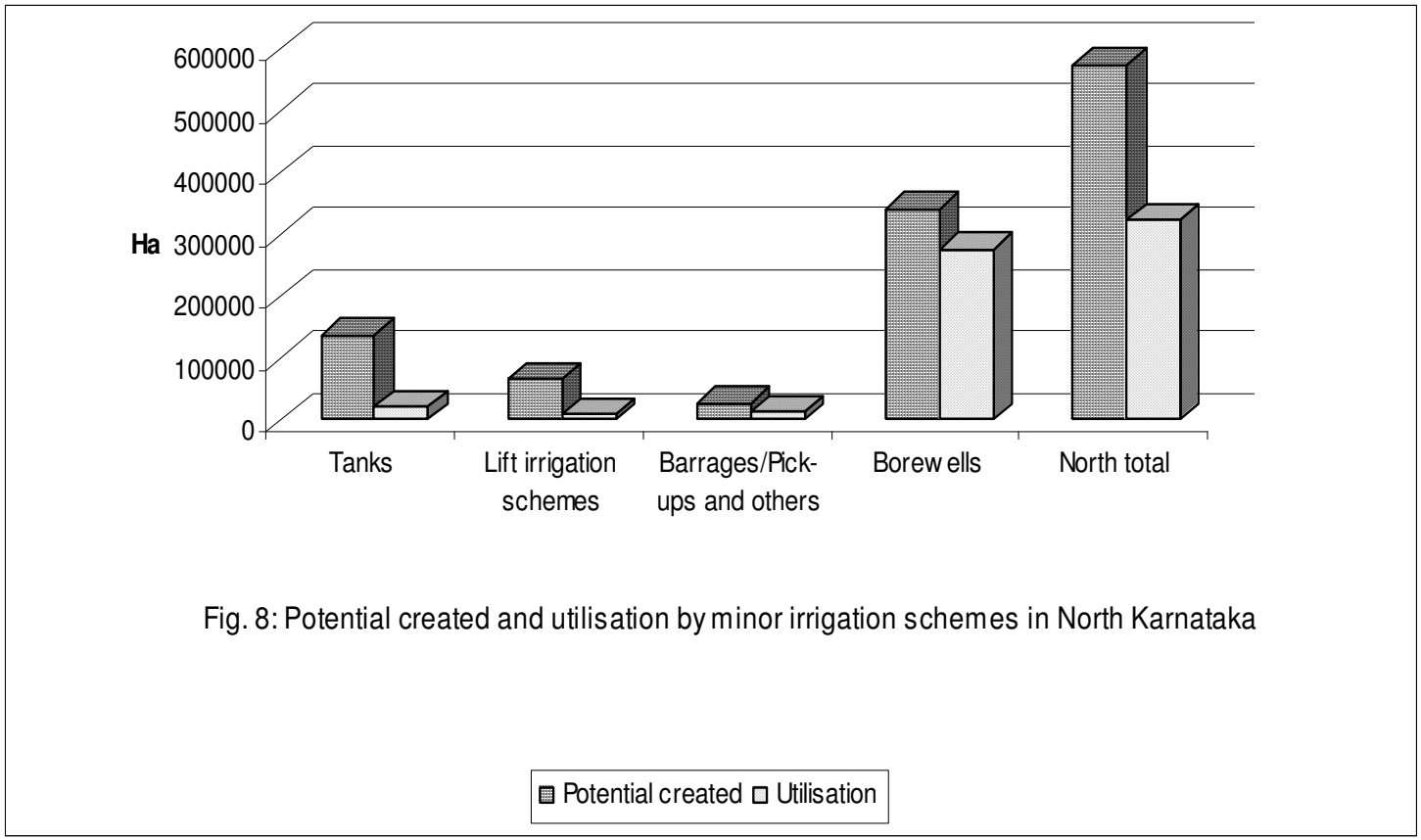


Fig. 8: Potential created and utilisation by minor irrigation schemes in North Karnataka

Fig.8: Potential created and utilization by minor irrigation schemes in north karnataka

4.3.3 Potential created by minor irrigation schemes in south Karnataka during the period-I

Growth rates for potential created by the minor irrigation schemes in south Karnataka for the period-I were computed and presented in Table 4.10.

Growth rate for potential created by the minor irrigation sources for the period-I in South Karnataka was 0.67 per cent and was significant.

Tanks

Growth rate for the potential created by tanks was 0.61 per cent. Among the districts, growth was observed to be 1.12 per cent in Hassan district, followed by Davangere (0.99 per cent) and Chikmagalur (0.74 per cent). It was observed that a positive and significant growth was recorded in all the districts.

Barrages and pick-ups

Growth in potential created by barrages and pick-ups for the region as a whole was 0.98 per cent which was significant. Growth rate was positive and significant in three districts namely Tumkur (2.99 per cent), Shimoga (1.66 per cent) and Chikmagalur (1.27 per cent). Negative but significant growth rate of -3.35 per cent was observed in Hassan district. Although growth rate was positive in Chitradurga and Davangere, it was non-significant.

Lift irrigation schemes

Southern region as a whole noticed negative (-0.35 per cent) growth rate in potential created by the lift irrigation schemes. Highest growth rate was found to be in Chikmagalur with 9.60 per cent. Lowest growth rate was found in Davangere district with 1.05 per cent and it was significant. Negative growth was observed in three districts namely Tumkur, Chitradurga and Hassan.

Total potential created

Growth rate with respect to potential created by minor irrigation schemes in the southern region as a whole was observed to be small at 0.67 per cent and was significant. Positive and significant growth rates were registered in all six districts, except Hassan where growth was positive but non-significant. High growth was observed in Chikmagalur with 0.95 per cent followed by Davangere (0.90 per cent) and Shimoga (0.70 per cent).

4.3.4 Potential created and utilisation under minor irrigation schemes in South Karnataka during period-II

Growth rates with respect to potential created and utilized in South Karnataka during period II are presented in Table 4.11.

Growth rate with respect to potential created by different minor irrigation schemes except borewells was found to be 0.36 per cent for the south Karnataka region as a whole. With regard to utilization negative growth of -0.68 and -2.51 per cent growth was recorded for both net irrigated and gross irrigated areas by the minor irrigation schemes.

4.3.4.1 Potential created

Tanks

Growth rates with respect to potential created by tanks was found to be negative (-0.41 per cent) for all the districts under Krishna basin as a whole. Among the districts, highest growth was recorded in Tumkur with 0.54 per cent followed by Chitradurga (0.20 per cent) and Chikmagalur (0.05 per cent). Negative growth was found in the remaining two districts.

Barrages and pick ups

Growth rate of potential created by these schemes in the southern region as a whole was found to be 5.31 per cent and significant. Highest growth rate was observed in

Table 4.10: District wise growth rates for potential created and utilization through minor irrigation schemes in southern region of Krishna river basin for period-I (1980-81 to 1996-97)

(in per cent)

Sl. No	Districts	Tanks	Barrages/pick-ups and others	Lift irrigation schemes	Total
1	Tumkur	0.44**	2.99**	-1.02	0.58**
2	Chitradurga	0.61**	1.04	-3.28**	0.31**
3	Davangere	0.99*	0.36	1.05**	0.90**
4	Shimoga	0.68**	1.66**	2.06*	0.7**
5	Hassan	1.12**	-3.35**	-6.71**	0.35
6	Chikmagalur	0.74**	1.27**	9.60*	0.95**
	Total	0.61**	0.98**	-0.35	0.67**

Note: ** and * indicate significant at 1 and 5 per cent respectively

Table 4.11: District wise growth rates for potential created and utilization through minor irrigation schemes in southern region of Krishna basin for period-II (1997-98 to 2005-06)

(in per cent)

Sl No	Districts	Potential				Utilisation	
		Tanks	Barrages/Pick-ups and others	Lift irrigation schemes	Total	Net irrigated area	Gross irrigated area
1	Tumkur	0.54**	-0.17*	-6.73*	0.44**	-10.78	-16.68*
2	Chitradurga	0.20	17.77**	-0.08**	1.89**	-21.86	-27.25
3	Davangere	-0.19	0	5.19**	1.58**	8.80	2.78
4	Shimoga	-2.66**	16.05*	6.49**	-0.56	-2.08**	-1.94**
5	Hassan	-0.25**	-2.11**	-18.60**	-2.19**	-31.03	-31.90
6	Chikmagalur	0.05	0.72**	-6.85	-0.02	7.32**	6.80**
	Total	**-0.41***	**5.31****	**0.96****	**0.36**	**-0.68**	**-2.51**

Note: ** and * indicate significant at 1 and 5 per cent respectively

Chitradurga with 17.77 per cent followed by Chikmagalur (0.72 per cent). Negative growth rate was observed in Tumkur and Hassan districts.

Lift irrigation schemes

With respect to potential created by lift irrigation schemes, 0.96 per cent growth rate was observed for the south Karnataka as a whole. Among the districts, positive growth was observed only in Davangere with 5.19 per cent and negative growth was observed in all the other districts.

With respect to total potential created by all the minor irrigation sources, positive growth was found in three districts namely Tumkur (0.44 per cent), Chitradurga (1.89 per cent) and Davangere (1.58 per cent). Growth rate was found to be negative in the remaining two districts.

Total potential created

Total potential created by minor irrigation schemes during period-II grew at a rate of 0.36 per cent per annum for the region as a whole. Among the districts positive and significant growth was observed in three districts namely, Chitradurga (1.89 per cent), Davangere (1.58 per cent) and Tumkur (0.44 per cent). Growth rate was observed to be negative in the remaining three districts.

4.3.4.2 Utilization of potential created

Net irrigated area

Growth rate with respect to net irrigated area under all the minor irrigation sources in the region was found to be highest in Chikmagalur with 7.32 per cent and it was significant followed by Davangere (8.80 per cent) which was non-significant. Negative growth was observed in rest of the three districts namely Tumkur, Chitradurga and Hassan.

Gross irrigated area

Growth rate with respect to gross area irrigated by minor irrigation sources was found highest in Chikmagalur (6.80 per cent) followed by Davangere (2.78 per cent). Negative growth was observed in all the other districts.

4.3.5 Borewells

4.3.5.1Net irrigated area and gross irrigated area by borewells

Growth rates with respect to net irrigated area and gross irrigated area in Krishna basin is presented in Table 4.12.

Growth rates with respect to net irrigated area and gross irrigated area for the Krishna basin as a whole was found to be positive and significant with 8.80 and 8.50 per cent per annum, respectively.

With respect to North Karnataka growth rate observed was 10.10 per cent and 9.43 per cent for net irrigated area and gross irrigated area respectively. Highest growth was observed in Gulbarga with 23.10 and 24.26 per cent, respectively followed by Bijapur (21.21 and 19.80 per cent) and Raichur (20.91 and 21.38 per cent). Positive and significant growth was observed in all the districts except Bellary and Dharwad, where growth rates were positive but non significant.

With respect to South Karnataka, growth rate with respect to net irrigated area and gross irrigated area from borewell was positive and non-significant at 4.69 per cent and 5.07 per cent, respectively. High growth rate was observed in Tumkur with 16.60 per cent, followed by Shimoga (11.38 and 11.37 per cent) and Hassan (10.48 and 11.10 per cent) respectively. Negative but significant growth rate was observed in case of the Chitradurga district with -1.71 and –0.72 per cent with respect to net irrigated area and gross irrigated area.

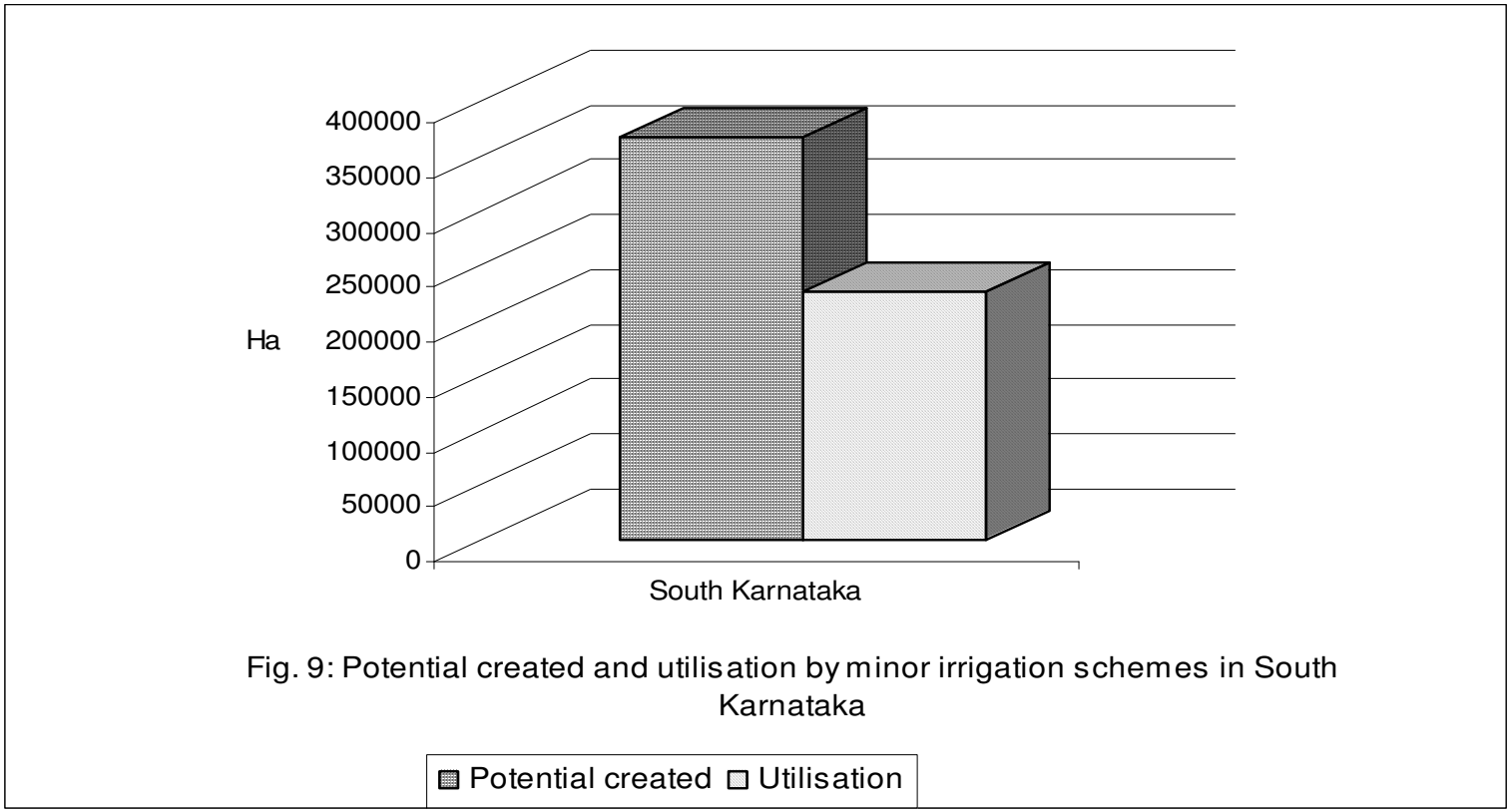


Fig. 9: Potential created and utilisation by minor irrigation schemes in South Karnataka

Fig.9 : Potential created and utilization by minor irrigation schemes in south karnataka

Table: 4.12 District wise compound growth rates for utilization of potential created by borewell (1992-93 to 2005-06)

(in per cent)

Sl. No.	Districts	Net irrigated area	Gross irrigated area
1	Belgaum	7.91**	7.64**
2	Bijapur	21.21**	19.80**
3	Bellary	5.65	2.99
4	Dharwad	1.96	1.92
5	Gulbarga	23.90**	24.26**
6	Raichur	20.91**	21.38**
	North total	**10.10****	**9.43****
1	Chitradurga	-1.71	-0.72
2	Shimoga	11.38**	11.77**
3	Hassan	10.46	11.00
4	Chikmagalur	5.97	7.28
5	Tumkur	16.60**	14.07**
	South total	**4.69**	**5.07**
	Basin total	**8.80****	**8.50****

Note: ** and * indicate significant at 1 and 5 per cent respectively

4.4 performance evaluation of minor irrigation schemes

4.4.1 Tanks

4.4.1.1 General information about the status of irrigation tanks

General information about the sample tanks in the study area is presented in Table 4.13. Tanks in the study area were medium to large with an average catchment area of 54.70 sq. km. Modal depth of the tanks was about 24.97 ft and siltation was 7.58 ft i.e., 30.35 per cent of the total depth of the tank. Average water spread area of the tanks was 91.83 ha with the live capacity of 86.12 mcft water. It was observed that, the current live capacity of the tanks in the study area was only 64.03 mcft. Average water availability in the tanks was to the extent of 15.42 ft. As per the opinion gathered from the village accountant, assistant engineers and neighbouring farmers, there was a 14.20 per cent encroachment of the tank bed area in more than 50 per cent of the tanks considered for the study.

Bunds were earthen made in the case of all tanks that were considered for the study. Average top width of the bund was 3.10 mt, maximum height of the bund was 9.79 mt and length was 684.40 mt. Two types of canal system were observed in all the sample tanks, left bank canal (LBC) and right bank canal (RBC). Average length of the left bank canal was 3,790 mt and the average length of the left bank canal was observed to be 3,683.33 mt. As per he opinion gathered from the farmers in the command area, canals were not maintained properly, linings were broken down because of poor masonry work and wastage of water was a common phenomenon through these breakages.

As per the opinion gathered from the village accountants, about 60 per cent of the tanks in the study area were having Tank Development Committee and it was also observed that almost all the committees were beset with constraints and were not functioning properly for the tank development.

4.4.1.2 Average filling of the tanks in the last five years

Data pertaining to the tank space filled by water in the last five years were gathered and are presented in Table 4.14.

Based on the information available with the village accountants and discussion with the farmers in the study area, pattern of water filling in the tanks during last five years (2002 to 2006) was gathered. It was observed that only 15 per cent of the tanks were completely (100 per cent) filled up during last five years. About 35 per cent of the tanks filled up only to the 50 per cent of their total capacity and about 50 per cent of the tanks filled up to 75 per cent of their capacity.

4.4.1.3 Number of villages and farmer-beneficiaries covered

Average number of villages and types of farmer beneficiaries covered under each minor irrigation scheme (tanks, lift irrigation scheme and barrage/pick-ups) is presented in Table 4.15.

It is evident from the table that approximately about 120 farmer beneficiaries of two villages were benefited from the tank irrigation system. More than 25 per cent of the tanks in the study area irrigated farms of more than two villages.

Among farmer-beneficiaries under tank irrigation system, share of small farmers was found to be highest, accounting to 60.72 per cent of the total beneficiaries followed by marginal farmers (21.30 per cent) and large farmers (17.96 per cent).

4.4.1.4 Cropping pattern identified under tank irrigation system

Cropping patterns followed by the farmers under different minor irrigation schemes (tanks, lift irrigation schemes and barrages/pick ups) were identified and are presented in Table 4.17.

Under tank irrigation system, the proportion of area devoted to *kharif* crops was as high as 62.83 per cent (237.25 ha), followed by *rabi* crops with 27.23 per cent (102.81 ha). During summer season only 9.93 per cent of the gross cropped area was irrigated. It is clear from the table that tanks were the main source of irrigation during *kharif* season.

Table 4.13: General status of tanks

Sl. No	Particulars	
1	Average catchment area per tank (sq. km)	54.70
2	Average live capacity (mcft)	86.12
3	Existing capacity (mcft)	64.03
4	Average depth of tank (feet)	24.97
5	Siltation in the tanks (feet)	7.88
6	Percentage of siltation to the total depth	31.55
7	Average water spread area per tank (ha)	91.83
8	Encroached tank bed (ha)	13.04
9	Percentage encroachment to the average water spread	14.20
10	Bund details (mts)	
	a. Top width	3.10
	b. Maximum height	9.79
	c. Length	684.40
12	Average length of the canal (mts)	
	a. LBC	3790.00
	b. RBC	3683.33
13	Average discharge of waste weirs (cusecs)	12611.50
14	Average registered command (ha)	321.75

Plate1: A panoramic view of completely filled Narendra tank

Plate2: A view of Siddanasamudra tank-Regestering declining trend over the year

Table 4.14: Proportion of irrigation tank space filled by water in the last five years

Years	Number of tanks				
	0%	25%	50%	75%	100%
2002	0	5	0	2	1
2003	0	4	2	2	0
2004	0	1	5	0	2
2005	0	0	3	4	1
2006	0	0	4	2	2
Per cent of the tank (100%)	0	25	35	25	15

Note: Eight tanks were considered for the study

Paddy was the major *kharif* crop in the tank commands of the study area with 11.12 per cent of the total cropped area, followed by bajra (10.22 per cent) and maize (10.19 per cent). Other important crops grown during *kharif* season were groundnut and ragi with 8.60 per cent and 6.54 per cent of the gross cropped area, respectively.

Bengal gram was the main *rabi* crop in the tank commands with 6.40 per cent of the total cropped area followed by sorghum (5.72 per cent) and wheat (5.16 per cent). Among summer crops, green gram was the main crop grown in 2.99 per cent of the total cropped area followed by maize with 2.78 per cent area.

Average cropping intensity under tank irrigation system worked out to be 159.14 per cent.

4.4.2 Lift irrigation schemes

4.4.2.1 General information about lift irrigation schemes

General information about the lift irrigation schemes in the study area is depicted in the Table 4.16.

It was observed from the table that average investment for construction of a lift irrigation scheme was Rs.174.26 lakhs. Average distance of lift irrigation schemes from the source (river), from where water was lifted was 108.42 mt. During the crop season, in *kharif,* a lift irrigation scheme lifts water for about 8.33 hours per day and average number of working days in a year was 120 days (June, July, August and September).

In the study area, minor lift irrigation schemes was designed to lift a discharge of 44.24 cusecs with a capacity of 525.41 HP and on an average four pumps were operating in a lift irrigation unit with 509.16 KVA motor.

Average number of rising main per lift irrigation scheme worked out to be 2.17 with a diameter of 106.67 cm. Average length of the rising main was 785.50 mt.

Average registered command area per lift irrigation was 814.89 ha, where only semi dry crops were recommended. Out of the total command area only 77.20 per cent of the area was irrigated by the lift irrigation scheme.

4.4.2.2Number of villages and farmer-beneficiaries covered

Average number of villages and types of farmer beneficiaries covered by a lift irrigation scheme in the study area are presented in Table 4.15.

It can be observed from the table that a lift irrigation scheme benefits about 202 farmer-beneficiaries of about three villages.

Among the total farmer-beneficiaries share of small farmers' was the highest with 44.46 per cent of the total farmer beneficiaries followed by large farmers with 33.05 per cent share. About 22.47 per cent of the marginal farmers were benefited from the lift irrigation schemes.

4.4.2.3Cropping pattern identified under lift irrigation schemes

Cropping pattern followed by farmers in the study area under lift irrigation schemes was identified and is presented in Table 4.17.

Under lift irrigation schemes, water was provided to irrigate the crops only during *kharif* season from June to September but not during *rabi* and summer season.

From the table it is evident that, gross cropped area was 629.10 ha. Maize was major *kharif* crop grown with 32.90 per cent of the total cropped area, followed by paddy with 16.21 per cent. Vegetables occupied an important place under lift irrigation schemes of the study area with 11.76 per cent of the total cropped area. Other important crops grown were groundnut and chilli with 10.10 per cent and 9.06 per cent, respectively.

Average cropping intensity under lift irrigation system worked out to be 100 per cent, which was lower compared to cropping intensity under tank irrigation system.

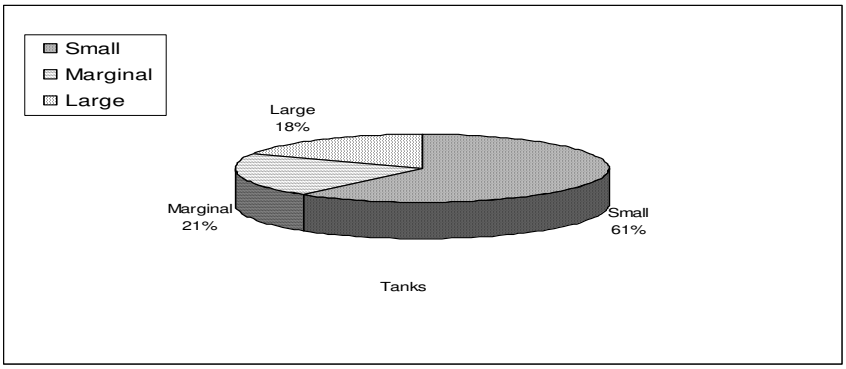
Table 4.16: General status of lift irrigation schemes

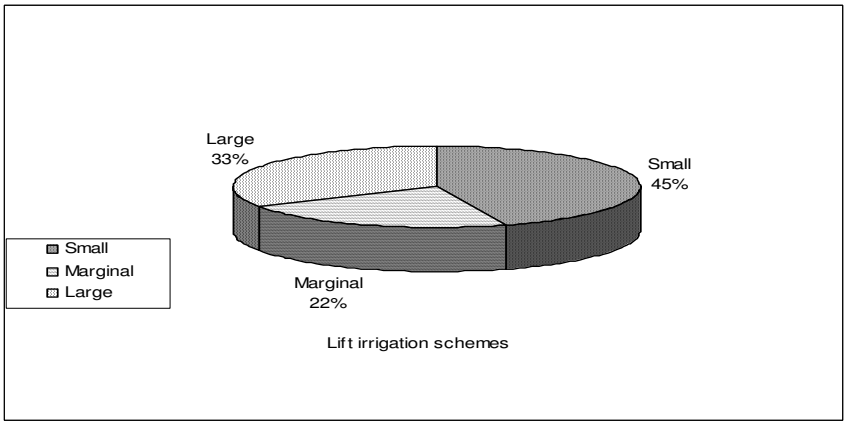
Sl. No	Particulars	
1	Average cost of construction (lakhs)	174.46
2	Average distance from the source (mts)	108.42
3	Number of working hours per day	8.33
4	Working days in a year	120
5	Discharge to be lifted	44.24
6	Total heads (numbers)	1.67
7	Horse power	525.41
8	Numbers of units operating	4
9	Number of units stand by	1.33
10	K V A of motor	509.16
11	Rising main details	
	a. Diameter (cms)	106.67
	b. Numbers	2.17
	c. Length (meters)	785.50
12	Registered atchkat (ha)	
	a. Garden	0
	b. Wet	0
	c. Semidry	814.89

Table 4.15: Number of villages and farmer beneficiaries covered under different minor irrigation schemes

Sl. No	Particulars	Tanks	Lift irrigation schemes	Barrages/pick up and others
1	Villages	2.16	2.83	2.34
2	Farmer beneficiaries			
	a. Small (0-2 ha)	72.66 (60.73)	89.67 (44.46)	19.33 (42.33)
	b. Marginal farmers (2-4 ha)	25.50 (21.31)	45.33 (22.47)	16.34 (35.76)
	c. Large farmers (> 4 ha)	21.50 (17.96)	66.66 (33.07)	10.00 (21.91)
	Total	119.66 (100)	201.66 (100)	45.66 (100)

Note: figures in parentheses are percentages to their respective total





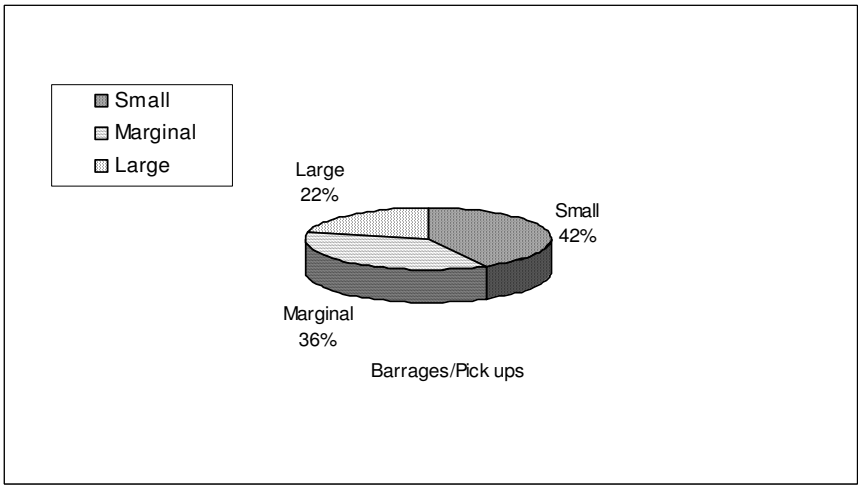


Fig 10: Farmer beneficiaries under minor irrigation scheme

Plate3: Eklaspur lift irrigation scheme suffering from inadequate power supply

Plate4: Power house indicating huge electricity requirements of MLIS

Table 4.17: Cropping pattern under the command area of different minor irrigation schemes

(Area in hectares)

Season/ Crop	Tanks	Lift irrigation schemes	Barrages/ pick ups
Kharif			
Bajra	38.60 (10.22)	14.50 (2.30)	-
Chilly	15.40 (4.07)	57.00 (9.06)	-
Groundnut	32.50 (8.60)	63.60 (10.10)	-
Maize	38.50 (10.19)	207.00 (32.90)	-
Paddy	42.00 (11.12)	102.00 (16.21)	-
Ragi	24.70 (6.54)	34.00 (5.40)	-
Sugarcane	7.10 (1.88)	18.50 (2.86)	-
Vegetables	-	74.50 (11.76)	-
Others	38.45 (10.17)	58.00 (9.21)	-
Sub total	237.25 (62.83)	629.10 (100)	-
Rabi			
Bengal gram	24.28 (6.40)	-	154.00 (23.83)
Green gram	9.33 (2.47)	-	22.50 (3.48)
Sorghum	21.65 (5.72)	-	327.70 (50.71)
Wheat	19.50 (5.16)	-	-
Red gram	14.20 (3.76)	-	6.00 (0.92)
Sunflower	7.85 (2.07)	-	84.40 (13.06)
Others	6.00 (1.58)	-	51.5 (7.97)
Sub total	102.81 (27.23)	-	646.10
Summer			
Green gram	11.30 (2.99)	-	-
Maize	10.50 (2.78)	-	-
Ragi	7.00 (1.85)	-	-
Others	8.70 (2.30)	-	-
Sub total	37.50 (9.93)	-	-
Total	377.56 (100)	629.10 (100)	646.10 (100)
Cropping intensity	159.14	100.00	100.00

Note: Figures in parentheses are percentages to their respective

4.4.3 Barrages/Pick ups

4.4.3.1 General information about barrages/pick ups

Salient features of barrages/pick ups in the study area have been depicted in Table 4.18.

It was observed that the average amount of investment for construction of barrages/pick ups was Rs.117.45 lakhs. Two types of barrages/pick ups were observed in the study area viz., vented-submersible bridge cum barrage and vented submersible barrage. It was observed that about 66.67 per cent of the barrages/pick ups in the study area were of vented submersible type and remaining 33.33 per cent were vented-submersible bridge cum barrage type.

Average height of the barrage/pick ups was found to be 3.58 mt and the length of the barrages was 88.53 mt. Maximum flood discharge through the barrage was found to be 1, 40,468.67 cusecs.

Average proposed utilization of water through the barrages was estimated at 39.20 mcft, but the existing utilization of water was only 32.27 mcft, thereby showing a gap of 17.67 per cent. Average registered command area per barrage/pick ups was 974.93 ha where only semi dry crops were recommended. Out of the total command area barrages/pick ups irrigated only 66.28 per cent of the area.

4.4.3.2Number of villages and farmer beneficiaries covered

Average number of villages and types of farmer beneficiaries covered by a barrage/pick up in the study area is presented in Table 4.15.

It is observed from the table that a barrage/pick up in the study area benefited about 35.50 beneficiaries of about three villages.

Among the total farmer-beneficiaries; share of small farmers' was the highest with 54.47 per cent of the total farmer beneficiaries, followed by marginal farmers with 46 per cent share. About 28.16 per cent of the large farmers benefited from the barrage/pick ups.

4.4.3.3 Cropping pattern identified under barrages/pick ups

Cropping pattern followed by the farmers under barrage/pick ups was identified and is presented in the Table 4.17.

In the case of barrage/pick up water was available to irrigate crops only during *rabi* season. It can be observed from the table that gross cropped area under barrage/pick up was 646.10 ha. Sorghum was the main crop grown under this system of irrigation with 50.71 per cent of the total cropped area, followed by bengal gram with 23.83 per cent area. Other important crops grown under barrage/pick ups were sunflower and green gram on an area of 13.06 per cent and 3.48 per cent, respectively.

Average cropping intensity under barrage/pick up worked out to be 100 per cent.

4.4.4 Borewell

4.4.4.1Salient features of borewell irrigation

General information on the borewell farms in the study area is depicted in Table 4.19. It was observed that the average depth of the borewells in the study area was 307.43 feet. Average net irrigated area per borewell was found to be 2.36 ha, where as average gross area irrigated per borewell was found to be 5.26 ha.

Average water yield per borewell declined to 2.06 inches from 2.68 inches when the borewell was drilled by 0.62 inch, while the average yield per borewell when drilled was 2.68 inches. Average power used by the farmer respondents was 5.87 hp. Average pumping hours per day per borewell in the study area was to 9.03 hours.

Average land holding of the borewell owned farmers was 10.40 ha, where as average area under borewell irrigation was five ha i.e., 48 per cent of the total land holding.

Table 4.18: General information about barrages/pick ups

Sl. No	Particulars	
1	Average cost of construction (lakhs)	117.45
2	Height (mtr)	3.58
3	Length (mtr)	88.53
4	Maximum flood discharge (cusecs)	1,40,468.67
5	Utilisation (mcft)	
	Proposed	39.20
	Existing	33.27
6	Registered atchkat (ha)	
	Garden	0
	Wet	0
	Semidry	974.73

Plate5: A view of flooded Godhihala-Nittur Barrage

Plate6: A view of completely filled Lingadahalli barrage

4.4.4.2 Cropping pattern on borewell farms

Cropping pattern followed by the borewell farmers in the study area is presented in the Table 4.20.

Under borewell irrigation system, proportion of the area devoted to *kharif* crops was as high as 52.28 per cent followed by summer crops with 39.14 per cent and *rabi* crops with 8.55 per cent of the gross cropped area.

It was observed that, sugarcane was the major crop grown during the *kharif* season with 19.58 per cent followed by chilli (10.65%), cotton (9.50%). Wheat was the only *rabi* crop grown under borewell irrigation and its contribution to the gross cropped area was 8.55 per cent. Chilli was the major summer crop with 13.11 per cent area followed by sugarcane (12.54%), cotton (10.45%) and maize (3.04%).

4.4.4.3 Number of irrigation provided to different crops

Number of irrigations provided to different crops through borewell in different seasons was gathered from the farmers in the study area. Total number of irrigation provided by a borewell to average gross cropped area of 5.26 hectare was 106. It was observed that more number of irrigations was given during the summer season i.e., 58.74 irrigations followed by during *kharif* season, with 44.83 irrigations. It was observed that among summer crops, maximum number of irrigation, 26.23 was provided to chilli followed by sugarcane with 20.34 irrigations and cotton with 8.34 irrigations.

Among *kharif* crops maximum irrigation i.e., 17.19 per cent of the total irrigation was provided to chilli crop followed by sugarcane (14.35%) and paddy (5.82%). It was observed that wheat was the only crop for which the borewell irrigation was provided in the study area and the average number of irrigations provided to wheat was to the extent of 2.61 per cent of the total number of irrigations.

The average cropping intensity under borewells worked out to be about 223 per cent.

4.4.4.4 Number of hours required irrigating one hectare of different crops under borewell irrigation

Time required to irrigate one hectare of a crop under borewell irrigation in different seasons is presented in Table 4.20.

It was observed that time required to irrigate one hectare of sugarcane was the highest in the *kharif* season with 55.46 hours, followed by chilli with 52.34 hours and cotton with 51.20 hours. Time required to irrigate one hectare of wheat crop during *rabi* season was 70.48 hours. Among summer crops, maximum time was required to irrigate chilli crop with 76.30 hours per hectare followed by sugarcane with 75 hours and cotton with 72.45 hours.

4.4.4.5 Investment on borewell

Investment made by the farmer respondents for drilling borewell, installing irrigation pump set, pipelines etc., is presented in Table 4.21.

This table reveals that the average cost of drilling a borewell was about Rs. 15,355 and the average cost of casing work accounted for Rs. 11,428, cost of installing pump set accounted for Rs.18, 903 and average deposit kept by the farmers with the Karnataka Electricity Board was Rs.3, 451. Miscellaneous costs, which included starter, cable wire, DP, GI pipe and indicator fitting accounted for Rs.17203.

To get a borewell ready, with an average depth of 287 ft depth, five horsepower and ten-phase motor, average investment required was Rs. 70628. Share of irrigation pump set was the highest at 26.77 per cent of the total cost followed by miscellaneous (24.35%) and drilling charges (21.74%).

Table 4.19: General status of borewell

Sl. No	Particulars	
1	Average depth (feet)	307.43
2	Average net irrigated area per borewell (ha)	2.36
3	Average gross irrigated area per borewell (ha)	5.26
4	Average water yield when drilled (inch)	2.68
5	Average present water yield (inch)	2.06
6	Average horse power of the motor (hp)	5.87
7	Pumping hours per day (hours)	9.03
8	Average total land holding of the farmer (ha)	10.43
9	Average land holding under borewell irrigation (ha)	4.96
10	Percent land holding under borewell irrigation to total land holding	47.57

Plate7: Borewell irrigation- Showuing an impressive growth in basin

Table 4.20: Cropping pattern under borewell irrigation

Sl. No	Season/Crop	Area (ha)	Percent	Number of irrigation	Hours to irrigate one hectare
I	*Kharif*				
	Chilli	0.56	10.56	18.29 (17.19)	52.34
	Cotton	0.50	9.50	3.31 (3.11)	51.20
	Maize	0.26	4.94	2.14 (2.01)	50.71
	Paddy	0.40	7.63	5.82 (5.47)	50.20
	Sugarcane	1.03	19.58	15.27 (14.35)	56.47
	Sub total	2.75	52.21	44.83 (42.15)	
II	Rabi				
	Wheat	0.45	8.55	2.78 (2.61)	70.48
III	Summer				
	Chilli	0.69	13.11	26.23 (24.66)	76.30
	Cotton	0.55	10.45	8.34 (7.84)	72.48
	Maize	0.16	3.14	3.83 (3.60)	71.20
	Sugarcane	0.66	12.54	20.34 (19.12)	75.00
	Sub total	2.06	39.24	58.74 (55.23)	
	Total	5.26	100	106.35 (100)	
	Cropping intensity	222.88			

Note: figures in the parentheses are percentages to the total

4.5 Development of minor irrigation schemes in Krishna basin

4.5.3 Opinions of experts

Opinions expressed by the experts and minor irrigation department officials regarding various aspects of minor irrigation development were elicited and are presented in Table 4.22.

About 96.67 per cent of the experts opined that there was a wide gap between potential created and utilisation by minor irrigation schemes in Krishna basin. About 47 per cent of the respondents opined financial assistance provided by the State Government was satisfactory. According to 50 per cent of the respondents, potential created through minor irrigation schemes was sufficient. About 40 per cent of the respondents opinion was that minor irrigation performed satisfactorily compared to major and medium irrigation. About 33.33 per cent of the respondents opined that development of minor irrigation in the basin had repercussions on Krishna water dispute. About 53.33 per cent of the respondents felt that there existed a regional imbalance between north and south Karnataka with respect to minor irrigation development.

4.5.4 Constraints

Various constraints in the development of minor irrigation schemes as opined by the respondents are presented in Table 4.23. Major constraints in the development of minor irrigation in the basin were identified and the extent of problem was identified as Yes or No.

Encroachment and siltation of the tanks were identified as major constraints in the growth of minor irrigation schemes as expressed by about 94 and 90 per cent of respondents, respectively which were followed by poor maintenance of minor irrigation schemes (86.67 per cent), declining rainfall (73.33 per cent) and inadequate supply of electricity (73 per cent).

Lack of institutional support, inadequate allocation and mis-utilisation of funds were identified as other major constraints in the development of minor irrigation schemes by about 66.67, 63.33 and 70 per cent of the respondents, respectively. About 54 per cent of the respondents felt that lack of political will among the state politicians was also major limiting factor.

About 51 per cent of the respondents opined that decline in ground water level also contributed to slower development of minor irrigation schemes in the basin. Less water discharge in the borewells and lift irrigation schemes and water related conflicts were also the important factors that were obstructing the development of minor irrigation sector in the basin as felt by about 43.33 per cent and 33.33 per cent respondents, respectively.

Similarly improper cropping pattern followed by the farmers in the commands was also a major constraint in efficient utilisation of potential as expressed by about 40 per cent of the experts.

Table 4.21: Investment on borewell in sample farms

Sl. No	Particulars	Value (Rs)
1	Drilling	15354.60 (21.74)
2	Casing	11428.00 (16.18)
3	Motor	18908.33 (26.77)
4	Deposit	3450.47 (4.88)
5	Network pipeline	4283.30 (6.06)
6	Miscellaneous	17203 (24.35)
	Total	70637.70 (100)

Note: Figures in the parentheses are percentages to total investment

Table: 4.22 Opinions of experts

Sl. No.	Particulars	Frequency of Yes	Percentage
1	Minor irrigation has been performing satisfactorily compared to major irrigation	12	40
2	Potential created by minor irrigation is sufficient	15	50
3	Utilisation level is satisfactory	4	13.34
4	There is gap between potential and utilisation	29	96.67
5	Development of minor irrigation has repercussion for Krishna water dispute	10	33.33
6	There is regional imbalance of minor irrigation between south and north Karnataka	16	53.33

Table: 4.23: Constraints in development of minor irrigation in Krishna basin

Sl. No	Constraints	Frequency of Yes	Percentage
1	Lack of institutional support	20	66.67
2	Lack of political will	16	53.33
3	Inadequate funds	19	63.33
4	Misutilisation of funds	21	70
5	Inadequate staff	17	56.67
6	Poor maintenance	26	86.67
7	Encroachment of tank bed	28	93.33
8	Siltation of tank	27	90.00
9	Inadequate power	23	73.00
10	Less water discharge	13	43.33
12	Declining rainfall	22	73.33
13	Declining ground water level	17	50.67
14	Improper cropping pattern	12	40.00
15	Water related conflicts	10	33.33

V. DISCUSSION

The results presented in the previous chapter are discussed under the following heads.

5.1 Growth in different minor irrigation schemes in Krishna basin

5.2 Investment on minor irrigation schemes

5.3 Potential created and utilization under minor irrigation schemes

5.4 Performance of minor irrigation schemes

5.5 Constraints in development of minor irrigation schemes

5.1 Growth in different minor irrigation schemes

5.1.1 Status of minor irrigation schemes in Krishna basin

Over the years, the main emphasis has been given on major and medium irrigation projects and minor irrigation attracted little attention. Of late, attention has shifted to development of minor irrigation sector due to environmental and rehabilitation issues and other difficulties and constraints associated with the major and medium irrigation sector. Minor irrigation is gradually getting more importance because of the several advantages that it offers. These include small investment, simpler components, quicker rewards and easier management. It is also farmer friendly as it can respond to individual needs. As a result, large bulk of the irrigation potential has been created under minor irrigation sector in the country in recent past.

From Table 4.1 presented in the previous chapter it is clear that, maximum number of minor irrigation schemes were located in northern part of the basin. This may be due to the reason that, about 80 per cent of the river basin lies in the northern Karnataka. Among different minor irrigation components borewells hold a unique position accounting for 98.61 per cent of the total minor irrigation schemes. Uniqueness of borewells may be attributed to individuality in ownership, as they were owned by individual farmer due to their open access nature. Tanks were the next important minor irrigation components in the basin with 0.99 per cent of all the components. This clearly indicated that tanks were still main irrigation sources in the basin, followed by barrages and lift irrigation schemes with 0.18 and 0.12 per cent of total minor irrigation schemes, respectively.

5.1.2 District wise growth in different minor irrigation schemes in North Karnataka

Tanks

It is clear from the past studies that tanks were the major source of irrigation in earlier days, as it was the only known technology and active community efforts were made towards their development. However, the growth with respect to number of tanks during the study period (1992-93 to 2005-06) in the northern region of Krishna increased by an impressive 11.35 per cent.

Though the northern region of the state has important river basins and reservoirs, distribution of water for irrigation was not satisfactory. Growth in the tanks in the study area might also be due to the construction of new tanks by government to overcome the problems of drought by its own funds and also with the help of NABARD and World Bank aided projects.

Among the districts, all the seven districts in the region showed positive growth rates and most of the districts came under average to medium rainfall and plain areas where the tank siltation was comparatively less.

Lift Irrigation Schemes

Lift irrigation schemes serve as important source of irrigation in the districts where rivers, stream and nala courses were perennial in nature. That is how, the highest growth

rates were noticed in Belgaum, Raichur and Gulbarga. No lift irrigation schemes were reported in Bidar district.

For North Karnataka as a whole and for the Bijapur district particularly, lift irrigation schemes showed declining growth. This could be attributed to decline in investment by the Government on new lift irrigation schemes due to the shortage of water in rivers and streams. This small change reflected upon the dilemma of Government regarding lift irrigation schemes. On the one hand Government was encouraging new projects and on the other hand, there were schemes which were closing down due to lack of funds for their maintenance.

Barrages/Pick ups

Barrages/pick ups were the other important irrigation structures built across rivers and streams to provide water for irrigation. Growth in the number of barrages/pick ups and other schemes for the region as a whole was 40.35 per cent and significant. The reason behind such an impressive growth in these schemes was requirement of smaller investments, easy management and assured irrigation. Another important reason behind the growth of barrages/pick ups was the availability of water from the perennial rivers like Krishna, Tungabhadra, Bhima etc. theses were also found to be easy mechanism to face drought.

Among the districts, high growth was observed in Belgaum and Bijapur. Belgaum with five rivers had the conducive environment for such structures and maximum drainage area of the Krishna river lies in Bijapur along with the Bhima sub-basin.

5.1.3 District wise growth in minor irrigation schemes in south Karnataka during period – I

Growth in different sources of minor irrigation in the southern region of Karnataka during the period – I is discussed here under.

Tanks

It was clear from Table 4.3 that, growth in the number of tanks in the Krishna basin in the southern region as a whole was 3.72 per cent annually and significant, indicating tanks were the main source of irrigation in this region.

Highest growth rate was observed in Hassan, Chikmagalur and Shimoga, as these districts fell under malnad and semi-malnad area and received annual average rainfall ranging from 1031 mm to 1886 mm. Tanks were the main source of irrigation. Tanks in these districts were small, irrigating an average command area of 26.34 acres. Rohit (1998) made similar observations. Tanks were also historically important source of important due to patronage of rulers.

Lift Irrigation Schemes

Lift irrigation was the means of irrigation wherever gravitational irrigation was not possible. A very small growth rate of 0.36 per cent was observed for the Krishna basin of the southern Karnataka, as in most of the districts like Tumkur, Chitradurga and Davanagere districts, average rainfall was less than 750 mm and no perennial and viable river systems were found. So it was not feasible to invest on the construction of lift schemes in these districts.

Barrages/pick ups and other schemes

From Table 4.3 it is clear that number of barrages/pick ups and other schemes increased by 2.22 per cent annually because there were no rivers of perennial nature and rainfall was less in Tumkur and Chitradurga districts. These schemes have been identified as drought proofing mechanism.

5.1.4 District wise growth in minor irrigation schemes in south Karnataka during period – II

Growth in different minor irrigation schemes in Krishna valley of southern Karnataka in period-II (which includes only those schemes maintained by minor irrigation department) is discussed under following heads.

Tanks

From the results presented in Table 4.4 it is clear that number of tanks in the period-II decreased significantly by -0.70 per cent annually. High negative growth of these traditional irrigation systems was observed in Shimoga and Hassan districts and a small growth was observed in Chikmagalur district. This declining trend may be attributed to factors like encroachment of catchment area, poor management across the catchment area for smooth running of rainwater into tank and siltation of tanks. Similar reasons were attributed for decline in number of tanks by Dasaratharamaiah (2006).

Lift Irrigation Schemes

It was observed from Table 4.4 that number of lift irrigation schemes declined at a rate of -0.42 per cent annually. In Tumkur, Hassan and Chikmagalur districts declining trend in the number of lift irrigation schemes was still faster. This might be due to the shortage of water in the river basins because of reduced rainfall during 2002 to 2004 and some of the schemes were also becoming disfunctional.

Barrages/Pick ups

Growth in the barrage/pick ups and other schemes in the region as a whole increased significantly at 1.46 per cent annually. High growth was observed in Shimoga as it was a thick forest but which had assured rainfall. Again in this period too, Chitradurga observed increasing growth in these schemes, which might be again because of construction of small minor irrigation schemes viz., check dams, feeder channels, planking arrangements etc.

5.1.5 District wise compound growth rates for borewell in Krishna basin

From Table 4.5 presented in previous chapter it is clear that growth in number of bore wells for whole of the Krishna basin of the state increased significantly at a rate of 10.58 per cent. Various advantages of ground water such as open access nature, individual's privilege, certainty of getting water throughout crop period etc., weighed heavily in favour of development of borewells in the study area (Hiremath.1998).

While comparing both the regions of the river basin, northern part of the river basin recorded a higher growth in number of bore wells compared to the southern, which could be due to availability of permanent water table, shortage of rainfall and need for irrigation which compelled the farmers to drill more and more bore wells in this region.

Among the districts, growth rate was found to be higher than the basin average in Bijapur, Bellary, Gulbarga, Raichur, Shimoga, Hassan, Chikmagalur and Tumkur which indicated that even in the canal irrigation areas like Bellary, Shimoga, Belgaum and Raichur, ground water assumed importance. In other districts though the growth rate was less than the basin average it was positive and significant and hence borewells for irrigation were the common feature in all the districts.

Bore wells owned by private individuals experienced a more than eight times higher growth rates, compared to bore wells dug by Government. Main reasons for this popularity of private tube wells among farmers may be convenience and suitable source of irrigation for individual farmers, very useful and cost of digging was within the reach of average farmers. This trend was confirmed by the studies of Hanif (2006).

5.2 Investment on minor irrigation works

Anonymous (2004) points that minor irrigation sub-sector has been a major thrust area for providing financial facilities by the state and central Government. Therefore public sector should give boost to investment in minor irrigation sectors as it has been identified as a panacea for many problems like deforestation, soil erosion, environmental imbalance and seismocity induced by major and medium irrigation projects.

According to Karnataka State Water Policy, investment had spread too thinly over large number of ongoing and new projects. Cost and time overruns resulted in more expenditure and less commensurate benefits. Priority for new constructions in making investments resulted in decreased availability of funds for operation and maintenance, rehabilitation and modernization of existing irrigation works.

From Table 4.6 presented in the previous chapter it is clear that high amount of investment was made on the construction of minor irrigation works during 2005-06. It was observed that out of the total investment, maximum was on the minor irrigation works carried in the northern Karnataka region. Higher quantum of investment in the northern Karnataka region was because of larger number of minor irrigation schemes taken up in the region as larger proportion of basin lies in the region. This was a welcome sign as it solved the drought problems of many districts in the north as they were often beset with the drought.

Among different minor irrigation works, highest investment (51.45 per cent) was made on the construction of different minor irrigation schemes viz., barrages, lift irrigation schemes, tanks, check dams, feeder channels etc., which involved a very high costs. It was observed that about 29 per cent of the investment was made on the annual repairs and maintenance of minor irrigation schemes. Investment made on flood control works was high in south Karnataka. This could be attributed to high rainfall in most of the districts like Chikmagalur, Shimoga and Hassan, causing floods in rivers and streams. In view of the frequent and devastating floods in the north Karnataka there was need to increase the amount allocated for flood control in the northern region.

5.2.1 Growth rates for investments on minor irrigation works

Results presented in Table 4.7 revealed that investment on the minor irrigation works increased over the years at a rate of 10.14 per cent.

With respect to construction of new minor irrigation schemes in the basin, investment made increased at a rate of 10.77 per cent annually. Growth in northern region was more than the basin average in case of the basin. Higher growth in fund allocation in the north region reflected upon the cognizance of regional imbalance by the state Government and accordingly the efforts in addressing them. This could be due to adequate flow of funds from different sources. The region received higher outlay from NABARD for the construction of new tanks, anicuts, pick-ups and lift irrigation schemes. Higher amounts of funds were also received from World Bank aided projects and HUDCO.

With regard to investment on rejuvenation and rehabilitation of minor irrigation schemes, a positive growth rate of 15.61 per cent was observed for the basin as a whole. Investment made on this sector was higher than the basin average in both north and southern parts of the basin. But high growth rate was observed in southern part of the state. This indicated that larger allocations were made on rejuvenation and rehabilitation of old minor irrigation schemes. Since Chikmagalur, Shimoga and some parts of Hassan receive high rainfall, silting up of tanks and barrages was quite common and hence the huge investment on rejuvenation and rehabilitation.

With respect to maintenance and repair of minor irrigation schemes, investment increased at a rate of 9.51 per cent annually. Growth rate was found to be higher than the basin average in south Karnataka region, as high amount of expenses were required to get repair the sluices, waste weirs and bunds of the tanks that were breached during the rainy season, flood damages caused to barrages/pick ups and check dams and repairs made to motors and canals of the lift irrigation schemes in the study area.

With respect to investment on the land acquisition figures showed an increasing trend of 6.63 per cent annually. It was evident from the previous discussions that there was high growth in the number of minor irrigation components, as the region registered high growth in number of tanks, barrages/pick ups and other schemes compared to southern region. So requirement of land for the construction of these schemes was also large and hence the higher growth in investment made to acquire the land.

Investment on the flood control works in the study area increased at a rate of 2.80 per cent annually. It was observed that more investment was made on the flood control works in the southern region of the basin. Main reason may be, most of the districts namely, Chikmagalur, Shimoga and Hassan received a high average annual rainfall of 1500 mm. Hence it was necessary to take the flood control works in the region. In north Karnataka region growth rate in investment on flood control was less and positive. But, in view of frequent floods in the northern region of the basin, higher amounts for flood control were needed.

5.3 Gap Potential created and irrigation utilization under minor irrigation schemes

5.3.1 Gap between potential created and utilization

From results presented in Table 4.8 it is clear that, there was 42.73 per cent gap between potential and utilization in Krishna basin. Greater extent of gap was found in North Karnataka with 45.60 per cent compared to South Karnataka where gap in potential and utilization was found to be 38 per cent. This indicated that potential created by minor irrigation schemes was harnessed more efficiently in South Karnataka. The gaps between the potential and utilization may be attributed to factors like,

a. Improper maintenance of minor irrigation schemes
b. Improper soil and water conservation practices
c. Inadequate power supply
d. Inefficient lifting devices
e. Reduced ground water level
f. Poor maintenance of catchment and command of minor irrigation schemes
g. Improper cropping patterns

According to Karnataka water Policy, gap in the utilisation of created irrigation potential was due to delay in the construction of field irrigation channels, leveling of land and lack of farmer participation in the irrigation management (Anonymous, 2001).

Therefore need of the hour on the part of the Government was to assure priority to command area development and to introduce the concept participatory irrigation management by encouraging Water User Associations for efficient utilisation of created potential.

5.3.2 District wise potential created and utilization in Northern Karnataka

Source wise growth rate of potential created and utilization by different minor irrigation schemes is discussed in the following paragraphs.

Tanks

From Table 4.9 it is clear that potential created through tanks in the study area increased over the years at a rate of 4.36 per cent. High growth rate was observed in Bidar, Bellary, Belgaum and Gulbarga, which was more than the region average. It was clear from the foregoing discussion that the number of tanks in this region recorded an impressive growth of 11.35 per cent annually. This indicated that increase in the number of tanks was the main factor contributing to increase in potential created. Though potential created by tanks increased at a lesser rate than the region average, in districts like Bijapur, Raichur and Dharwad growth was still positive which indicated that area targeted to be brought under tank irrigation system increased over the years.

With respect to utilization of the potential created by the tanks, growth rate was observed to be negative for the region as a whole, which was declining at a rate of 3.53 per cent annually. Declining trend in the utilization was observed in five districts namely, Belgaum, Bellary, Gulbarga and Bijapur. This could be attributed to the improper attention towards tanks and their catchments, declining trend in forests, encroachment of tank bed area and catchment, siltation of the tanks, these factors reduce the live water storage capacity of the tanks. Hiremath (1998) pointed that reducing cohesion among the people in the management of tanks and rapid development in ground water resources as an important source of irrigation were the reasons that might be attributed for declining trend in tank irrigation area. Reddy *et al* (1993) pointed that resource constraint on minor irrigation works affected not only restoration and maintenance of tanks but also nipped in the bud the programme of conserving water stored in the tanks from evaporation and transpiration leading to lost of area under tank irrigation system.

Barrage/pick up and others

Potential created by barrages/pick ups and other schemes showed very high growth rate of 30.57 per cent annually for the northern region. This might be due to high growth rate that was observed with respect to number of schemes in the study period. A very high growth rate was observed in Bijapur district as river Krishna has its largest drainage area in the district. A large number of barrages were built across the Krishna and Bheema rivers in Bijapur. Highest growth of 85.18 per cent was observed in erstwhile Dharwad district. It was observed that most of the barrages/pick ups were built in Haveri and Ranebennur taluks across the Varada and Kumudvathi rivers.

In case of utilization of the potential created too, an impressive 35.61 per cent growth was observed for the northern region. A very high growth with respect to utilization of potential was observed in Belgaum, Bellary, Gulbarga and Bijapur districts. This might be attributed to the fact that, Krishna river over flows and brings floods in these districts during rainy season (June-September) and the water will be available for the irrigation in the barrages/pick ups during *rabi*/summer seasons.

Since flow in the Varada and Kumudavathi rivers of Dharwad district during monsoon was promising, growth rates in potential created was 16.24 per cent annually. There were no barrages built in the Krishna basin of Bidar.

Lift Irrigation Schemes

Table 4.9 depicts the growth in potential created through lift irrigation schemes in the Krishna basin, which was 0.64 per cent. Among the districts, smaller growth rates were observed in Belgaum, Gulbarga, Bijapur, Raichur and Dharwad with 1.25, 0.81, 0.28, 1.89 and 1.96 per cent, respectively. Positive growth in the potential created by these schemes was found in the districts where the growth in number of lift irrigation schemes showed positive growth except for Bijapur, where the growth in number of these schemes was found to be declining over the years. Smaller growth in the potential created by lift irrigation schemes indicated that there was large scope to bring more area under irrigation by constructing new lift irrigation schemes in the region, especially where irrigation from big dams was not possible. Such suitable locations should be identified and lift irrigation schemes should be built.

As far as the utilization of the potential was concerned a negative growth was observed for the region as a whole, i.e., utilization declined at a rate of -4.83 annually. High growth rates were noticed in Dharwad and Bijapur districts with 83.93 and 23.85 per cent, respectively. This indicated that potential created through these schemes in the districts had utilized water more efficiently compared to other districts. In Belgaum and Bellary growth with respect to utilization reduced drastically over the years at a rate of –11.72 and –12.91 per cent, respectively in spite of presence of major rivers. Major reason for this short fall in the utilization of potential might be due to non-functioning of schemes, which was mainly due to the non-availability of water in the rivers through out the year. Another important factor contributing for the inefficient utilization of the potential was the inadequate supply of electricity to make the heavy pump sets to lift the water.

These undesirable conditions could be avoided if only the Government shifts its priority towards minor lift irrigation sector. This cause for greater attention on the part of the government towards minor irrigation schemes rather than major and medium irrigation in achieving the ultimate irrigation potential of the state.

Total potential created and utilization

Positive growth with respect to potential created by the minor irrigation schemes was observed for the northern Karnataka as a whole. This could be attributed to growth in the number of tanks, barrages/pick ups and other schemes in the region.

Utilization of the potential created increased at positive but lesser rate compared to potential created resulting in large gaps in utilisation. This might be due to poor management of tanks, poor irrigation management and poorly maintained canals with respect to both tank and lift irrigation schemes and poor development of command areas. Anonymous (2005) made similar study of gaps in potential and utilisation and attributed the gaps to inadequate

water, lower discharge, breakdown of channels, non-filling of storage and siltation. Therefore, measures should be taken to enhance utilisation of potential.

5.3.3 Potential created by minor irrigation schemes in south Karnataka during the period-I

Source wise growth rates pertaining to potential created by minor irrigation schemes presented in Table 4.10 are discussed as follows.

Tanks

With respect to potential created, tanks showed a very small but positive growth of 0.61 per cent annually. All districts in the region experienced a similar growth, which indicated that potential created through the tanks was not in proportion with the growth in number of tanks. It may be due to the silting up of the tanks in heavy rainfall receiving- malnad districts namely Chikmagalur, Shimoga and parts of Hassan. In a similar study Rohit (1998) pointed out that, tanks in malnad districts were old and small which silted up in spite of thick forests in the foreshore due to steeped catchments. It was difficult to desilt the tanks completely because of their interior location inside the forests.

Barrages and pick-ups

Growth in the potential created by barrages/pick ups and other schemes showed a positive growth rate, which was less than one. Positive growth in Tumkur, Chitradurga, Davanagere and Chikmagalur could be partly because of increase in number of schemes, which included check dams, feeder channel, planking arrangement etc. as there were no perennial rivers to construct barrages/pick-ups.

Lift Irrigation Schemes

Growth in potential created by the lift irrigation for the southern Karnataka during period-I showed a declining trend at a rate of -0.35 per cent annually. Declining growth rates were noticed in Tumkur, Chitradurga and Hassan districts with –1.02, -3.28 and –6.71 per cent, respectively. Declining growth rate in potential created by these schemes was mainly due to the declining number of schemes in these districts except for Hassan, where growth in number of schemes was positive. In other districts potential created was positive, as there was a positive growth in the number of these schemes.

Total potential created

With respect to potential created by all minor irrigation schemes a small positive growth of 0.67 per cent was observed for the Krishna valley in southern Karnataka for the period-II. This could be attributed to increase in number of tanks, barrages/pick ups and other schemes in all the districts and also increase in number of lift irrigation schemes in all except in Tumkur and Chitradurga.

5.3.4 Potential created and utilization by minor irrigation schemes in south Karnataka during period – II

5.3.4.1 Potential created

Tanks

Growth rate with respect to potential created by tanks in this region for the period-II was observed to be declining at a rate of 0.41 per cent. Negative growth rate was observed in Shimoga and Hassan as there was a significant negative growth in number of tanks in these districts. Small but positive growth was observed in Tumkur, Chitradurga and Chikmagalur districts. Factors attributed to this smaller growth were improper management of tank catchments, encroachment, siltation (in Chikmagalur district) etc.

In a similar study Sud (2006) pointed that many of the tanks in the southern peninsular India suffered from lack of proper maintenance. Growing siltation reduced their irrigation capacity. In 1960s an area of about 4.8 million ha was estimated to be irrigated through tanks, this acreage has now reckoned to have dropped by 1.7 million ha due to drying up of the tanks or other reasons.

Barrages/Pick ups and others

Positive growth rate of 5.31 per cent was observed with respect to potential created by pick-ups and other schemes for southern Karnataka. Very high growth rates were observed in the case of Chitradurga and Shimoga districts. This could be due to the construction of new schemes across rivers and streams. Negative growth rate was observed in Hassan and Tumkur districts, as there was a declining trend in number of these schemes in this region.

Lift irrigation schemes

For the southern Karnataka as a whole growth in the potential created by the lift irrigation schemes was 0.96 per cent. Drastic reduction in potential created in Hassan (-18.6 per cent) Tumkur (-6.73 per cent) districts brought down the over all growth of lift irrigation in period-II in the southern region. Positive growth was observed only in two districts namely Davangere and Shimoga. But, it was noticed that potential created by these schemes decreased steadily over the years. This could be due to the neglect of lift irrigation schemes and popularization of canal irrigation system in Hassan and Tumkur districts. Further, lift irrigation schemes are beset with a set of problems.

Total potential

Total potential created by minor irrigation schemes in the southern region in period-II increased at a rate of 0.36 per cent per annum which seems to be small. Substantial negative growth in different minor irrigation schemes- all schemes in Hassan, tanks in Shimoga, lift irrigation in Tumkur brought down the over all growth in potential created.

5.3.4.2 Utilisation of potential created

With regard to utilization of potential, negative growth was observed in the case of both net irrigated and gross irrigated areas at a rate of –0.68 and –2.51 per cent, respectively. Positive growth was observed in only two districts namely Davangere and Chikmagalur. Negative growth was observed in all the other districts with respect to both net and gross irrigated areas due to various technical factors like accumulation of silt and encroachment of tank bed thereby reducing storage capacity in tanks, improper irrigation management practice, diversion from the recommended-cropping pattern, fast dwindling catchment in case of tanks, reduced water flow in the rivers and inadequate power supply to lift irrigation schemes.

Anonymous (2005) pointed out that notified area actually utilized by the farmers in the upper Krishna project area was 70 per cent in *kharif* and 83 per cent in *rabi* seasons. Study identified silting up of canals, choking of CDs, jungle growth, absence of control structures etc, at different stages of canals were the factors which contributed to gaps in utilizing the irrigation potential.

5.3.5 Net irrigated area and gross irrigated area by borewells

Borewells have become popular in recent past in all the districts of the Krishna basin except Chitradurga where availability of groundwater was very less, probably because of the hard rock structure. Growth in area irrigated by borewells was also high in tune with the growth in number of borewells in the basin. Highest growth in borewell irrigation in northern region was observed in Gulbarga, which could be attributed to absence of perennial source of water and perennial drought which compelled farmers to depend heavily on the ground water. In all the districts and even in canal areas the borewell-irrigated area increased significantly indicating inevitability of borewell irrigation to support commercial and modern agriculture.

5.4 Performance evaluation of minor irrigation schemes

5.4.1 Tanks

5.4.1.1 General information about the status of irrigation tanks

Eight tanks were selected for the study from three taluks of Krishna river basin namely Ranebennur, Haveri and Bailahongal on the advice of experts in minor irrigation department. (Details are presented in appendix). Majority of the tanks in the study area were

medium to large with an average tank bed area of 91.83 ha. So is the case of depth of the tanks where the modal depth of the tanks was more than 24 ft. It was observed that live capacity of the tanks in the study area declined by 22.09 mcft. This could be attributed to siltation of the tank bed that reduced the water storage capacity of the tanks. Silting up of the tanks in the study area was mainly due to lesser forest cover in the catchment of tanks, where no natural obstacles were found to stop gushing rainwater which brought the silt into tank bed. Encroachment was another factor that had its effect on reducing the live capacity of tank bed.

Though modal depth of tanks was 25 ft, average water availability was only to the extent of 15.42 ft. Again, this shortfall may be attributed to siltation and encroachment of tank bed by neighbouring farmers. As per the opinion gathered from the village officials, engineers and neighbouring farmers, there was 14.20 per cent of encroachment of the tank bed area in more than 50 per cent of the tanks considered for the study and depth of the siltation accounted for 30.35 per cent of the total depth of the tank.

Angadi (1995) pointed that through the restoration of tank, the capacity regained was equal to volume of silt removed, on the principle of parity between silt volume and water volume. In some cases, water percolated from the tank bed area after the desiltation of the tank. Sivanna (1995) observed that desilting was not the only means for rehabilitation of tank. To increase water availability, strengthening and raising the embankment to a required height was also necessary. Contour bunding in the catchment could be adapted to reduce the siltation of water-spread area.

Since tanks were old, sluices and spillways were not strong enough to hold the large amount of water during season. Hence, they should be repaired in order to avoid breach. Two types of canals were found constructed in the case of tanks for the distribution of water to farms. Because of the poor management, most of the canals were broken up and thereby avoided the water flow to the tail end farms. Though about 60 per cent of the tanks were having formal Tank Development Committee (TDC) it was observed that no committee was working for the development of tank. This could be attributed to lack of required funds, vested interests and power politics in the villages. Therefore, there is need to educate the farmers on the concept of participatory irrigation management and organize Water User Associations.

Anonymous (2002) suggested to undertake complete rehabilitation and development of all minor irrigation tanks on the basis of participation by water users including farmer and also subsequent operation and maintenance with Tank Users Associations which would regulate water use, cropping pattern, levy and collection of water-user charges.

5.4.1.2 Average filling of the tanks in the last five years

It is clear from the results presented in Table 4.14 that only 15 per cent of the tanks in the study area filled up completely during the previous five years considered for the study. This could be attributed to the pattern of rainfall in the area. Average annual rainfall of the study area was only 700 mm and also state was badly affected by drought during 2002 to 2004, which was responsible for the tanks to fill less than their actual capacity. Besides, encroachment of the tank bed, poor management of the catchment area for smooth running of rainwater into the tank had their significant contribution in not filling up to their full capacity. This observation is in line with the findings of Rohit (1998). Therefore, there was an urgent need on the part of the Government to fill the tanks by flowing water through canals, which are the important water bodies of the rural India for both domestic and agricultural purpose. Recently efforts to fill up tanks from canal water have been initiated but results are not encouraging because of logistical difficulties and lack of political and beauracratic will.

5.4.1.3 Number of villages and farmers beneficiaries covered

From the results presented in Table 4.15 it can be observed that, on an average, about 120 farmers benefited across two villages. From the foregoing discussions it follows that tanks in the study area were medium to large in size with a storage capacity of 86.12 mcft. More number of farmer beneficiaries and villages could have been brought under tank command if public bodies responsible for the maintenance and management of tanks paid sincere attention to increase the water storage capacities through desiltation of tank bed, checking the unauthorized encroachment by the private individuals and regular maintenance of irrigation canals.

It was observed that, out of the total farmers beneficiaries under tank irrigation system, 60.71 per cent were small farmers with a holding up to two ha. Only 17.96 per cent of the large farmers having land holding of more than four hectare depended on tank irrigation. In a similar study, Timothy and Krishnamoorthy (1990) reported that about 52.56 per cent of the farms under the tank command were small, 21.79 per cent marginal and only 3.8 per cent large. The study observed that there was a positive influence of farm area on the productivity, which could be due to the presence of supplementary irrigation on farms of larger area.

5.4.1.4 Cropping pattern identified under tank irrigation system

It was observed that paddy was the most popular *kharif* crop in the tank commands as there was assured irrigation facility during the season. It was also observed that paddy was the popular crop among the head and middle reach farms due to assured irrigation. Bajra, maize and groundnut were grown on the mid reach farms but they were predominant crops of the tail end reach farms. Though sugarcane was grown to some extent in the command, supplementary irrigation was provided during late *rabi* and summer seasons through bore wells.

Similarly in *rabi*, bengal gram occupied a large chunk of area which was one of the major commercial crops followed by sorghum which was the staple food crop of the region. During summer only ten per cent of the gross cropped area was irrigated, as the farmers maintained some reserve water in the tanks as security against failure of monsoon.

Cropping intensity worked out was only 159.14 per cent, lower cropping intensity was because of the decline in net-cropped area during *rabi* and summer seasons due to shortage of water.

5.4.2 Lift Irrigation Schemes

5.4.2.1 General information about lift irrigation schemes

Eight lift irrigation schemes were selected for the study, which were built across the tributaries of river Krishna in Haveri, Ranebennur and Bailahongal taluks. (Details are presented in Appendix I). Average distance of the lift irrigation schemes from the river was 108.42 m. The schemes were found to function only during *kharif* season, as the water flow was fair only during this season due to south-west monsoon. During crop season, in *kharif*, a lift irrigation scheme in the study area operates for eight to nine hours in a day with an average of four pumps in a unit.

Average command area registered under each scheme was 814 ha. It was recommended to grow only semidry crops based on the crop-environmental relationships, crop-water requirements and which were mainly based on the availability of water in the rivers and streams. It was found that only 77 per cent of the notified command area was irrigated by the lift irrigation schemes. This might be attributed to reduced flow of water in the riverbed, poorly maintained and silted irrigation canals across the command area and shortage of electrical power to lift the water.

5.4.2.2 Average number of villages and farmer beneficiaries covered

From Table 4.15 of the previous chapter, it is clear that a lift irrigation benefited about 201 farmers across three villages. As in the case of tanks, small farmers formed a major chunk (44.46 %) of beneficiaries followed by marginal farmers (22.47 %) and large farmers (33.05 %) under lift irrigation schemes. Irrigation should be promoted for the cause of equity as they covered a larger proportion of small farmers.

5.4.2.3 Cropping pattern identified under lift irrigation scheme**s**

It is clear from the earlier discussion that, farmers in the study area got irrigation only during *kharif* season through minor lift irrigations schemes.

In the cropping pattern under study area maize dominated followed by paddy, as both the crops required assured irrigation facilities. Chilli and vegetable crops also dominated the cropping pattern in the study area, especially in Haveri and Ranebennur, which were popular in the state for growing these crops. Irrigation to chilli crop during *rabi* and early summer was provided through bore well irrigation. Ragi also held important position in the cropping pattern,

which was grown on the tail end farms. Cropping intensity under lift irrigation command was found to be 100 per cent as crops were grown only during *kharif* season.

5.4.3 Barrages / Pick ups

5.4.3.1 General information about barrages/pick ups

As in the case of tanks and lift irrigation schemes, eight barrages/pick ups were considered for the study.

Average height of the barrage/pick up was found to be four meters and length was 88.53 m. It was found that as per the Government rule, barrages/pick ups constructed under minor irrigation schemes should be limited to four meter. In the study area, height of the barrages/pick ups was ranging between three and four meters. Flood discharge through the barrages was found to be maximum during the rainy season as rivers and streams experienced high flow during this season.

In terms of water utilisation gap between the proposed and existing utilization was found to be 6.93 mcft. Average command area per barrage/pick up was 974.94 ha. It was observed that only 66.28 per cent of the total command was irrigated. This could again be attributed to siltation of riverbed, which reduced water storage capacity of the barrage and also to inefficient water lifting mechanisms.

5.4.3.2 Number of villages and farmers beneficiaries

It was observed that a barrage/pick up irrigated farms of about three villages. As in the case of other two irrigation schemes namely tanks and lift irrigation schemes large chunk of small farmers got benefited from the barrages/pick ups followed by marginal farmers, which again reflected upon positive social equity aspect of minor irrigation schemes.

5.4.3.3 Cropping pattern

As discussed earlier, barrages/pick ups in the study area provided irrigation only during *rabi* season because rivers and streams over flow during *kharif* and there was no dearth for irrigation and during summer river bed dries off. It was observed that sorghum was the major crop grown under command of barrage/pick ups, as it was the main staple food crop of the people followed by bengal gram and sunflower, which were important commercial crops. Cropping intensity was found to be 100 per cent.

5.4.4 Borewells

5.4.4.1 Salient features of borewell farms in the study area

From Table 4.19 presented in the previous chapter it is clear that the average depth of borewell was 287.43 ft. This could be due to the low water table as the average annual rainfall in the study area was 706 mm. Average net irrigated area per borewell was 2.36 ha where as average gross irrigated area per borewell was 5.26 ha. It was observed that water yield of the borewells declined by 0.62 inches compared to the yield at the time of drilling. This reflected upon excess extraction of ground water in the study area and could be due to interference of neighbouring borewells and high density of borewells per unit area.

Average pumping hours per day was about nine hours, ranging between 5 hours per day to 24 hours per day on few farms. This may be due to the limited scheduled power supply to villages. Some of the farms were under the electricity supply network of nearby cities/towns and industrial area, hence 24 hors pumping was observed on those farms.

It was observed that about 48 per cent of the total land holding was under borewell irrigation. This clearly indicated the increasing popularity of the borewells among the farmers for providing irrigation to crop. The reasons for popularity of borewell irrigation were,

a. Convenient and dependable source of irrigation
b. Cost of digging is within the reach of average farmer
c. Open access nature and individual privilege
d. Certainty of getting water throughout the crop period.

5.4.4.2 Cropping pattern on borewell farms

Results presented in Table 4.20 showed season wise crops grown under borewell irrigation. It was observed that *kharif* crops had a large chunk under borewell irrigation followed by summer season crops. This may be due to the availability of rainwater as a complementary source of irrigation during *kharif* season. Around 75.85 per cent of the gross cropped area was occupied by cash crops like chilli, cotton and sugarcane. It was also observed that around 42.35 per cent of the gross cropped area was occupied by sugarcane alone. This phenomenon was mainly due to the presence of two sugarcane factories at a short distance in the study area. Farmers in the study area also grew water intensive crop i.e., paddy. Among different crops grown, cereals (maize, paddy and wheat) accounted only for about 24.14 per cent of the area and rest of the area was occupied by chilli, cotton and sugarcane indicating commercial nature of farming in the study area.

Cropping intensity on borewell farms worked out to be about 223 per cent, which was 123 per cent over the cropping intensity under rainfed farming (100%). Cultivation of crops in *rabi* and summer seasons due to the availability of borewell irrigation brought about a substantial increase in the cropping intensity in the study area.

5.4.4.3 Number of irrigation provided to different crops

It was observed that total number of irrigation provided to the crops by a borewell in all the seasons was about 107, of which maximum number of irrigations (about 55.23 % of the total) were provided to crops grown during summer season followed by *kharif* crops (42.15 %). This was mainly due to the high water requirement of crops during summer due to the high temparature and heavy moisture loss from both plant body and soil surface and availability of rain water as a complementary irrigation during *kharif* season. Among crops, chilli was provided with highest number of irrigations as there was a practice among farmers of providing irrigation once in every ten days from the day of nursery preparation to till the day of last picking. Lowest number of irrigation was provided to *rabi* wheat as borewell irrigation was just a supplementary.

5.4.4.4 Time required to irrigate one hectare under borewell irrigation

It was observed that time required to irrigate one hectare area crop during summer season was the highest compared to those grown during *kharif* season. As there was high temperature during summer season water absorption by the soil and the crops was more and hence the time required to irrigate one hectare crop was more.

5.4.4.5 Investment on borewell

The results presented in Table 4.21 with respect to investment made by farmers on the borewell installation is discussed under the following paragraphs. Total cost of installing a borewell with an average depth of 287.43 ft, five HP, ten-phase borewell in the study area was about Rs. 70,638.

Among different components of investment in ground water development, the drilling cost accounted for Rs. 15,355 (21.74 %) and the casing cost accounted for Rs. 11,428 (16.18 per cent). Cost of irrigation pumpset with all the accessories formed the major item of investment with 26.71 per cent of the total cost. This revealed that the extraction component was more expensive than the exploration.

Borewell drilling, casing and pump set installation together accounted for 64 per cent of the total investment. It was observed that about 40 per cent of the farmers in the study area invested on conveyance and distribution system. PVC pipes were used for carrying the ground water from source to the different plots in order to reduce the wastage of ground water through open channels. The cost incurred was to the extent of 6.06 per cent.

5.5 Development of minor irrigation schemes in Krishna basin

5.5.1 Opinions of experts

It is clear from the results presented in the Table 4.22 that about 40 per cent of the respondents opined that minor irrigation sector performed satisfactorily when compared to major irrigation development. This might be due to shifted priority of the Government to development of minor irrigation sector over major irrigation sector due to environmental and rehabilitation issues and other conflicts. This might also be due to small investments, simpler components, quicker rewards and easier management of minor irrigation projects compared to major and medium irrigation. This opinion is supported by the findings of Sud (2006).

About 50 per cent of the respondents felt that potential created through minor irrigation sector was sufficient. In contrast to this only 13 per cent of the respondents felt utilisation of the potential was satisfactory and a majority of about 97 per cent opined there was a gap between potential created and utilisation. This clearly indicated the need on the part of the Government to address various constraints that prevented efficient utilisation of created potential, instead of creating additional potential in the basin.

About 34 per cent of the respondents opined that development of minor irrigation had repercussion on Krishna water disputes between the riparian states. This showed the responsibility of the Government for arguing the case of farming community in the basin before the Krishna Water Dispute Tribunal. About 54 per cent of the respondents felt that there existed regional imbalance between north and south Karnataka with respect to minor irrigation development. This imbalance might also due to historical factors, lack of proper vision, political will and competitiveness among the politicians of this region.

5.5.2 Constraints in the development of minor irrigation

Major constraints identified in the way of minor irrigation development in the Krishna basin were encroachment and siltation of tank bed, poor maintenance, inadequate power supply, declining rainfall, mis-utilisation and inadequate funds, lack of institutional support and political will.

Encroachment and siltation of tank bed were observed to be major constraints as opined by about 94 and 90 per cent of the respondents, respectively. Therefore, Government should intervene to check the unauthorised encroachment by private individuals and silt should be removed from the tank beds for every 3-4 years.

Poor maintenance of the minor irrigation projects was also one of the important constraint as opined by about 87 per cent of the respondents. So it is necessary to form the Water User's Association and thereby efficient management of these schemes at the ground level with the proper funding from the Government. Poor maintenance might also be due to the inadequate staff in Minor Irrigation Department, as opined by about 57 per cent of the respondents. Therefore, it is necessary to recruit the personnel and post them to project site for effective maintenance.

Inadequate supply of electricity was another major constraint, especially for the proper functioning of lift irrigation schemes due to which most of these schemes closed down. Therefore, government should arrange to provide uninterrupted supply of electricity to these schemes. Similarly declined rainfall in the basin was also major constraint as opined by about 74 per cent of the respondents. Therefore, it is necessary to encourage the afforestation in the catchments, especially in the tank catchments. This can be taken in collaboration with State Watershed Department and Tank development Committees.

Mis-utilisation of funds allocated to minor irrigation works was also another important factor in limiting the minor irrigation development in the basin. So it is necessary to form vigilance and over-view committee to check the mis-utilisation of funds.

Lack of institutional support and political will among the politicians of the state was a major constraint in minor irrigation development in the basin. This could be due to the lack of vision about the importance, advantages and need of minor irrigation schemes among politicians in bringing about the social equity.

Low water discharge was a limiting factor in efficient functioning of lift irrigation schemes. This could be due to inefficient lifting mechanisms, inadequate power supply and reduced water flow in the river basin. Declining ground water level was a major factor that contributed to drying up of borewells and tanks in the basin. Therefore, excessive exploitation of ground water resources should be regulated and ground water recharge projects should be developed.

Improper cropping pattern i.e., diversion of cropping pattern from growing semidry crops to water intensive crops was another major factor in creating gap between potential and utilisation. Attempts have been made to stop violation of prescribed cropping patterns but without any positive response from the farmers. Therefore, a more effective way would be to educate them about these aspects.

VI. SUMMARY AND POLICY IMPLICATIONS

Irrigation has been on the priority list ever since the planned development began in India. Huge investment, both public and private, has gone into creation of irrigation infrastructure through major, medium and minor irrigation projects. As a result, the gross irrigation potential has expanded from the pre-plan level of 22.6 m ha in 1950-51 to a little over 89 m ha at present. But, the country's total irrigation potential through all sources estimated at 113.5 m ha earlier has now been assessed at whopping 139.9 million hectares. But a worrisome aspect of the irrigation sector is the large gap between the irrigation potential and its utilization. So far, only about 64 per cent of this potential has been gainfully harnessed.

Apart from the environmental and rehabilitation issues that have been impeding implementation of major and medium irrigation projects, paucity of resources has been the most formidable bane of this sector. The failure to meet the targets, resulting in inordinate delays in the completion of irrigation projects have resulted in escalation of costs, making further progress in this sector all the more difficult. Many of the projects are not even catering to the needs of the potential command areas for want of resources for operation and maintenance. A large number of these projects have spilled over from one plan to another chiefly for want of adequate resources.

Over the years, the main emphasis has been given on major and medium irrigation projects and minor irrigation attracted little attention. In recent days minor irrigation is gradually becoming more important because of the several advantages it offers. These include small investment, simpler components, quicker rewards and easier management. It is also farmer friendly as it can respond to individual needs. As a result, the bulk of the minor irrigation potential has been created in the country in recent past.

The present study was conducted to evaluate the temporal growth and performance of minor irrigation schemes namely tanks, lift irrigation schemes, borewells and barrages/pick-ups in Krishna basin of Karnataka. The study is an attempt to provide an insight to policy makers in framing the policies for effective development, judicious management and maintenance of minor irrigation schemes to make them fully potential as most of the districts in the study area fall under rain scarcity areas, particularly in North Karnataka region. The findings of the study can serve as a data base which can be utilised by a body like Technical Advisory Cell constituted by Government of Karnataka to assist in putting the right facts about states irrigation before the Brijesh Kumar Tribunal.

SPECIFIC OBJECTIVES

1. To estimate the extent and pattern of growth of minor irrigation in Krishna river basin of Karnataka
2. To analyse the trend and pattern of investment in minor irrigation development in the study area
3. To study the potential created and utilisation of irrigation
4. To study the performance of selected minor irrigation schemes
5. To identify the constraints for the development of minor irrigation in the study area

The main aim of the study was to analyse the temporal growth, investment, potential created and utililised and document constraints in working of minor irrigation schemes in Krishna river basin purposively selected for the study.

For evaluating the objectives of the study, secondary data were collected from Department of Minor irrigation (South) Bangalore, Department of Minor irrigation (North) Bijapur, Directorate of Economics and Statistics Bangalore, office of Executive Engineers Minor Irrigation Department Dharwad, Belgaum and Assistant Executive Engineer, Minor irrigation Department Ranebennur division. For evaluating the performance of minor irrigation schemes, eight schemes under each component- tanks, lift irrigation schemes and barrages/pick-ups were selected randomly from Ranebennur, Haveri, Dharwad and Bailahongal taluks. To evaluate the performance of borewells the necessary field data for the

agricultural year 2005-06 were collected through survey method from 30 borewell farmers. The primary data so collected were analysed using the tabular analysis.

Analysis was carried out for individual districts of South and North Karnataka and the basin as a whole. Annual compound growth rates for growth in different minor irrigation components, investment made, potential created and utilized were computed by estimating the exponential growth model.

Major findings of the study

The major findings of the study are summerised under following heads,

- Growth in different minor irrigation schemes
- Investment on minor irrigation schemes
- Potential created and utilization by minor irrigation schemes
- Performance of minor irrigation schemes
- Constraints in development of minor irrigation schemes

It is clear from the study that the total number of minor irrigation schemes in the Krishna basin accounted for 2,20,074, of which borewells held the unique position with 98.68 per cent of the total schemes, followed by tanks (0.99 per cent), barrages/pick-ups (0.18 per cent) and lift irrigation schemes (0.12 per cent). More number of schemes were located in northern Karnataka than in South Karnataka as more number of schemes as about 80 per cent of the basin lies in North Karnataka.

With regard to growth of different minor irrigation schemes in the basin it was found that minor irrigation schemes grew at a rate of 9.10 per cent annually in North Karnataka. Among the different irrigation schemes, higher growth was observed in barrages/pick-ups and other schemes with 40.35 per cent followed by tanks. Negative growth was observed in lift irrigation schemes. Among the districts, positive growth was noticed in all districts in the region. In south, during period-I minor irrigation schemes grew at a rate of 4.17 per cent annually. Highest growth was observed in tanks with 3.72 per cent followed by barrages/pick-ups and lift irrigation schemes. Positive and significant growth was observed in all the districts. During period-II, negative growth was observed with number of minor irrigation schemes at a rate of –0.48 per cent annually. Among different components declining trend was observed in case of tanks and lift irrigation schemes.

With respect to number of borewells, it was found that they grew at a rate of 10.58 per cent annually in Krishna basin as a whole, 11.21 per cent in North and at 9.67 per cent in South Karnataka. Among districts positive and significant growth was observed in all the districts of the basin.

An amount of about Rs. 10,521 lakhs has been invested on minor irrigation development in Krishna basin as a whole in which the share of northern region was higher at about 77 per cent when compared to the southern region with 23 per cent. Growth rates estimated for the investment made on the minor irrigation works in the basin as a whole exhibited a significant growth, while North Karnataka registered higher growth.

With regard to potential created and utilization in North Karnataka, positive growth rates were observed. Among different minor irrigation components, high growth rates were found in the case of barrages/pick-ups. With respect to tanks and lift irrigation schemes, growth rates for the potential created were positive and significant but it was negative with respect to utilization, thereby indicating gaps in potential and utilisation. Among the districts positive growth rates were found in all seven districts with respect to potential and negative growth was observed in case of utilisation in three districts. The growth rates estimated for the potential created were found to be increasing where as utilization in both net and gross irrigated areas registered negative growth in Northern Karnataka. Growth rate with respect to potential created was highest in barrages/pick-ups and it was found to be significant.

A gap of 42.73 per cent was observed in the utlisation of potential created for the Krishna basin as a whole and it was slightly higher in North Karnataka with 45.60 per cent when compared to South Karnataka where the gap was found to be 38 per cent. This is

matter of concern for the policy makers as the systems are beset with certain constraints to make fullest use of potential created. Another important observation in the study is the slow growth of potential and utilisation and also gaps between them in the backward Hyderabad-Karnataka region of the state. This impinges upon regional imbalances in the state economy and hence more focused efforts are required in this direction.

Tanks in the study area were medium to large sized with an average command area of 321.75 ha. It was observed that tanks irrigated only 60 per cent of the total command, as there was a decline in the storage capacity of the tanks due to siltation, encroachment and breakage of irrigation channels. Only 15 per cent of the tanks were completely filled up during last five years and about 35 per cent of the tanks were filled up to only 50 per cent of their total capacity. Under tank irrigation system kharif crops dominated the cropping pattern followed by rabi and summer season crops.

Average investment made for the construction of a lift irrigation scheme was Rs. 174.46 lakhs. Average command area registered under a lift irrigation scheme was found to be 814.89 ha. Out of the total command area only 77.20 per cent of the area had been irrigated by these schemes. It was found that lift irrigation schemes in study area functioned only during kharif season. Maize was the major crop grown under the lift irrigation command followed by paddy. Vegetables too occupied important place under lift irrigation schemes.

Average investment on the construction of barrages/pick-ups was Rs.117.45 lakhs. Average height of the barrages/pick-ups was found to be 3.58 mt and the length of the barrage was 88.53 mt. These schemes were found to irrigate only during rabi season. It was observed that existing utilization of water reduced by 6.93 mcft. Average command per barrage/pick-up was 974.93 ha, of which only 66.28 per cent was irrigated. Sorghum crop dominated the cropping pattern followed by bengal gram and sunflower.

It was observed that the average number of villages covered by tanks were two and about three villages were covered by lift irrigation scheme and barrage/pick-up. Among the farmer beneficiaries, small farmers formed the major beneficiary group under all the three minor irrigation schemes in the study area, which reflected upon social equity dimension of minor irrigation.

In over all situation of cropping intensities, the average cropping intensity was higher under tank irrigation system at 159.14 per cent where as it was 100 per cent under both lift irrigation schemes and barrages/pick-ups.

Average depth of the borewells in the study area was found to be 287.43 ft. Average net irrigated area was 2.36 ha and gross irrigated area per borewell was 5.26 ha. It was observed that out of the total land holding of farmers about 48 per cent was under borewell irrigation. Average yield of the borewell in the study area has declined by 0.62 inches from 2.68 inches when drilled. Kharif crops dominated the cropping pattern followed by summer and rabi. Sugarcane and chilli occupied a large chunk of gross cropped area indicating commercial nature of farming under borewell irrigation. Cropping intensity worked out to be about 223 per cent. Average cost to install a borewell in the study area was about to Rs. 70,628, of which cost of installing was the highest compared to cost of drilling.

POLICY IMLPICATIONS

The findings of this study assume importance in view of the long pending water sharing disputes among various riparian states of south India. In the context of on going debate on irrigation issues especially development and utilisation of minor irrigation, the findings of the study would be quite useful in advancing technical arguments.

Though huge potential has been created through minor irrigation schemes compared to major and medium irrigation sector, a worrisome aspect of this sector is the large gap between the potential and its utilisation. This lag is mainly due to a set of severe constraints that are associated with this sector. These constraints need to be addressed in achieving the targets fixed.

1. In the view of technical advantages and positive social equity dimensions and worldwide growing demand for small and sustainable irrigation works, the State Government should focus its attention more on the development of minor irrigation.

This calls for allocation of larger amounts of money, effective monitoring and supervision of works by strengthening the Minor Irrigation Department.

2. For the purpose of restoring and efficient utilization of the created potential; extension, renovation and modernization of the existing and old minor irrigation schemes need to be taken up and more efficient water management practices through sprinkler, drip etc. should be introduced in the irrigation command areas.
3. Expected water yields are not achieved at the project sites after completion due to the soil conservation measures adopted by individual farmers and by the State. Therefore, for better realization of the investment, the schemes need to be designed with rational consideration of catchments while calculating yield.
4. Investments should be prioritized and resources allocated for the time bound completion of ongoing projects, instead of spreading the limited resources thinly on new schemes.
5. For the equitable distribution and efficient utilization of water, farmers' participatory irrigation needs to be encouraged by promoting Water User's Associations (WUA's). Involvement and participation of farmer beneficiaries and other stake holders should be encouraged right from the project planning itself to avoid some of the difficulties encountered at present.
6. Since the available water in the tanks was not adequate to irrigate the stipulated command area due to the poor management, the Government should intervene to check unauthorized encroachment by the private individuals and ensure regular maintenance.
7. Exploitation of ground water resources should be regulated as not to exceed the recharging possibilities, as also to ensure social equity. Further to avoid the detrimental environmental consequences of over exploitation of ground water, ground water recharge projects should be developed and implemented for improving both the quality and availability of ground water resource.
8. Shortage of water in the river course is a severe limiting factor. Government should construct small scale, farmer managed barrages with participation of beneficiaries for storing water in reservoirs.
9. There is need to enhance funds for flood control works in the North Karnataka region as this region is severely affected by floods every year in recent years.
10. Violation of cropping system in the commands of minor irrigation schemes (tanks, lift irrigation schemes and barrages/pick-ups) need to be stopped and only semi dry crops should be encouraged to avoid high water intensive crops. This can be achieved through effective demonstrations by the CADA or Agricultural Universities and also by providing suitable incentives.
11. Inadequate supply of electricity is one of important limiting factor for the efficient functioning of lift irrigation schemes. Therefore, government should arrange to provide uninterrupted electricity to these schemes.
12. Afforestation in the catchment area and promoting scientific water management practices in command areas, through a centrally sponsored scheme in collaboration with ICAR, State Agricultural Universities and State Government need to taken up on priority.

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APPENDIX

Appendix 1: Minor irrigation schemes selected for performance evaluation

Sl No	Taluk	Tanks	Lift irrigation schemes	Barrages/ pick-ups
1	Haveri	Heggeri tank (s.n 119 and 56)	Havanur LIS	Karjagi barrage
		Hommaradi tank (S No. 202)	Meundi LIS	Hosaritti barrage
		Guttal tank (S No. 378)	Agasanamatti LIS	Maradur barrage
2	Ranibennur	Asundinala tank	Airani LIS	Lingadahalli barrage
		Kudrihala tank	Medleri LIS	Hiremaganur barrage
		Medleri tank	Eklaspur LIS	Nittur barrage
3	Bailahongala	Siddasamudra tank	M.K.Hubli LIS	M.K.Hubli bandhara
		Bailur tank Sy No. 68	Kyarkoppa LIS	Nesragi bandhara

Appendix 2: Cost and return structure of different crops grown under borewell irrigation

Sl. No	Particulars	Crops					
		Sugar cane	Chilly	Cotton	Maize	Wheat	Tomato
1	Total variable cost	39910.62 (94.48)	56925.75 (95.74)	30290.77 (92.74)	18266.26 (91.16)	16978.13 (87.75)	37122.20 (93.71)
2	Total fixed cost	2109.33 (5.10)	2527.25 (4.25)	2352.41 (7.28)	1771.25 (8.83)	2368.50 (12.24)	2491.45 (6.28)
3	Total cost	42019.95	59453.00	32643.18	20037.51	19346.66	39613.65
4	Gross returns	113891.02	198496.20	60070.00	35785.00	31510.58	59796.88
5	Net returns	71871.07	139043.32	27426.82	14753.25	12163.95	20183.23
6	B:C ratio	2.71	3.33	1.84	1.78	1.62	1.50

Appendix 3: Talukwise area under Krishna basin

Sl. No	Taluk	% in Krishna basin
	1. Bagalkot	
1	Bagalkot	100
2	Badami	100
3	Bilgi	100
4	Hungund	100
5	Jamkhandi	100
6	Mudhol	100
	2. Belgaum	
7	Belgaum	100
8	Athani	100
9	Bailahongal	68.54
10	Chikodi	100
11	Gokak	100
12	Hukkeri	100
13	Khanapur	35.38
14	Raibag	100
15	Ramdurg	100
16	Saundatti	100
	3. Bellary	
17	Bellary	100
18	Hadagali	100
19	H.B Halli	100
20	Hospet	100
21	Kudligi	100
22	Sandur	100
23	Siraguppa	100
	4. Bidar	
24	Basavakalyan	65.68
25	Humnabad	17.94
	5. Bijapur Dist	
26	Bijapur	100
27	Bagewadi	100
28	Indi	100
29	Muddebihal	100
30	Sindgi	100
	6. Chikmagalur	
31	Chikmagalur	77.19
32	Kadur	100
33	Koppa	100
34	Mudigere	44.5
35	N.R Pura	100
36	Sringeri	100
37	Tarikere	100

Sl. No	Taluk	% in Krishna basin
	7. Chitradurga	
38	Chitradurga	100
39	Challakere	100
40	Hiriyur	100
41	holalkere	100
42	Hosadurga	100
43	Molakalmur	100
	8. Davanagere	
44	Davanagere	100
45	Channagiri	100
46	Harapanahalli	100
47	Harihara	100
48	Honnali	100
49	Jagalur	100
	9. Dharwad	
50	Dharwad	46.06
51	Hubli	43.42
52	Navalgund	100
53	Kundgol	100
	10. Gadag	
54	Gadag	100
55	Mundargi	100
56	Naragund	100
57	Rona	100
58	Shirahatti	100
	11. Gulbarga	
59	Gulbarga	100
60	Afzalpur	100
61	Aland	100
62	Chincholi	100
63	Chithapur	100
64	Jewargi	100
65	Sedam	100
66	Shahpur	100
67	Shorapur	100
68	Yadgiri	100
	12. Hassan	
69	Hassan	6.64
70	Arasikere	79.43
71	Belur	35.98
	14. Koppal	
72	Koppal	100
73	Gangavathy	100
74	Kushtagi	100
75	Yelbarga	100

Sl. No	Taluk	% in Krishna basin
	15. Raichur	
76	Raichur	100
77	Devadurga	100
78	Lingasagur	100
79	Manvi	100
80	Sindhanur	100
	16. Shimoga	
81	Shimoga	100
82	Bhadravathy	100
83	Hosanagara	23.28
84	Sagara	30.72
85	Shikaripura	100
86	Soraba	91.11
87	Thirthahalli	83.81
	17. Tumkur	
88	Tumkur	5
89	C. N Halli	95.75
90	Gubbi	33.5
91	Koratagere	5.92
92	Madhugiri	20.7
93	Pavagada	19.73
94	Sira	100
95	Tiptur	38.95
	13. Haveri	
96	Haveri	100
97	Byadagi	100
98	Hangal	100
99	Hirekerur	100
100	Ranebennur	100
101	Savanur	100
102	Shiggaon	66.89
	18. Uttara Kannada	
103	Mundgod	11.98
104	Siddapur	22.58
105	Sirsi	27.46

PERFORMANCE OF MINOR IRRIGATION IN KRISHNA BASIN OF KARNATAKA- AN ECONOMIC PERSPECTIVE

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ABSTRACT

Minor irrigation is gradually becoming more important because of several advantages like small investment, simple components, quicker rewards and easier management. Present study was conducted with the objective of documenting the temporal growth in irrigated area investment, potential created, utilisation identifying the constraints and evaluating the performance of minor irrigation schemes in Krishna basin of Karnataka.

Total number of schemes in the basin accounted for 2, 20,074 of which 2, 17,190 were borewells followed by tanks (2195), barrages/pick-ups (404) and LIS (285). Minor irrigation schemes grew at a rate of 9.10 per cent in north Karnataka and at a rate of 4.17 per cent during period-I and -0.48 per cent during period-II in south Karnataka. Total investment on minor irrigation grew at a rate of 10.14 per cent. It was 10.27 per cent in north Karnataka and 9.76 per cent in south. Total potential created by minor irrigation schemes in the basin accounted for 9, 69,334 ha of which only 5, 55,077 ha was utilised leading to a gap of 42.73 per cent. Large gap was observed in north Karnataka (45.60%) compared to south (38%). Modal depth of the tanks was 24.97 ft and siltation was 30.35 per cent of total depth. Encroachment of the tank bed was to the extent of 14.20 per cent. While average investment for construction of a LIS was Rs. 174.26 lakhs it was Rs. 117.45 lakhs for barrage/pick-up. Small farmers formed a majority of beneficiaries reflecting upon social equity dimension. Encroachment and siltation of tank bed, poor maintenance, inadequate power supply, declining rainfall, inadequate funds and lack of institutional support were identified as major constraints for minor irrigation development in basin. Construction of farmer managed minor irrigation schemes with participatory approach is suggested.