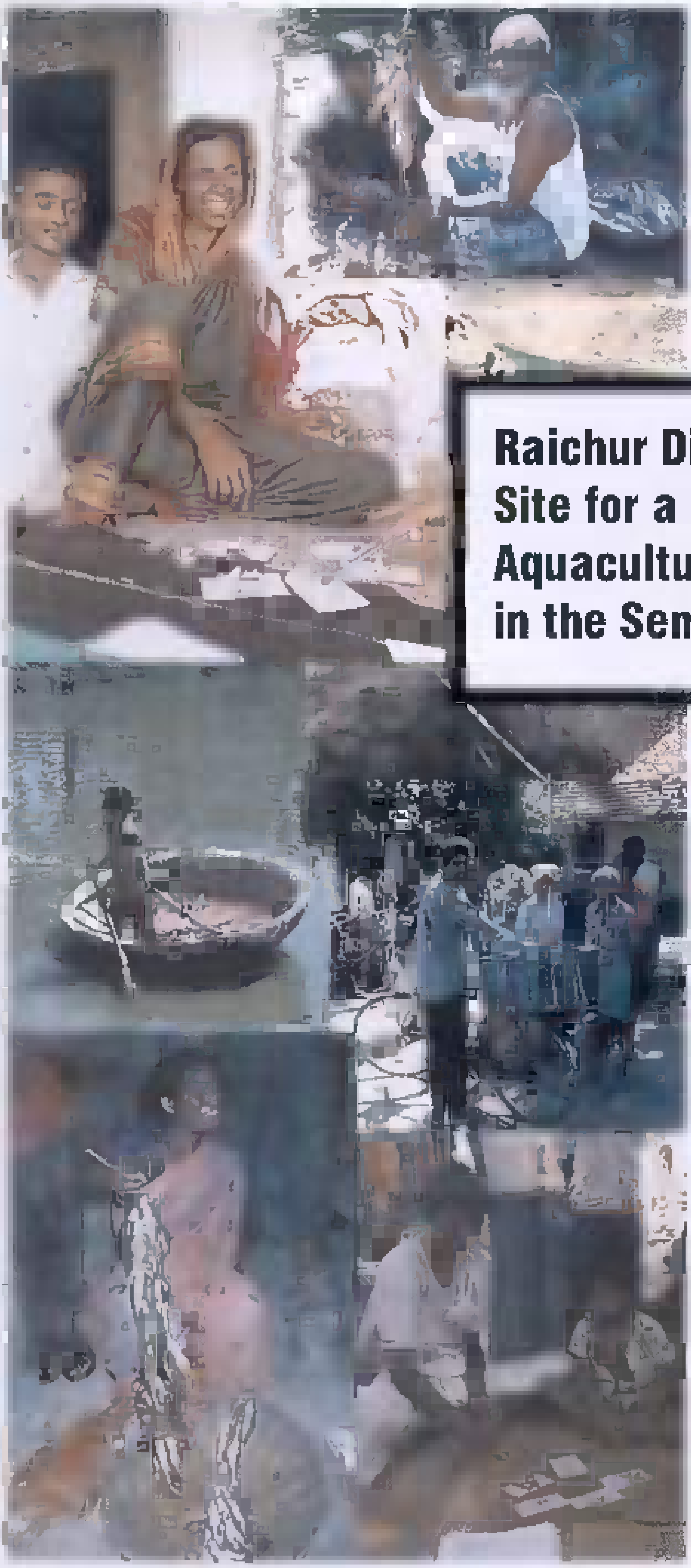


Working Paper No. 1
(July 1998)

Raichur District: Site for a Study of Aquaculture Development in the Semi-arid Tropics

Aquaculture in Small-scale Farmer-managed Irrigation Systems Funded by DFID Aquaculture Research Programme

Institute of Aquaculture
University of Stirling
Scotland, UK

Working Paper No. 1
(July 1998)

Raichur District: Site for a Study of Aquaculture Development in the Semi-Arid Tropics

Aquaculture in Small-Scale Farmer-Managed Irrigation Systems
Funded by DFID Aquaculture Research Programme

Institute of Aquaculture, University of Stirling, Scotland, UK.

Glossary

ARP	Aquaculture Research Programme
CDR	Complex Diverse Risk Prone
CIFA	Central Institute for Freshwater Aquaculture
DANIDA	Danish International Development Agency
DFID	Department for International Development (formerly ODA).
DPU	Drought Prone Upland
GoI	Government of India
GoK	Government of Karnataka
IM	Moisture Index. Balance between moisture availability and extent of dryness and thermal efficiency (PET) indicative of radiation energy received and summer concentration (SC*)
Kharif	The first growing season (June-October)
LGP	Length of Growing Period
Myrada	Mysore Rural Agricultural Development Agency
PAD	Peninsular Aquaculture division, branch of CIFA
PET	Potential evapo-transpiration in one year
PIA	Project Implementing Agency.
PRA	Participatory Rural Appraisal
Rabi	The second growing season (November-March)
RNR	Renewable Natural Resources
RRA	Rapid Rural Appraisal
Rs	Indian unit of currency.
SAT	Semi-Arid Tropics
SC*	Summer Concentration
SC	Scheduled Caste. Lower castes identified by the Indian government as a means of classifying castes for the allocation of benefits
ST	Scheduled Tribe. All tribals. SCs and STs together constitute the 'socially and educationally backward classes of citizens'. The terms form the basis for policies of protection and positive discrimination
Taluk	Sub-administrative region
TB	Tungabhadra
UKP	Upper Krishna Project
UNICEF	United Nations Children's Fund
WD	Water Deficit
WS	Water surplus
WWF	World Wide Fund for Nature
1 ha =	2.4 acres

List of Working Papers

Project Summary Report
1. Raichur District: Site for a Study of Aquaculture Development in the Semi-arid Tropics
2. Methods for Participatory Information Gathering and Analysis
3. Socio-economic Analysis of Villages in Relation to Aquaculture Potential in Raichur District, Karnataka, India
4. Investigation of Gender Issues in Relation to Aquaculture Potential in Raichur District, Karnataka, India
5. On-farm Resources for Small-scale Farmer-managed Aquaculture in Raichur District, Karnataka, India
6. Inland Fisheries Resources and the Current Status of Aquaculture in Raichur District and Karnataka State, India
7. An Investigation of Aquaculture Potential in Small-scale Farmer-managed Irrigation Systems of Raichur District, Karnataka, India
8. Indigenous Freshwater Fish Resources of Karnataka State and their Potential for Aquaculture
9. Institutional Linkages of Relevance to Small-scale Aquaculture Development in Karnataka State, India
10. Fisheries Marketing, Demand and Credit in Raichur District, Karnataka, India

Project background

The arid and semi-arid tropics are areas in urgent need of development. As a home to a large proportion of the world's poor these regions face a future of scarcity of food and insufficient water for consumption and irrigation of crops. It has been predicted that India and Sri Lanka will face a fresh-water crisis in the near future, and as much water is currently wasted due to inadequate management and conservation practices there is a need for more integrated approaches to water management. The majority of India's surface water bodies are used primarily for irrigation. Although large-scale irrigation systems cover more surface area and supply a greater area of farmland, more farmers are dependent on small-scale systems for their daily livelihood. Irrigation systems are often very inefficient water distribution systems, and studies suggest that the efficiency of water use could be improved. The integration of aquaculture (which can be non-consumptive in terms of water use) has the potential to increase food production and improve the efficiency of the use of small-scale irrigation water resource.

These Working Papers are the first stage of the research project 'Small-scale farmer-managed aquaculture in engineered water systems' (DFID project R7064). The project aims to investigate the potential for integration of aquaculture into small-scale farmer-managed irrigation systems in arid and semi-arid regions of India and Sri Lanka. Intended beneficiaries include the rural poor, which in India belong to the Scheduled Castes (SCs)[1] and Scheduled Tribes (STs)[2]. This part of the project focuses on Karnataka State on the south west of the Indian peninsular.

During the research, the economic and technical feasibility and the social acceptability of the production of fish in such systems of arid and semi-arid regions of Karnataka were investigated. Field research took place from 6 April to 21 May 1998 and included a 'Rapid Rural Appraisal' of four villages in Raichur District, Karnataka, and semi-structured interviews with representatives from the Government Department of Fisheries, marketing organisations, academics and other relevant institutional sectors within the state.

All fieldwork was undertaken in collaboration with the NGO Samuha, an organisation undertaking wide-ranging activities in the arid and semi-arid areas of Karnataka State. Samuha has extensive experience within participatory development and its initiatives range across health, disabilities, women's development, HIV/AIDS, education, animal husbandry, drinking water and sanitation, irrigation and watershed development (Pradeep, 1994). The majority of the work of Samuha is carried out in the districts of Koppal and Raichur with a smaller project in Bangalore. The activities of Samuha are supported by a number of bodies: ActionAid; OXFAM; the Swiss Development Cooperation; the Government of Karnataka and the Government of India as well as individual donors.

The results and analysis are presented in the ten Working Papers listed above. For an overview of the content of each of the Working Papers, see the Summary Report. This series of working papers have been produced principally as a resource for a stakeholder workshop to be held in Coimbatore, 19th - 20th November 1998. Conclusions and the research agenda are therefore preliminary.

[1] SCs: lower castes identified by the Indian government as a means of classifying castes for the allocation of benefits.
[2] STs: all tribals. SCs and STs together constitute the 'socially and educationally backward classes of citizens'. The terms form the basis for policies of protection and positive discrimination.

Summary

1. A common method for increasing the cropping potential for land in the arid and semi-arid tropics is irrigation. Whilst large-scale, state managed operations supply the larger area of irrigated land, the majority of farmers are dependent on small-scale irrigation systems where water is stored on individual farms. These small-scale systems are the focus of the current project.

2. The focus of improved rainfed water management is increasingly at the catchment level. The Indian government currently spends some US$300 million on a variety of watershed development programmes in semi-arid areas. Integrated approaches to watershed development include soil and water conservation measures, integrated production systems, implementation of sound crop production systems and attempts to build infrastructural sustainability (principally through the establishment of community institutions). This is an attempt to reduce disparities between irrigated and rainfed areas. Such programmes are becoming increasingly integrated and participatory in outlook, moving away from a traditionally more sectoral approach, and Non Governmental Organisations (NGOs) are becoming more involved in their implementation.

3. Raichur District, located in northern Karnataka State, was selected as a suitable research location for investigation of poverty focused aquaculture potential in small-scale irrigation systems because of the large number of such systems, its arid to semi-arid climate, and the large number of resource poor farmers. In addition, non-vegetarian fish-eating rural poor from lower castes make up a high proportion of the population. Links with Samuha provides a potential to work with a well-established NGO that manages an extensive watershed development programme within the district.

4. Raichur is a drought prone upland district. Rainfall is markedly seasonal (with prolonged dry spells) and highly erratic (typically less than 650mm per year). The district has experienced drought on average once every three years over the last 50 years. Increasing variability in rainfall patterns has been mirrored by an increase in the severity of drought. Last years drought caused considerable hardship and a recent spate of suicides within the region.

5. Red and black soils (alfisols and vertisols) predominate. Black soils exhibit a very narrow range of workable moisture and typically produce only one crop per year under rainfed conditions. Red soils characteristic of upland areas are prone to crusting, causing high runoff and soil erosion (and nutrient deficiency) in heavy rains. The principal dry land crops grown are sorghum, millet, maize, wheat and pulses.

Raichur District: Site for a Study of Aquaculture Development in the Semi-arid Tropics

Table of Contents:

List of Tables:

List of Figures

1 Introduction

This paper provides the contextual background to an analysis of the social, economic and technical feasibility of aquaculture options integrated within small-scale farmer managed irrigation systems in northern Karnataka.

1.1 Arid and semi-arid regions

This project aims to investigate the potential for aquaculture in the arid and semi-arid areas of India. Figure 1 is a map of semi-arid regions and associated nutritional data around the world. From this it is clear that the majority of the Indian landmass belongs to the semi-arid tropics (SAT).

In addition it is evident that poverty and hunger is a common feature of the semi-arid tropics (SAT). This is in part due to the low productivity of the soils dominating SAT areas (von Oppen & Subba Rao, 1987) but also important is the very short duration of the wetter seasons, where rainfall is adequate to support dryland agriculture. Details about the Length of Growing Period (LPG) are given in Box 1.

Box 1: Length of Growing Period (LGP).

Length of Growing Period (LGP): The period when soil moisture is adequate to support plant growth. According to an FAO model (Higgins and Kassam, 1981), the growing period starts when precipitation (P) exceeds 50% of the PET[3]. and ends with the utilisation of an assumed 100mm of soil moisture after P falls below PET Overlaying LGP zones and bio-climatic zones produced the LPG predictions shown in Table 1.

Arid and semi-arid refer to bio-climatic zones, of which nine types have been identified throughout the world (listed in Table 1). Their definition relates to information about the monthly and annual water surplus (WS)[4] and water deficit (WD)[5] determining the moisture index (IM)[6] in an area of a specific rainfall and potential evapo-transpiration (PET) (NBSS, 1992).
The bio-climatic classification can be seen in Table 1.

Table 1: The moisture index of various bio-climatic types. LPG: see Box 1.

Symbol & climate type	Moisture Index	Classification	Corresponding LPG for India (days)
E Arid	-66.7 to –100	DRY	< 90
D Semi-arid	-33.3 to –66.7	DRY	90 - 150
C1 Dry sub-humid	0 to –33.3	DRY	150 - 210
C2 Moist sub-humid	0 to 20	MOIST	150 - 210
B1 Humid	20 to 40	MOIST	> 210
B2 Humid	40 to 60	MOIST	> 210
B3 Humid	60 to 80	MOIST	> 210
B4 Humid	80 to 100	MOIST	> 210
A Perhumid	> 100	WET	> 210

Source: NBSS (1992).

The moisture index indicates the relative dryness of an ecosystem and thus contains vital information regarding the crops that can be grown in the area as well as the agricultural techniques that can be used. As can be seen from Table 1, semi-arid and arid regions constitute the driest areas of the world. The short growing period in arid and semi-arid regions severely restrict the production potential of food crops and food shortages are common (Figure 1). Conventional dryland cultivation is normally characterised by extremely low productivity but despite this the rain-fed drylands (receiving less than 800mm rainfall per annum (Myrada & IIRR, 1997), provide almost 44% of India's food supply and support 40% of the population, and as such is an area of great importance. One very effective means of increasing the productivity of SAT areas is by irrigating the dryland (El-Swaify *et al.*, 1984), and it is in association with small-scale irrigation systems that aquaculture may have a role to play.

[3] PET: Potential evapo-transpiration in one year.
[4] WS: water surplus (Bhattacharjee *et al.*, 1982).
[5] WD: water deficit(Bhattacharjee *et al.*, 1982).
[6] IM: Moisture index: balance between moisture availability and extent of dryness and thermal efficiency (PET) indicative of radiation energy received and summer concentration (SC) (Bhattacharjee *et al.*, 1982).

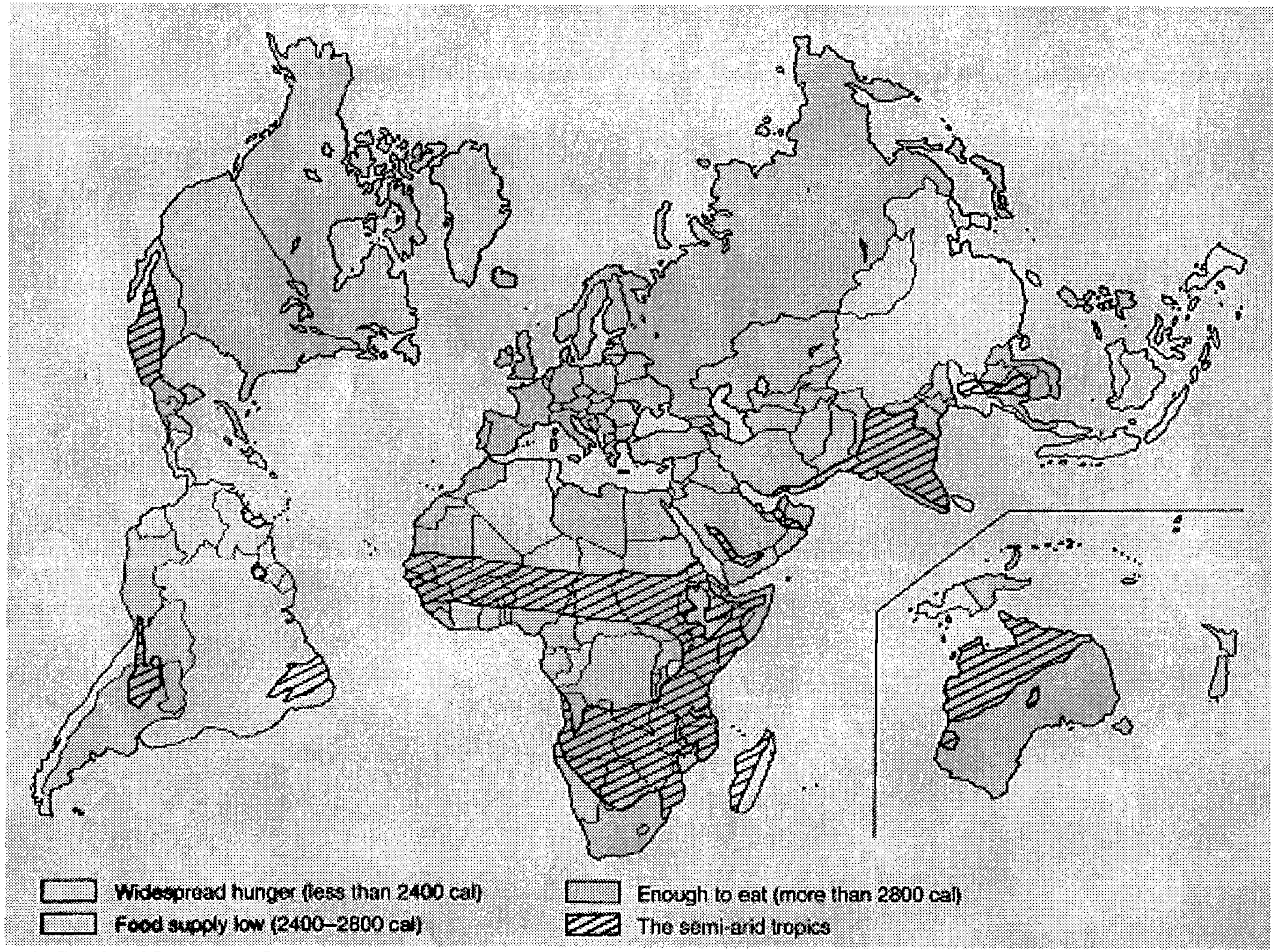


Figure 1: Semi-arid areas and average daily calorie supply per person throughout the world. Source: ICRISAT (1997).

Further details of the climate characteristics of the project area are given in section 4.2.

1.2 Small-scale farmer managed irrigation systems

Irrigation is defined as any process, other than natural precipitation, which supplies water to crops or any other cultivated plants (Stern, 1979). In India irrigation systems are categorised for administrative purposes irrigation systems into major, medium and minor systems (von Oppen & Subba Rao, 1987), as detailed in Box 3. This project is concerned with the opportunities for aquaculture in small-scale farmer managed irrigation systems.

Box 3: Classification of irrigation systems in India. Source: von Oppen & Subba Rao (1987).

Major: Large dams and canals constructed on perennial rivers, irrigating thousands of hectares.
Medium: Reservoirs of run-off water.
Minor: All surface and ground water sources, which cost < Rs 2.5 million per project.

Small-scale irrigation systems belong to the minor and medium categories and where large systems are usually supplied with water from large rivers, small-scale systems are commonly fed by rain water, flood water or ground water. These are systems that are planned, organised and managed at the individual or small community level and constructed with locally available materials and technology. In contrast large scale irrigation systems are planned and managed on the national or state level, often involve major infrastructural works and use outside contractors for construction (Haylor, 1994).

Many nations will be approaching their maximum exploitable water supply by the year 2000 (Council on Environmental Quality and Department of State, 1982), and with this increasing pressure on world water resources, especially in arid and semi-arid areas, there is a movement towards integration of water uses (Redding & Midlen, 1990). The majority of farmers in the world, including the poorest and those in the most marginal areas, rely on small-scale irrigation to increase the outputs of their land (Wolf, 1986), and there is therefore a great need to consider multiple uses of the water stored in such systems. Aquaculture can provide an excellent additional source of cheap and high quality protein in arid and semi-arid regions where the local animal protein supply is often insufficient to meet the FAO/WHO recommended safe standards. Although small-scale storage of water for irrigation has been carried out for thousands of years, attempts to integrate fish production into these water bodies are few, have only been considered relatively recently (Haylor & Stewart, 1998), and are normally based on a conventional fisheries approach. Indeed the integration of fish production into existing agricultural systems is encouraged as one of the means of optimising the efficiency of water use and enhancing food security, and is recommended as a course of action for aquaculture development by the FAO (Harrison, 1996; Pretto, 1996).

Two closely related DFID projects are looking at aquaculture in irrigation systems. The focus of this DFID ARP[7] project is small-scale irrigation systems managed by individual farmers or groups of farmers in the State of Karnataka, India and in Sri Lanka. A linked DFID Engineering Programme project is investigating the potential for integrating aquaculture into medium and major irrigation systems of semi-arid areas.

1.3 The need for effective water management in India

India is currently self sufficient in grain (Government of India, 1998), but production must be continually increased to keep pace with the needs of an ever-expanding population (at present nearly one billion and growing at 2% p.a.). A recent UNICEF (United Nations Children's Fund) and WWF (World Wide Fund for Nature) report (Nigam *et al.*, 1998), presented studies on five ecological zones in India (located within the states Andhra Pradesh, Maharashtra and Tamil Nadu), and assessed the impact that a freshwater crisis would have on future generations. Apart from large areas of India being historically water-short, it suggests that India as a whole will be a 'water-stressed' nation by the year 2017, facing prolonged periods of acute water shortage. Furthermore, the demand for

[7] ARP: Aquaculture Research Programme

freshwater by agriculture, industry and cities is expected to double by the year 2025. Currently nearly 95% of the demand for water in India is for agriculture. This means that there is an immediate requirement for more efficient use of both land and water resources. Aquaculture techniques relevant to water-stressed environments are therefore an important component if fish production is to be supported.

Of course, as UNICEF and WWF suggest that the impending crisis will not only be the result of natural factors such as drought, but largely a result of poor water management, increased pollution of surface water, and the shortcomings of legislation designed to address these problems. The report is critical of the failure of successive governments to implement the existing national water policy, which prioritizes the water needs of humans and animals. Instead, water is used as a political tool, with water poverty compounding the existing poverty of underprivileged groups (Nigam *et al.*, 1998).

Major causes of the problems associated with water shortages in India can be seen in Box 2.

Box 2: Major causes of problems associated with water shortages in India. Source: Nigam *et al.* (1998).

- The system of water rights under common law in India. This sees ground water as a resource belonging to the individual landholder and not a common resource from a common pool
- Denial of control of water to local people
- Uncontrolled use of bore well technology, which has allowed water to be extracted at a rate exceeding water recharge (50% of irrigation and 80% of domestic water supply is from this source)
- Pollution of fresh water resources
- Inadequate efforts made towards water conservation, efficiency in use, groundwater recharge and ecosystem sustainability

Clearly, the problem needs to be tackled in a number of ways at different levels. The integration of multiple production activities into irrigation systems (and in particular uses with low water consumption requirements such as some forms of aquaculture) may be one method of improving the productive value of this scarce resource. Many farmers and communities in rain fed areas use small irrigation systems, incorporating small-scale seasonal water storage structures to manage watersheds in these arid and semi-arid areas. The integration of aquaculture into water harvesting systems is consistent with current Renewable Natural Resource (RNR) objectives of Government and International Development policy in India (CIFA, 1996).

2 A situation analysis

The purpose of this project is to identify the social and bio-economic constraints to the introduction of aqualculture into farmer-managed irrigation systems. The method employed is sometimes referred to as a situation analysis. A participatory situation analysis can be described as the process of supporting local participants to study and reflect on their local situation in order to identify constraints to sustainable development and opportunities to overcome these constraints. A situation analysis helps outsiders and villagers better understand the local situation and generate ideas for further activities. Furthermore a participatory situation analysis aims to strengthen the capacity of the village for critical reflection and analysis in development and to lay the foundation for subsequent farmers' control of and participation in future activities (van Veldhuizen *et al.*, 1997).

Some of the major socio-economic and technical components for aquaculture situation analyses are shown in Box 4.

3 Introduction to research area

This project aims to investigate the potential for integration of aquaculture into small-scale farmer-managed irrigation systems in arid and semi-arid regions of India and Sri Lanka. Intended beneficiaries include the rural poor, which in India belong to the Scheduled Castes (SCs) and Scheduled Tribes (STs). This part of the project focuses on Karnataka State on the south west of the Indian peninsular.

Box 4: Major components of a situation analysis for aquaculture related development. Adapted from Haylor, Lawrence and Meusch (1997).

Aquaculture situation analysis

Includes information about:

a) Social structure of local community (castes, wealth categories) and main priorities of these.
b) Patterns of land holdings of local community.
c) Local economy (labour, sources of income, credit, cash flow).
d) Farming systems (main crops, livestock, seasonality, pattern of workloads).
e) Role of women in farming systems (resource access and ownership and decision making powers).
f) Physical nature of area (temperature range, rainfall data, soil types, water bodies).
g) Existing indigenous knowledge relevant to research.
h) Local perceptions and demand for fish and fish farming.
i) Institutional support:
    - Process orientated: Aquacultural and agricultural information systems, research bodies and support schemes. Policymaking bodies.
    - Action orientated: NGO's. International development organisations, fisheries departments, banking and credit.
j) Seed and fisheries production patterns (including history of aquaculture development).
k) Fisheries marketing patterns and infrastructure.

3.1 Karnataka State

Karnataka State lies on the western seaboard of peninsular India, bordered by the other five peninsular states: Goa, Maharashtra, Andhra Pradesh, Kerala, and Tamil Nadu. It is predominantly rural (especially in the north), with agriculture and allied activities employing 65% of the workforce. The state has a total population of 45 million and a cultivable area of 10.3 million ha, of which nearly 80% is rain-fed (Government of India, 1991). Maps of Karnataka and Raichur District are shown in Figure 2.

3.2 Raichur District

Irrigation

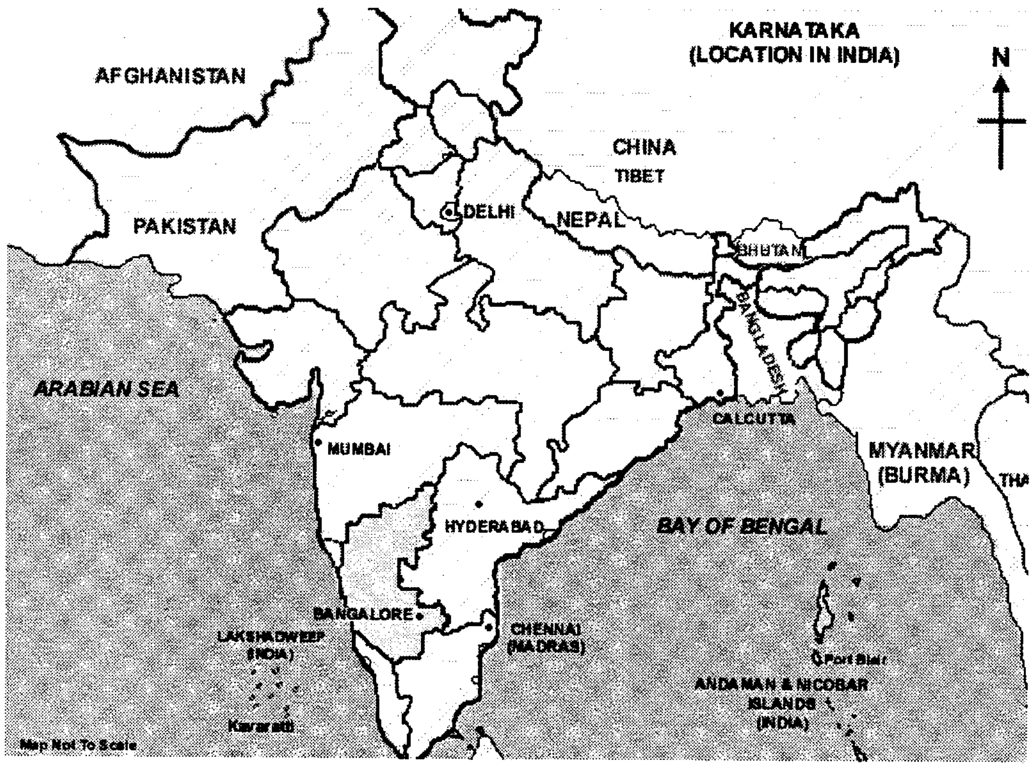
Raichur District is situated in the north eastern part of Karnataka (see Figure 2). Its agro-climate is representative of the arid and semi-arid tropics. In the northern taluks[8] of the district (Koppal, Yelbarga, Lingsugur, Deodurg, and Raichur) small-scale farmer managed irrigation is a common means of improving the productivity of individual plots of land. The southern taluks Manvi, Gangawati, and Sindnur are known as the 'irrigated belt', and here paddy and cotton are common crops grown from larger-scale irrigation systems. Appendix 3 details the major irrigation schemes in the area and their impact on Raichur District.

The extent of irrigation in Raichur is shown in Table 2. The gross irrigated area forms almost 30% of the gross area cropped. Of the irrigated area in Raichur, 44% is canal-fed, 18.6% is from open wells, 16% from bore wells and 10% from tanks (the balance from assorted other sources) (Government of Karnataka, 1996). This indicates that although the majority of farmers are reliant on small-scale irrigation, this only supplies a minor proportion of the total cultivable land according to official figures. Most small-scale farmer-managed irrigation systems are not recorded within this classification by government statistics.

[8] Taluk: administrative sub-region

Figure 2: Location of Karnataka in India and districts of Karnataka. Source: Compare Infobase (1998).

Location of Karnataka State



Districts of Karnataka

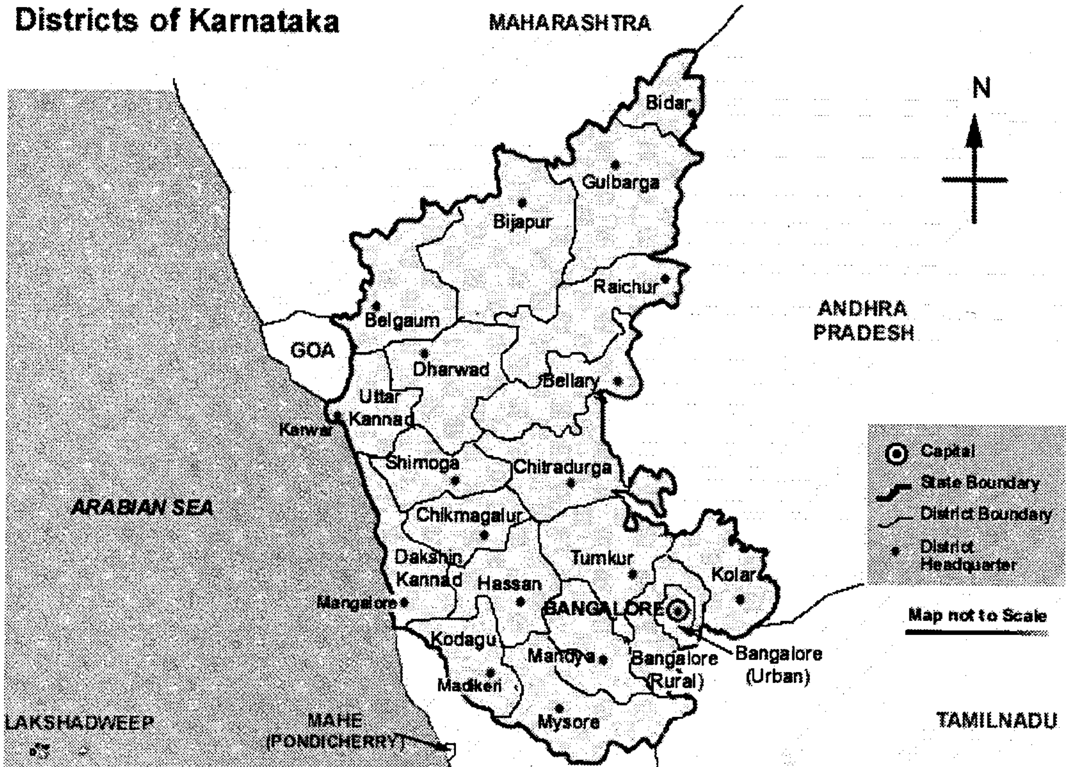


Table 2: Extent of arable land and irrigation in Raichur.

Arable land utilisation	Area (ha)	Irrigation	Area (ha)
Geographical area	1,388,000	Irrigated area	229,000
Total area cropped	925,000	More than one crop	92,000
Area cropped more than once	152,000	Gross irrigated area	321,000
Gross area cropped	1,087,000	Gross irrigated area as % of gross area cropped	29%

Source: Government of Karnataka (1996).

Population and wealth

Table 3 shows that SCs and STs constitute a great proportion of the total population. In addition to being amongst the poorest in the Indian society, lower caste individuals commonly eat fish and meat, in contrast to higher caste Indians who are often vegetarians. Social issues and their impacts on the potential for aquaculture are dealt with in greater detail in Working Paper 3.

Table 3: Population and wealth in Raichur, 1991.

Demography		Wealth		Land holdings	
Land area (ha)	1,388,000	Per capita income (Rs)	5,239	< 1ha (no) (total ha)	73,000 (118,000)
Population (million) (annual growth rate) India Karnataka State Raichur District	 937 (2.00%) 37 (2.11%) 2.3 (2.95%)	Green card holders*	305,643	1-2ha (no) (total ha)	118,000 (176,000)
Population density (people m^{-2})	165	SC population	398,000	2-4ha (no) (total ha)	110,000 (307,000)
Rural population	1,830,000	ST population	180,000	4-10ha (no) (total ha)	69,000 (408,000)
No. of villages inhabited	1,396	1981-1991 growth rate (%)	29	>10ha (no) (total ha)	14,000 (206,000)
Sex ratio (females per 1,000 males)	0.966	Literacy (%): Male Female Total	 49.5 22.2 36	Total holdings (total ha)	384,000 (1,142,000)

*: Indian farmers earning less than Rs 11,400 (approximately $317) (and having less than 5 acres of irrigated land or 20 acres of dry land) per annum are entitled to green ration cards, giving them access to a range of Government subsidies and entitlements.
Source: Government of India (1991), Government of Karnataka (1996) and Kushtagi Panchayat office, pers com.

Table 3 includes a range of poverty indicators. Raichur is one of the poorest districts of Karnataka, with a mean annual per capita income of Rs 5,239 (approximately $146) (only Bidar and Kolar Districts show lower mean incomes). The quality of land is poor and land holdings are small (the majority below 4ha), and fragmentation continues as land is shared between descendants. The population growth rate is high (Table 3), which suggests a strong need for future management of resources. The per capita income and land-holding figures in Table 3 suggest that many more farmers than are indicated should be eligible for ration cards, reducing the value of this measure alone as a poverty indicator.

Soils and crops

Soils have a big impact on cropping pattern and water storage in the semi-arid tropics. The two main soil types of the semi-arid tropics are black and red soils. These are both represented in Raichur with black alluvial soils dominating in the western part of the district and red soils in the eastern part.

Typically only one annual crop is produced limited by the hardness of black soils before the rain and high plasticity and unworkable nature after rains. Sorghum is relatively tolerant of these conditions, and may be grown as rabi (second) crop. In red soil areas of Raichur, erosion and depletion of groundwater is a major problem, and the extent of fallow lands is reportedly increasing each year. Red soils, which become crusted and sealed, show high runoff rates, resulting in a higher water storage capacity requirement for a given catchment size. Fodder is often limited in supply during the kharif (first) growing season, limiting inputs for livestock and potentially aquaculture at this time.

Working Paper 5 assesses the potential availability and suitability of on-farm resources for aquaculture inputs in a number of villages.

Table 4: Dryland and irrigated agricultural production in Raichur 1995-96. Most dryland crops are also grown on irrigated land to a smaller extent. Mt: metric tonnes.

Dryland crops		**Irrigated crops**	
Cereals	***Mt***		***Mt***
Sorghum	308,571	Paddy	145,038
Millet	77,767	High yield variety	329,070
Maize	8,211	Groundnut	111,240
Wheat	17,079	Sugarcane	4,630
Other	16,843	Cotton	94,618
Total	428,471	Total	684,596
Pulses	***Mt***		
Gram	34,961		
Tur	25,705		
Other	25705		
Total	86,300		
Inorganic fertiliser use	***Mt***	***Livestock***	***Number***
N	72,000	Cattle	611,000
P	25,400	Buffalo	211,000
K	13,100	Sheep	364,000
Total	110,500	Goats	267,000
		Total	1,453,000

Source: Government of Karnataka (1996).

Nearly 70% of the total land area in Raichur is under cultivation, the remainder being largely covered by dryland thorn-scrub forest (Government of India, 1991). Table 4 shows that crops produced in the irrigated belt are principally paddy (rice), cotton and sugarcane. The remaining taluks (administrative sub-regions) are rain-fed and are characterised by the production of dryland crops including sorghum, millet, maize, wheat and pulses.

3.3 District and state administration

Karnataka State is organised into four administrative divisions, and Raichur District belongs to Gulbarga division. Until recently, Raichur consisted of nine taluks (administrative sub-regions), which were grouped into three revenue subdivisions: Raichur subdivision encompassed Raichur, Deoodurg and Manvi taluks: Koppal sub-division included Koppal, Gangawati and Yelbarga taluks and Lingsugur the remaining Lingsugur, Kushtagi and Sindhnur taluks.

Box 5: The division of Raichur District in 1997.

Raichur District

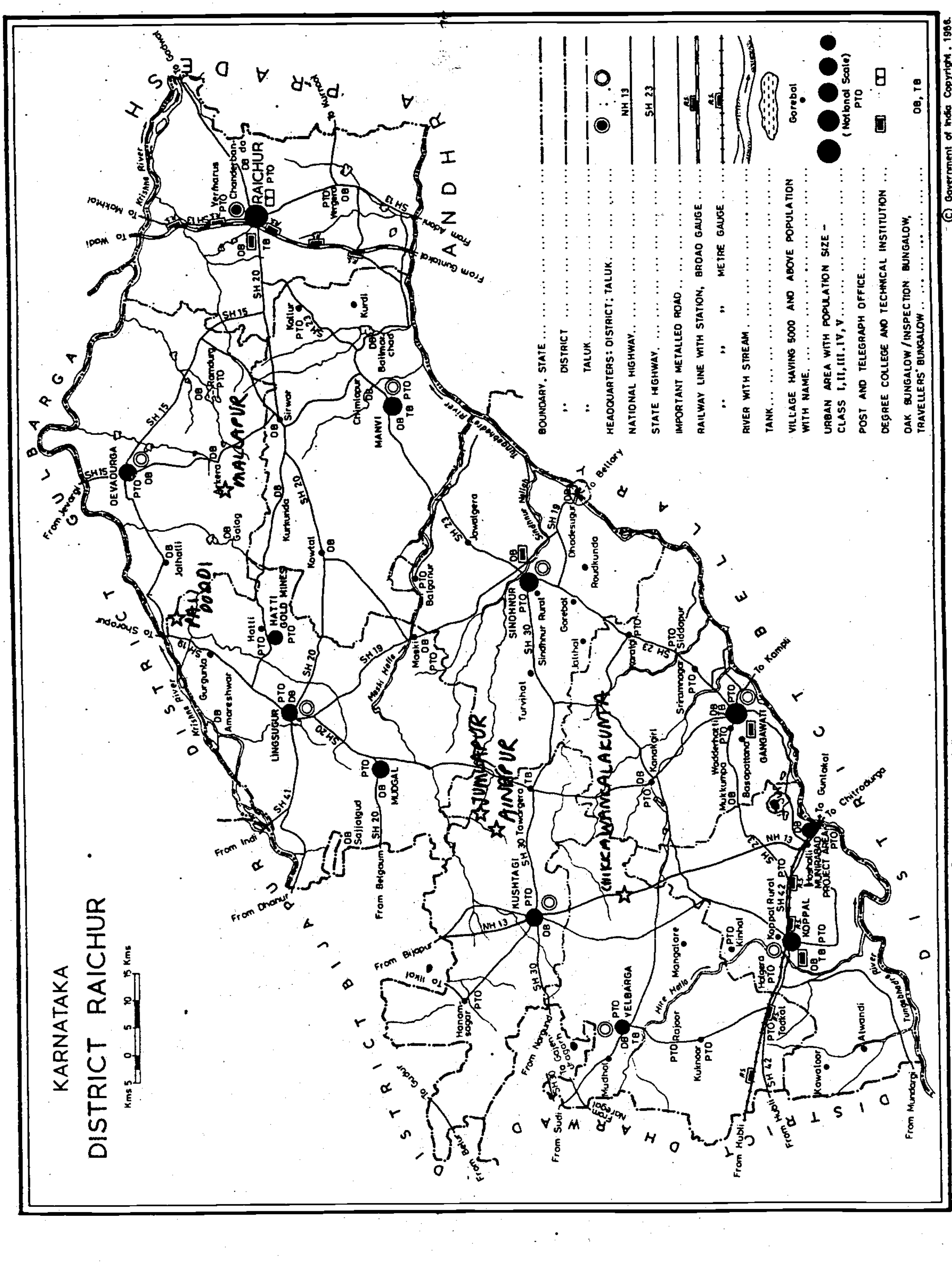
1997 divided into:

	Koppal District	**Raichur District**
Taluks:	Koppal	Raichur
	Kushtagi	Manvi
	Gangawati	Deodurg
	Yelbarga	Lingsugur

Sindnur?

Raichur was formerly the third largest district in Karnataka, with a population of 2.3 million in 1991. In the autumn of 1997, Raichur was divided into two as shown in Box 5. At present there is some dispute over the inclusion of Sindnur taluk. Given that this is a recent administrative division, reference to Raichur in this analysis will include both districts (unless specifically designated taluk, district or city). Figure 2 shows the distribution of districts and taluks within Karnataka State, and Figure 3 a more detailed map of Raichur District.

Figure 3: Map of Raichur District (source: Government of India, 1981)



3.4 Village selection and characteristics

As outlined in the project background all fieldwork was undertaken in collaboration with the local NGO Samuha. In Raichur District, Samuha has village projects in five taluks, namely Koppal, Kushtagi, Yelbarga, Lingsugur, and Deodurg (see Figure 3). After the preliminary study of the Samuha project area and the villages within the project, a few representative villages were chosen for further study as shown in Figure 4. To fulfill the project requirements, these representative villages were situated in dryland areas and contained water bodies suitable for aquaculture as well as having climatic conditions representative of a larger area within Karnataka and India. In addition to having inhabitants who are likely to consider aquaculture (i.e. fish-eaters or people interested in growing fish for selling purposes), the villages should ideally represent a greater area in terms of socio-economical characteristics. Furthermore, because the project is poverty focused, the villages should have high percentages of inhabitants belonging to the 'Backward Communities' as designated by the Indian Government, i.e. SCs or STs.

Since all Samuha project villages in Raichur are situated in rainfed dryland areas, they were all suitable climatically. Small-scale irrigation water resources in the area were examined and classified into six different types: nala bunds, check dams, open wells, farm irrigation ponds, farm ponds, and ravine reclamation structures. Of these nala bunds and ravine reclamation structures were very rare. An inventory of the Samuha project villages and their waterbodies was constructed, outlining the number of waterbodies suitable for aquaculture in each village. Superimposed on this were the caste composition of each village as identified in the secondary data and as described by social maps and Samuha team leaders in the five taluks. This table is shown in Table A1.1, Appendix 1. Summary statistics of each of the Samuha project villages in Raichur are shown in Table A1.2, Appendix 1.

As described in section 3.2 a great proportion of high caste Indians are vegetarians. Thus people of the Lingayat, the Brahmin, the Badigera and the Jangamma (priests of Lingayats) castes normally do not eat meat or fish. However people belonging to the SCs or the STs, as well as Muslims and some general castes, do eat fish. The SCs and STs generally represent the poorest communities, and thus areas containing higher proportions of fish-eaters (SC, ST and Muslims) as well as poorer people (SC and ST) were considered to be most suitable for the development of aquaculture. The parameters used for selection of the villages, the villages visited and those chosen for the situation analysis are shown in Figure 4. As can be seen the villages in Koppal taluk were slightly atypical in that they had almost no water bodies suitable for aquaculture as well as a fairly low number of ST and SC, and the taluk was thus not considered further.

4 Physical and climatic characteristics of study area

4.1 Agro-climatic and agro-ecological zones in Karnataka

As outlined in section 1.2 Bhattacharjee *et al.*, (1982) produced a bio-climatic map of India using a water balance approach. By combining this classification with additional factors, including land use, Length of Growing Period (LGP), (see Box 1), soils and physiography, a division of India into six broad ecosystem types with twenty agro-ecological sub-divisions was achieved (Figure 5). The dry northern parts of Karnataka State (Inland of the Western Ghats) are included in the Arid and Semi-Arid ecosystem types. Detailed descriptions of these two agro-ecological types are given below.

Hot arid eco-region with red and black soils (arid ecosystem)

Climate: This is one of three arid ecosystem types within the country. It comprises a 4.9m ha area of the Deccan plateau, including the districts of Bellary, S.W. Bijapur and Raichur within Karnataka, and Anantapur in Andhra Pradesh (1.5% of the total area of India). The climate is characterised by hot, dry summers and mild winters. Rainfall is erratic, ranging from 400-500mm p.a. (about 20-25% of the annual PET demand). The region experiences severe drought conditions almost year-round with a gross annual water deficit of 1500-1600mm.

The natural vegetation of the area comprises tropical thorn forest. The traditional practice is rain-fed farming, which includes fallowing the land in the rainy season, and growing crops post-rains on stored residual soil moisture. Gently sloping shallow and medium red soils and medium red loamy

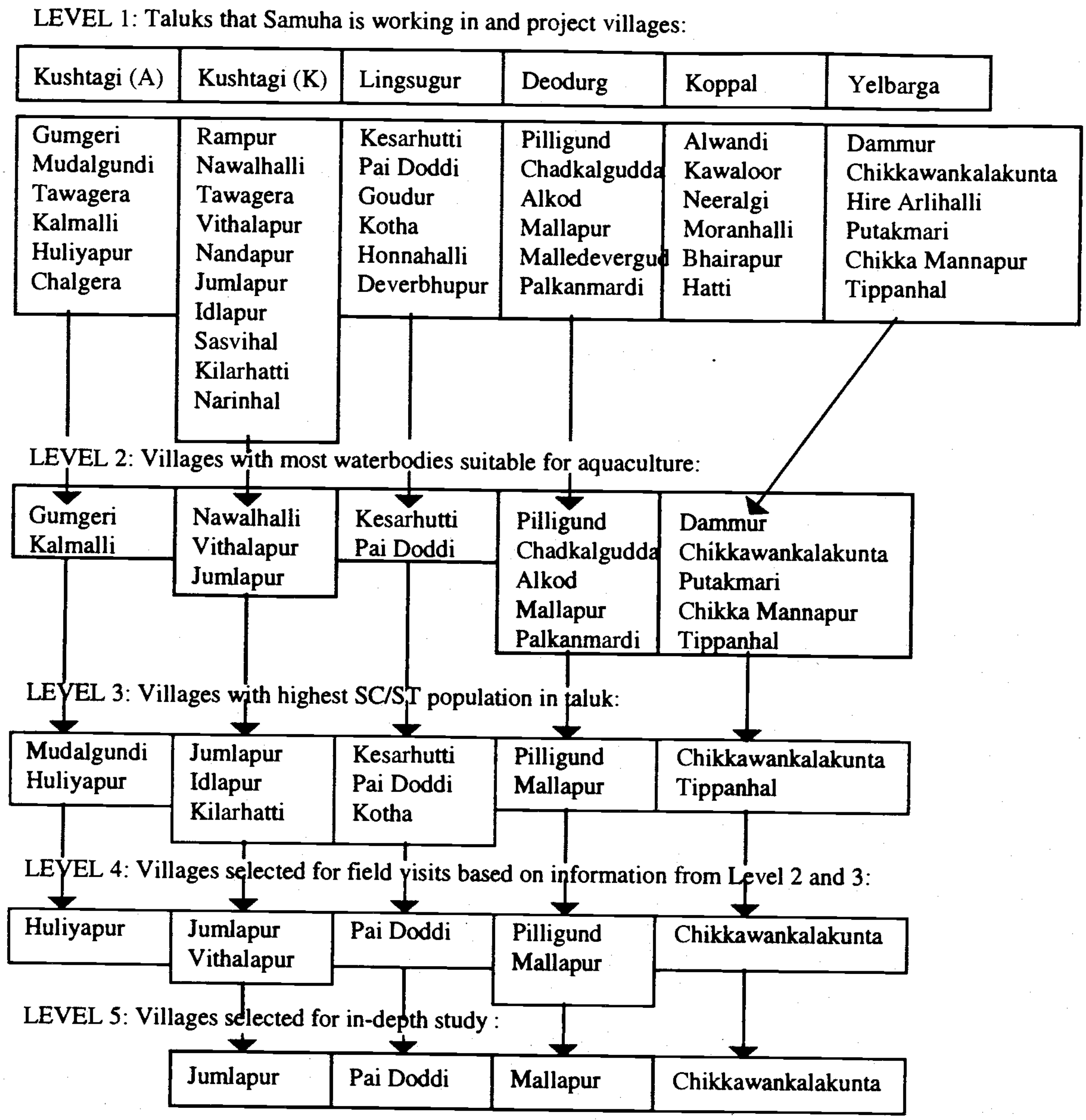
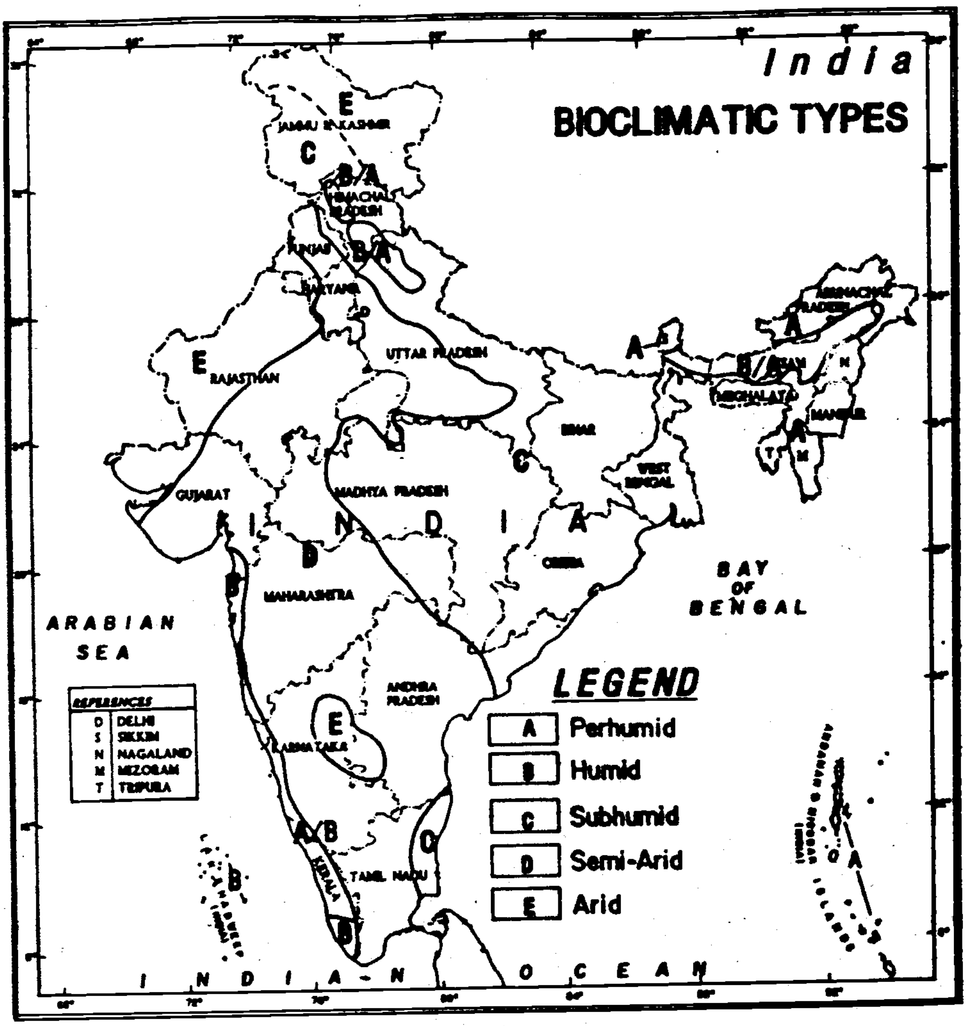


Figure 4: Flow chart showing selection of villages for study. At level 4Huliyapur and Vithalapur were included on the advice of Samuha (mainly ease of access) and because they contained water bodies which needed investigation for classification purposes. Furthermore after Pai Doddi and Chikkawankalakunta were found to be suitable for research, visits to Kesarhutti and Tippanhal were not made because of time constraints. At level 5 time constraints meant that only four villages could be chosen. Huliyapur was excluded because of lack of water bodies suitable for aquaculture, and Vithalapur was excluded because the proportion of the population belonging to SC or ST was low. Mallapur was included rather than Pilligund because it was more remote and therefore less developed.

Figure 5: Map of India showing bioclimatic types. Source: NBSS (1992).



soils dominate. These are slightly acidic. Level to very gently undulating, deep black soils are slightly alkaline and calcareous in nature.

Hot semi-arid agro-eco-region with shallow and medium (dominant) black soils

This region covers the Deccan plateau, comprising most of the Central and Western parts of Maharashtra, Northern parts of Karnataka, and Western parts of Andhra Pradesh. Spread over 31m ha it covers 9.5% of the country. Within Karnataka it includes the northern districts of Belgaum, Bidar, Dharwad, Gulbarga, and parts of Raichur and Bijapur.

The region experiences hot and humid summers and mild dry winters. Mean annual precipitation is between 600-1000mm, covering approx. 40% of the PET demand (giving an annual water deficit of 800-1000mm). The LGP is from 90-150 days. Within this region, seven districts in Maharashtra and Bidar, Gulbarga, Bijapur and Dharwad in Karnataka State are drought-prone areas. Severe drought spells repeat approximately once every three years in these areas, with LGP accounting for 90 days or less, often resulting in severe crop failure.

The common soil-scapes in the region are represented by moderately to gently sloping red loamy alfisols, grading to very gently sloping black fluvisols in the valleys. There are two main soil series: the Paragon series are shallow loamy, skeletal and highly calcareous in nature, while the Sawargaon soils are clays, calcareous and moderately alkaline. However, the area has high productivity potential under careful irrigation and watershed management practices.

The natural vegetation comprises tropical, dry deciduous and thorn forests. Rain-fed agriculture is again the normal practice. Rainfall is bi-modal in the drought-prone districts and crops are therefore grown from September to October on stored residual soil moisture during the inter-modal dry period. Post-rainy season crops are grown on residual soil moisture. A typical growing system in the Raichur region may have a kharif (rainy season) crop using 300-400mm of water leaving some 150mm in residual soil moisture for a rabi crop, and around 50mm of rainfall available during the dry season (Haylor, 1997).

Constraints to crop production in these two zones are as follows:

- Prolonged dry spells during the crop-growing period resulting in occasional crop failure.
- High runoff and soil erosion during heavy rains.
- Narrow range of workable soil moisture in black soils.
- The plasticity of wetted black soil effects drainage and oxygen availability.
- High subsoil density in red loamy soils limits the effective rooting depth. Many of these soils have a deficiency of N, P and Zn.

Box 6: Impacts of the 1997 drought in North Karnataka. Source: semi-structured interviews and newspaper articles.

Raichur is a transitional area falling between the arid and the semi-arid agro-climatic types described in section 4.1. Gulbarga, Bijapur and Bidar districts to the North are more exclusively hot arid eco-regions, and have suffered particular hardship after last year's monsoon failure. Crop losses arising as a result of drought have been compounded by the widespread sale of sub-standard pesticides, and the illegal re-sale of condemned Government cereal seeds from Andhra Pradesh at inflated prices. The consequent debt-burden resulted in a spate of suicides, with farmers swallowing pesticides in their fields. Over 150 such cases in these areas have been recorded in press so far this year. This has politicised the crisis and there is currently much debate over the level of compensation that should be paid to distressed farmers, though none has yet been forthcoming. Such events were also recorded in Koppal to a lesser extent. Here, the failure of canal irrigation due to frequent breaching was also contributory.

4.2 Climate in Raichur District

Located on one of the highest points of the Deccan plateau, the area receives highly erratic rainfall. With an annual average less than 650mm, Raichur can be classified as a drought-prone upland area (DPU). 20-30 % of the district is composed of highly eroding, nutrient-poor red alfisol soils, whilst black vertisols are prevalent in lower accumulative areas. Raichur is known as a 'doab' meaning twin catchments. 81 streams (mostly seasonal) drain the two catchments into the Krishna and Tungabhadra rivers. Originating in the Western Ghats these perennial rivers form natural district boundaries to the North and South. Because the general slope of the district is from northwest to southeast, the majority of these streams drain into the Tungabhadra (Government of India, 1991).

Raichur District falls between an arid and a semi-arid bio-climatic classification (see section 1.1). Temperature and precipitation can be singled out as the two most important climatic variables and the two annual monsoons the most important climatic determinants. The south west monsoon is active from June through to September and the north west monsoon active from October to December. This results in a bimodal annual rainfall distribution, with peaks in June and October (Figure 6). Fields are left fallow during these months, with subsequent months marking the start of the kharif and rabi growing seasons respectively. Although rainfall levels are much higher during the SW monsoon (approximately 70% of the annual total), the rainfall in the NW monsoon falls much more intensely over fewer days. This brings potential for serious crop damage during the rabi season.

In addition to this marked seasonality, total annual rainfall levels are generally low and display high variability between successive years (see Table 6). Between 1988-98, both districts had a co-efficient of variance of approximately 28.5%, with an annual rainfall range from 371-1001mm. This compares with a mean co-efficient of variance of 19.1% for the previous twelve years (Sivasankar 1991), suggesting that rainfall patterns are becoming more erratic and the potential for drought is increasing. The lowest levels of rainfall in the eleven-year period were recorded in 1997 when the monsoon failed and rainfall levels fell to less than two thirds of the 50-year average (mean district annual rainfall: 396mm). This resulted in one of the worst droughts in the regions for many years, bringing about serious crop failures and severe hardship in many districts of North Karnataka. Rainfall data for Deodurg from 1930 shows that the taluk had experienced 18 meteorological and hydrological droughts (i.e. insufficient rain or rain falling when it was not needed). This makes for an average of one drought every three years. Since 1930, the taluk of Deodurg has averaged a total of just 41 rain days per year (Government of India, 1991) further demonstrating the highly seasonal nature of rainfall patterns.

Mean annual rainfall levels over 50 years (1944-94) are 572mm and 620mm for Koppal and Raichur districts respectively (Table 5). These figures show no systematic differences in annual rainfall levels between the taluks of the two districts (see Appendix 2). Between 1985-1995, Raichur was the third driest district in the state after Bijapur and Chitradurga. All other states exceeded 700mm.

Seasonal temperature patterns are also bimodal (Figure 8). The monsoonal temperature depression is less during the second monsoon as heavier rain falls on fewer days during this period (Figure 7). Temperatures can reach 43°C during summer (April – June) and drop to 15°C during the winter (December-March). Seasonal temperatures show relative stability compared to rainfall with a ten year co-efficient of variance of 8.7%. Source rainfall and temperature data are shown in Appendix 1.

Table 5: Summary District Rainfall statistics over an eleven year period, 1987-1997 and seasonal rainfall distribution in Raichur (mm), 1985-1995.

Rainfall	Koppal District	Raichur District
Max (mm)	1,001	975
Min (mm)	371	420
Mean (mm)	635	683
Co-efficient of variance (%)	28.6	28.5
1944-94 mean rainfall (mm)	572	620

Seasonal rainfall in Raichur District (mm)

SW Monsoon (June–Sept.)	N.E. monsoon (Oct-Dec)	Winter (Jan–Feb)	Summer (March–May)	Total annual rainfall.
414	120	8	65	607

Sources: Raichur Department of Statistics & Government of Karnataka (1996).

Table 6 Taluk-wise mean annual rainfall and co-efficient of variance over two decades.

Taluk	Mean rainfall 1977-1989 (mm)	Co-efficient of Variance (%)	Mean rainfall 1987-1997 (mm)	Co-efficient of Variance (%)	Mean annual rainy days 1987-1997
Raichur District					
Raichur	730	18.2	730	25.9	55
Manvi	676	24.1	654	24.3	38
Deodurga	741	18.6	755	27.1	52
Sindhanur	629	31.6	656	42.5	34
Lingsagur	605	19.5	616	22.9	43
District avg	676	22.5	683	28.5	222
Koppal District					
Koppal	585	18.2	704	36.7	39
Kustagi	480	35.8	592	26.8	38
Yelburga	572	18.9	600	16.4	38
Gangawati	661	28.8	644	34.4	39
District avg	575	25.25	635	28.5	154
Total / Mean	653	19.1	659	28.5	188

Source Sivasankar (1991) and Raichur Department of Statistics, pers. com.

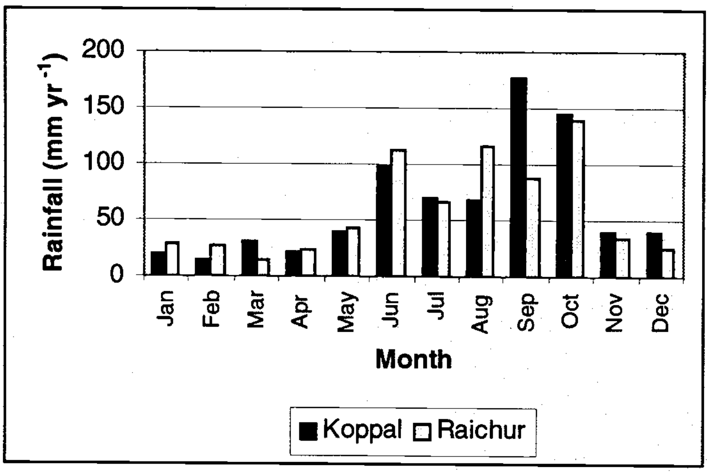


Figure 6: Mean monthly rainfall in Koppal and Raichur districts. Source: Directorate for Economics and Statistics, Raichur.

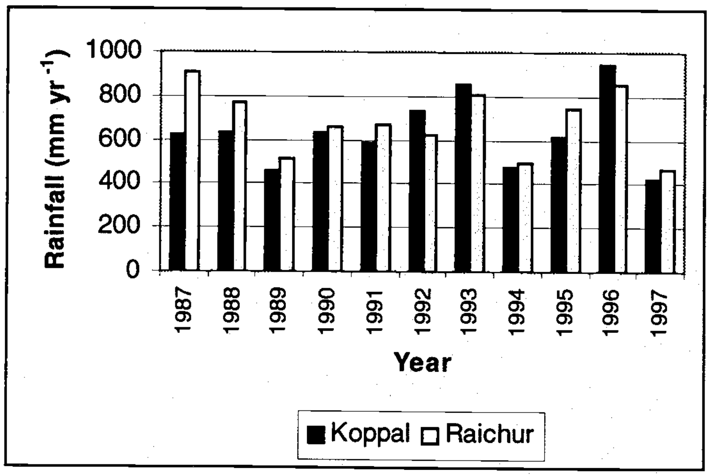


Figure 7: Eleven year mean annual rainfall in Raichur and Koppal districts. Source: Directorate for Economics and Statistics, Raichur.

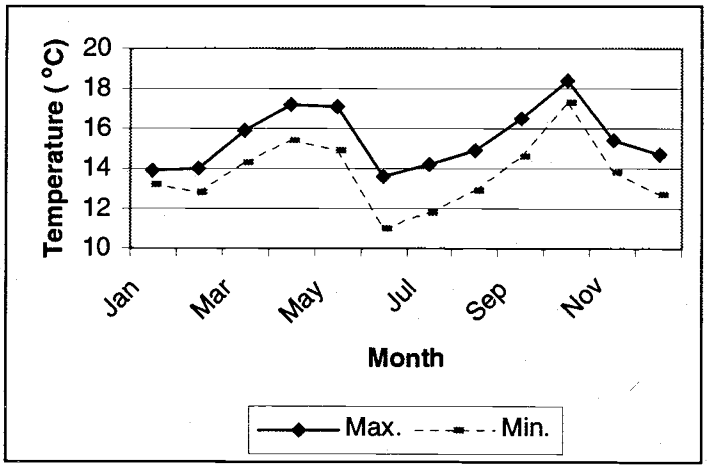


Figure 8: Mean monthly temperature in Kushtagi taluk, Raichur District (1989-1998). Source: Kushtagi taluk Panchayat Office Records.

5 Water resource management and micro-irrigation

5.1 The watershed approach to dryland management

Watershed development involves the use of many interventions that are required for the introduction of sustainable aquaculture systems. These include rainfall harvesting, the prevention of soil erosion, and the sustainable enhancement of the production of fodder, food, associated manure and fertilisers. Most dryland development in India is now being undertaken on a watershed basis. A watershed may be defined as any surface area through which rainfall is collected and drained at a common point (Myrada & IIRR, 1997), thus forming a single hydrological unit. The watershed is both a natural ecosystem and a logical unit that integrates the socio-economic and biophysical factors that lead to environmental degradation and food insecurity (Barr, 1998). Myrada & IIRR (1997) divide watershed management activities into the four components listed in Table 7.

Table 7: The components of integrated watershed development.

Criteria	Description
In-situ and ex-situ soil and moisture conservation.	Treatments on arable non-arable land and drainage line. This includes the creation of silt and water harvesting structures (see below).
Integrated production systems:	Including forestry, agroforestry, horticulture, aquaculture in stored water etc.
Implementation of sound crop production systems.	These should be identified and implemented through the involvement of developmental and input agencies. i.e. inter-cropping, multiple cropping.
Infrastructural sustainability	Developing suitable infrastructure and people organisations to maintain developed resources.

Source: Myrada & IIRR (1997)

5.2 Soil conservation and watershed management

Soil loss in India as a result of wind and water erosion averages 16.3mt ha^{-1} $year^{-1}$. Much of this material will find its way into reservoirs where sedimentation averages 8.02mt ha^{-1} $year^{-1}$, with consequent impacts on water storage capacity and fisheries potential. According to the Times of India, siltation has reduced the Tungabhadra Dam discharge capacity by approximately 28% over the last 50 years. On farm it will reduce agricultural production through reduced rainfall infiltration, moisture-holding capacity and loss of nutrients. In India, it is estimated that 4-6.3% of agricultural productivity is lost due to soil erosion (Myrada & IIRR, 1997). Appendix 4 describes attempts currently being undertaken to remediate tank siltation in Karnataka State.

Traditional soil conservation practices in drought-prone areas have focused on silt harvesting, and neglected on-farm prevention of erosion. Measures of field drainage to avert field flooding are partially motivated by the objective of silt harvesting in the lower reaches which are usually occupied by larger and more powerful farmers. These farmers often object to erosion control measures in the upper reaches occupied by the more marginal groups. In addition to this potential conflict, improvement of depth and soil quality in upper reaches requires a higher level of investment than that for lower reaches (Barr, 1998). Most of the Samuha project villages in the study area are located in upper watershed areas. Working Paper 3 includes details of village selection and Working Paper 9 describes the structure and function of the NGO Samuha with respect to watershed management.

5.3 Water harvesting and watershed management

Water harvesting is defined as the process of collection of natural precipitation from prepared watersheds for beneficial usage (Myrada & IIRR, 1997). The suitability of these structures will be the primary determinant of the potential for aquaculture integration. High intensity dryland rainfall causes 25-30% of rainfall to be lost as surface runoff. The harvesting technology chosen to conserve such waters depends on the type of soil, level of rainfall and topographic conditions. Table 8 shows some of the structures employed by Myrada in their Karnataka watershed development programmes, as well as their potential for integrated aquaculture.

Table 8: Dryland water-harvesting devices with potential for integrated aquaculture.

Water harvesting device	Ownership/description	Function
Farm ponds	Individual Usually square or rectangular. Depth 3-5m, area 80 –140 m^2 Containment 150 –250 m^3. Catchment approximately 1ha Pond size fixed to hold 50% of runoff to ensure replenishment in dry years.	Protective irrigation for high value crops (i.e. vegetables and short duration field crops) Fish rearing if sufficient storage time
Percolation tanks	Community Constructed on sloping terrain to extend the flooding period of nalas. The maximum water spread in these structures can be tens of hectares	The primary function is for ground water recharge to augment the water supply in wells
Embankment/ surface pond	Community/individual Surface impoundments made by cut and fill. These are the most common water storage systems used in India. Wall height includes protection for over-topping and earthwork consolidation. A core of impervious soil may be used to reduce seepage losses.	Community uses Groundwater recharge Seedling nursery irrigation Fish rearing
Nala bund	Community These are embankments built across nalas or gullies to hold the maximum potential runoff water . They are designed to flood the land on its banks and make it possible to bring the land in the normally dry nala under cultivation.	Reclamation of gullied land Groundwater recharge Protective irrigation Minimises runoff velocity.
Low earthen dam	Community These mirror minor irrigation tanks and are constructed across streams to create a water reservoir	Community uses Protective irrigation Ground water recharge Fish rearing

Modified from Myrada & IIRR, 1997.

5.4 Watershed development programmes

The catchment-scale of land and water management (rather than at individual farm level) is now widely established in India. The Indian Government is spending about US$300 million dollars per year on these projects (Barr, 1998) through a variety of schemes (Table 9). This scale of approach is particularly relevant to areas where groundwater recharge is an issue.

Some of the important issues in watershed management were evident in Mallapur project village where farmers were individually deepening their open wells and reporting a concurrent drop in the water table. The situation was compounded by the availability of heavily subsidised bore well electricity. By contrast, watershed initiatives at community level employ silt and water-harvesting devices designed to harvest rain and recharge groundwater. The links between individual on-farm soil and water management and collective watershed management systems are key to successful developments.

Table 9: Watershed development initiatives sponsored by the Government of India (GoI) and international development agencies.

Watershed development scheme and initiating agency:	**Description**
GoI National Watershed Development Project in Rain-fed Areas. (NWDPRA)	Launched 1990, now active in 25 states covering 2,554 micro watersheds. Applying an integrated farming systems approach which conserves top soil and water, its aims are: • Ecological balance with sustainable biomass production • Poverty-focused employment in rain-fed areas. Participatory execution of project works in watersheds by developing self-help groups, using low cost replicable technology. Integrated activities include: sericulture, agro-forestry and processing, horticulture, animal husbandry and fisheries development. For eligibility at district level, at least 70% of land area must be rain-fed. Target area 2,800,000ha. Budget: Rs 11 billion.
GoI Drought-Prone Area Programme (DPAP)	Launched 1973. Aims: • To counter the effects of drought on farming systems through integrated development of a natural resource base. • Restoration of ecological balance through conservation of natural resources, including landwater (including rainfall harvesting). • To improve the social and economic conditions of disadvantaged people including women and the asset-less. Now active 947 taluks of 12 states covering 74,600,000ha with 50:50 GoI : State funding. A watershed of approx. 500ha is the field level unit for development. GoI funding to date is Rs 17 billion. Since 1995 implemented on watershed guidelines (see NWDPRA). The **Samuha Akanksha** projects in Raichur and Koppal are part of this programme.
GoI Desert Development Programme (DDP)	Launched in 1977. Aims: To control desertification by integrating other central and state government projects To develop, conserve and harness land and water resources and restore ecological balance. Now implemented on the same watershed guidelines as the DPAP. Also includes sandy areas where watershed units are difficult to define using village clusters, cold and tropical semi-arid areas. Active in 227 taluks in seven states. 75% GoI for arid non-sandy areas, 100% for other areas. funding for GoI funding to date Rs 5.95 billion
World Bank Integrated Watershed Development Programme	Launched 1991, Divided into hills (active in five states) and plains projects (active in three states): Aims: to reverse degradation and increase production using appropriate soil and moisture conservation technology. Seven year programme. Target area 150,000ha. Budget Rs 1.87 billion. No project in Karnataka. A separate world bank sustainable ADP (agriculture development programme) is scheduled to begin in Karnataka this year.
Danida Phase 1: Integrated Watershed Development Project – Karnataka	Four projects are operational in Karnataka, Tami Nadu and Orissa. In Karnataka a 5.5 year project was launched in 1990. 41,000ha were developed in Karnataka, costing Rs 88 million. Based on its success Phase 2 was commenced in 1995.
EEC Integrated Watershed Management Projects	Three projects launched in Uttar Pradesh since 1989 covering 242,000ha at a cost of Rs 355 million. Major components are soil conservation, forestry, horticulture, animal husbandry and minor irrigation.
Swiss Development Corporation (SDC) Indo-Swiss participative watershed development project	Commenced 1998, this 3 year project aims to develop five watersheds in three agro-climatic zones of Karnataka. Project districts: Bidar Gulburga, Bijapur, Chickmanglur and Raichur (see **Samuha Kanakanala** Working Paper 9). Target area is 30,000ha at a cost of Rs 210 million. Emphasis on developing farmer participation by the development of Sanghas (self-help groups) with NGO facilitation. A similar second project in Rajastan commenced in 1996.

These projects are part of a wider government rural development policy to reduce regional disparities between irrigated and vast rain-fed areas, and prevent further migration from rural areas to already congested cities. They mark a progressive change from the previously sectorial initiatives towards a more integrated approach. In the past, many projects have languished because of the inefficiency and corruption inherent in Government project implementation agencies (PIAs). Consequently, there is an increasing trend to invite NGOs with good track records to tender for projects.

Table 10: Government of India (GoI) irrigation development initiatives targeting individual farmers.

Name of scheme	Description
Jawahar Rosgar Yojana (JRY- Million Wells Scheme)	Launched as part of an employment programme in 1988. Now independent as JRY since 1995. Provides subsidies to SC/ST and recently all marginal farmers for construction of irrigation sources. Allocation is district-wise according to level of non-irrigated land. Over 1million wells built to date. Cost: Rs 5.59 billion.
Ganga Kalyan Yojana (GKY)	Launched February 1997. Aims: To provide irrigation through exploitation of ground water (ground wells and bore wells) to marginal farmers. Provides subsidy and credit through financial institutions. 80:20 GoI, State funding and 50% ST/SC reservation. Annual budget: Rs 2 billion.

Source: Government of India (1998).

6 Summing up

This working paper provides background and information about the caste study areas in southern India where, working with farmers and support organisations, the project characterised social, technical and econmic issues relevant to researching the potential for aquaculture in small-scale farmer-managed irrigation systems.

Similar case study areas in Sri Lanka are also being characterised.

References

Barr, J. (1998) Current issues in Water Management on-farm in relation to the rain-fed farming systems of N.E India. A review of options. DIFD Research project R6759. Cenre for land use and water resources research, University of Newcastle.

Bhattacharjee, J.C.; Roychowdhury, C.; Landey, R.J. & Pandey, S. (1982) Bioclimatic Analysis of India, *NBSS LUP Bull.* **7**. Nagpur, India, NBSS LUP, 21pp + maps.

El-Swaify, S.A.; Walker, T.S. & Virmani, S.M. (1984) Dryland Management Alternatives and Research Needs for Alfisols in the Semi-Arid Tropics: An Interpretive Summary of the Consultants' Workshop on the State of the Art and Management Alternatives for Optimizing the Productivity of SAT Alfisols and Related Soils, ICRISAT Center, 1-3 December 1983. Patancheru, A.P., India: ICRISAT.

Government of India. (1991) Census of India, series 11: Karnataka. Part XII-B. District Census Handbook, Raichur. Village and townwise primary census abstracts. Directorate of census operations, Karnataka.

Government of India. (1981) Census of India, series 11: Karnataka. Part XII-B. District Census Handbook, Raichur. Village and townwise primary census abstracts. Directorate of census operations, Karnataka.

Government of India (1998) India 1998. Compiled and edited by: S.K. Chopra; J.P. Gautam; and Dharmesh Bharti. Co-ordination editor: K. Ramachandran. 784pp.

Government of Karnataka (1996).Karnataka at a glance 1995-96. Government of Karnataka Directorate of economics and statistics Bangalore.

Haylor, G. (1994) Fish Production from Engineered Water Systems in Developing Countries. *Recent Advances in Aquaculture* V: 1-102.

Haylor, G. (1997) Karnataka Watershed Development Project: Aquaculture Specialist's Report, September 1997. Institute of Aquaculture, University of Stirling, Stirling, Scotland. 48pp.

Haylor, G.; Lawrence, A. & Meusch, E. (1997) Identification of technical, social & economic constraints to the rearing of fish in rice fields in Lao PDR: resource management and information systems – a situation analysis. ODA Natural Resources Systems Programme: Aquaculture Research R6380CB: Addressing technical, social and economic constraints to rice fish culture in Laos, emphasising women's involvement. Project Report No. 3.

Haylor, G. & Stewart, A. (1998) The status of aquaculture in India with special reference to Eastern India. Integrated aquaculture in Eastern India. DFID NRSP High Potential Systems. Institute of Aquaculture, Working Paper 1. 2pp.

Harrison, E. (1996) Options for small-scale aquaculture development. FAO fisheries report no. 548: Report of the expert consultation on small-scale rural aquaculture. Rome, Italy, 28-31 May 1996. Compiled by M.M. Espinosa. Pp: 31-68.

Higgins, G.M. & Kassam, A.H. (1981) The FAO agro-ecological zone approach to determination of land potential, *Pedologie* **XXXI** (2): 147-168.

ICRISAT (1997) This is ICRISAT. International Crops Research Institute for the Semi-Arid Tropics. Patancheru 502 324, A.P., India.

Myrada & IIRR (1997) Resource management in rainfed drylands – an information kit. MYRADA, Bangalore, India and International Institute of Rural Reconstruction IIRR, Silang, Cavite, Philippines. Bangalore, India. 244pp.

NBSS (1992) Agro-ecological regions of India. Technical Bulletin. NBSS Publication 24. National Bureau of Soil Survey (NBSS) & Land Use Planning (LUP). Indian Council of Agricultural Research, Nagpur. Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, India.

Nigam, A; Gujja, B.; Bandyopadhyay, J. & Talbot, R. (1998) Fresh Water for India's Children and Nature. Learning from Local-level Approaches. UNICEF and WWF, Delhi, India. 82pp.

Pradeep (Ed.) (1994) Samuha Newsletter, November 1994. Samuha, Jalahalli, Deodurg Taluk, Raichur, Karnataka. 5pp.

Pretto, R. (1996) Objectives and indicators for aquaculture development. In: FAO Fisheries Report no. 548: Report of the expert consultation on small-scale rural aquaculture. Rome, Italy, 28-31 May 1996. Compiled by M.M. Espinosa. Pp: 13-15.

Redding, T.A. & Midlen, A. B (1990) Fish production in irrigation canals. A review. *FAO Fisheries Technical Paper* **317**. Rome, FAO. 111p.

Sivisankar N. and Umesh K (1993) A review of inland fish production of Raichur District over a decade Karnataka J. Agril Sci. 6 (2) Pp 171-173.

Stern, P. H. (1979) Small-scale irrigation: A Manual of Low-cost Water Technology. Intermediate Technology Publications Ltd, London. 152pp.

van Veldhuizen, L.; Waters-Bayer, A. & Zeeuw, H. De (1997) Developing technology with farmers: a trainer's guide for participatory learning. Zed Books Ltd. London and New York. 230 pp.

von Oppen, M. & Subba Rao, K.V. (1987) Tank Irrigation in Semi-Arid Tropical India: Economic Evaluation and Alternatives for Improvement. Research Bulletin no. 10. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Wolf, E.C. (1986) Beyond the green revolution: New approaches for third world agriculture. Worldwatch Paper 73. Worldwatch Institute, 1776, Massachusetts Ave. Washington D.C. 20036.

Appendix 1 table A1.1

	Population statistics									Waterbodies:						
Village name	**HH**	**Pop.**	**Pop.**	**Lit. M**	**Lit. F**	**ST**	**ST**	**SC**	**SC**	**FIP**	**CD**	**CD**	**OW**	**OW**	**FP**	**FP**
Devadurga	**(1)**	**(1)**	**(2)**	**(1)**	**(1)**	**(1)**	**(2)**	**(1)**	**(2)**		**(3)**	**(2)**		**(2)**	**(3)**	**(2)**
Pilligund	98	539		23	8	72	86	4	3.5					10	8	7
Malledevergud	141	754		24	6	0	70	7				1		6	8	7
Alkod	202	1178		23	8	0	50	33						20	3	3
Mallapur	219	1343		7	2	75	100	2			1	1		1	10	10
Chadkalgudda	161	1137		12	2	3	80	11						35		
Palkanmardi & Maddekal	182	928		13	4	19	50	25						20		
Village name	**HH**	**Pop.**	**Pop.**	**Lit. M**	**Lit. F**	**ST**	**ST**	**SC**	**SC**	**FIP**	**CD**		**OW**		**FP**	
Koppal:	**(1)**	**(1)**	**(2)**	**(1)**	**(1)**	**(1)**	**(2)**	**(1)**	**(2)**						**(3)**	
Alwandi	1105	6039		56	25	2		17								
Kawaloor	1174	6171		47	24	7		21								
Neeralgi	245	1581		54	15	8		12								
Moranhalli	196	1170		37	5	0		0								
Bhairapur	155	839		41	9	0		0								
Hatti	272	1614		32	5	0		1							3	
Village name	**HH**	**Pop.**	**Pop.**	**Lit. M**	**Lit. F**	**ST**	**ST**	**SC**	**SC**	**FIP**	**CD**	**PT**	**OW**		**FP**	
Kushtagi:	**(1)**	**(1)**	**(2)**	**(1)**	**(1)**	**(1)**	**(2)**	**(1)**	**(2)**	**(3)**	**(3)**	**(3)**	**(3)**		**(3)**	
Rampur (Jagir)	73	438		30	9	0		3			7		1			
Nawalhalli	244	1445		45	13	0		16			19 (2)		2			
Tawargera	1763	10471		52	25	4		13		1	1				5	
Vithalapur	101	612		22	10	0		21		1		1	6			
Nandapur	168	1079		44	12	0		18			5 (3)		2			
Jumlapur	247	1491	143	35	7	21	56	14	27		16		8			
Idlapur	91	591		33	10	51		5			7					
Ainapur	Uninhabited		147				33		18		2		6			
Sasvihal	114	646		43	14	5		13			8		2			
Kilarhatti	98	567		22	6	37		26								
Narinhal	115	762		33	6	0		3								
Gumgeri	251	1278		33	11	0		15							20	
Mudalgundi	100	584		25	7	0		23			2				1	
Kalmalli											1 (1)				12	
Huliyapur	211	1281		33	6	1		23								
Chalgera	637	3589		52	25	8		16								

Continues next page..

Village name	HH	Pop.	Pop.	Lit. M	Lit. F	ST	ST	SC	SC	FIP	CD		OW		FP	
Lingsugur:	**(1)**	**(1)**	**(2)**	**(1)**	**(1)**	**(1)**	**(2)**	**(1)**	**(2)**		**(3)**	**(2)**	**(3)**	**(2)**	**(3)**	**(2)**
Kesarhutti	132	890		20	2	0	40	52	10					40	6	6
Pai Doddi	164	1088	1200	17	3	0	70	12	30		4	5 (3)			17	17
Goudur	444		3000				50*		50*		1	1			6	6
Kotha	643	3617	4000	32	9	4	60	17			1 (1)	1			2	2
Honnahalli	344	1955	3000	41	11	0	15*	18	15*		1	1 (pickup)			1	1 (1)
Deverbhupur	378	2446	2500	0	0	0	60	11			1 (1)	2			7	7
Village name	**HH**	**Pop.**	**Pop.**	**Lit. M**	**Lit. F**	**ST**	**ST**	**SC**	**SC**	**FIP**	**CD**		**OW**		**FP**	
Yelbarga:	**(1)**	**(1)**	**(2)**	**(1)**	**(1)**	**(1)**	**(2)**	**(1)**	**(2)**		**(3)**	**(2)**	**(3)**	**(2)**	**(3)**	**(2)**
Dammur	201	1260		29	5	0		18						10 (25)	8	8
Chikwankalakunta & Uch	102	626		21	3	87	95	6	5					5	11	11
Hire Arlihalli	270	1867		46	15	4	15	5	10			1			2	2
Putakmari & Jarakunda	88	529		38	7	0	10	2	15					15 (10)	27	27
Chikka Mannapur	110	657		31	6	12	10	8	10					16 (10)	28	28
Tippanhal	102	585		39	11	28	100*	2	100*					5 (9)	12	12

Key:

(1): Government Census 1991	Pop: Village population	SC: % Scheduled Castes	FIP: Farm Irrigation Pond	FP: Farm Pond
(2): Samuha field team leaders	Literacy m: Male literacy levels (%)	ST: % Scheduled Tribes	CD: Check Dam	
(3): Central Akanksha Office	Literacy f: Female literacy levels (%)	HH: Households in village	OW: Open Well	

Table A1.1: Population statistics and waterbodies suitable for aquaculture in Samuha project villages in Raichur District according to (1): Government 1991 Census, (2) Samuha field team leaders and (3) Central Akanksha Office. * both SC and ST. Numbers in brackets for water bodies denote incomplete structures.

Village name		Population		SC	ST	Literates	
Deodurg taluk:	**Households**	**Total**	**sex-ratio**	**%**	**%**	**% males**	**% females**
Pilligund	98	539	953	4	72	23	8
Malledevergud	141	754	1000	7	0	24	6
Alkod	202	1178	925	33	0	23	8
Mallapur	219	1343	868	2	75	7	2
Chadkalgudda	161	1137	1009	11	3	12	2
Palkanmardi	182	928	970	25	19	13	4
Koppal taluk:							
Alwandi	1105	6039	925	17	2	56	25
Kawaloor	1174	6171	982	21	7	47	24
Neeralgi	245	1581	1043	12	8	54	15
Moranhalli	196	1170	993	0	0	37	5
Bhairapur	155	839	993	0	0	41	9
Hatti	272	1614	961	1	0	32	5
Kushtagi taluk (KWDP):							
Rampur (Jagir)	73	438	938	3	0	30	9
Nawalhalli	244	1445	963	16	0	45	13
Tawargera	1763	10471	973	13	4	52	25
Vithalapur	101	612	993	21	0	22	10
Nandapur	168	1079	944	18	0	44	12
Jumlapur	247	1491	949	14	21	35	7
Idlapur	91	591	957	5	51	33	10
Ainapur	Uninhabited						
Sasvihal	114	646	894	13	5	43	14
Kilarhatti	98	567	896	26	37	22	6
Narinhal	115	762	947	3	0	33	6
Kushtagi taluk (Akanksha):							
Gumgeri	251	1278	1006	15	0	33	11
Tawargera	1763	10471	973	13	4	52	25
Mudalgundi	100	584	986	23	0	25	7
Kalmalli	No data						
Huliyapur	211	1281	980	23	1	33	6
Chalgera	637	3589	932	16	8	52	25
Lingsugur taluk:							
Kesarhutti	132	890	1023	52	0	20	2
Pai Doddi	164	1088	953	12	0	17	3
Goudur	444						
Kotha	643	3617	989	17	4	32	9
Honnahalli	344	1955	1032	18	0	41	11
Deverbhupur	378	2446	973	11	0	0	0
Yelbarga taluk:							
Dammur	201	1260	941	18	0	29	5
Chikwankalakunta	102	626	956	6	87	21	3
Hire Arlihalli	270	1867	935	5	4	46	15
Putakmari	88	529	1019	2	0	38	7
Chikka Mannapur	110	657	1060	8	12	31	6
Tippanhal	102	585	881	2	28	39	11

Table A1.2: Summary statistics for villages in the taluks considered for further study. Source: Government 1991 Census for Raichur District.

Appendix 2: Raichur rainfall and temperature statistics

Table A2.1: Ten year average rainfall statistics for Raichur district. Source: Raichur Executive of Statistics and economics

	Koppal	Yelbarga	Kushtagi	Gangawati	Deodurg	Lingsugur	Manvi	Sindhnur	Raichur
1997	590	379	416	312	602	539	376	331	496
1996	1346	695	789	960	894	739	792	846	987
1995	765	532	508	638	956	565	676	548	987
1994	453	541	456	474	478	467	428	500	612
1993	930	739	929	823	632	781	742	1057	825
1992	638	616	689	990	846	546	699	490	556
1991	647	674	580	435	718	793	669	517	652
1990	623	591	552	774	729	483	572	900	594
1989	375	566	419	459	437	462	548	540	570
1988	667	672	551	655	1045	576	875	355	990
1987	715	598	623	570	976	831	825	1134	761
Max	1346	739	929	990	1045	831	875	1134	990
Min	375	379	416	312	437	462	376	331	496
STD	258.2	98.7	158.9	221.6	204.8	140.9	159.3	278.8	189.4
Mean	704.5	600.3	592.0	644.5	755.7	616.5	654.7	656.2	730.0
Co Var %	36.7	16.4	26.8	34.4	27.1	22.9	24.3	42.5	25.9

Table A2.2: Normal 50 year rainfall (mean rainfall 1944-94)

	Koppal	Yelbarga	Kushtagi	Gangawati	Deordurg	Lingsugur	Manvi	Sindnur	Raichur
1944-1994	599	593	571	523	632	560	640	582	688

Source: Raichur Executive of Statistics and economics.

Table A2.3a and b: Temperature data Kushtagi taluk (1989-1998):

Mean maximum °C per month

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989									32	31	32	34
1990	33	36	38	41	40	35	31	33	33	33	31	31
1991	33	34	37	38	38	38	29	28	29	31	30	30
1992	30	31	33	38	28	36	32	21	34	32	32	27
1993	30	32	34	38	40	38	33	30	32	30	31	29
1994	30	32	34	37	38	32	31	31	32	30	29	29
1995	30	33	37	38	41	33	31	32	31	37	38	28
1996	29	36	35	38	41	33	33	33	32	30	30	28
1997	31	34	38	37	39	38	34	31	35	32	30	31
1998	33	35	38	41	38							
Mean	31.0	33.7	36.0	38.4	38.1	35.4	31.8	29.9	32.3	31.9	31.4	29.1

Mean minimum °C per month

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989									26	10	24	26
1990	28	21	25	29	28	24	22	28	22	22	22	21
1991	20	23	26	26	26	25	26	23	24	24	23	20
1992	20	21	23	26	25	23	25	24	23	26	24	20
1993	20	21	25	26	28	26	25	24	25	25	25	23
1994	23	24	25	25	26	25	21	20	20	20	18	18
1995	19	22	24	28	26	26	25	20	14	28	29	18
1996	18	20	24	28	26	26	23	23	22	22	20	20
1997	19	20	24	26	28	24	24	23	24	23	22	23
1998	21	21	26	27	22							
Mean	20.9	21.4	24.7	26.8	26.1	24.9	23.9	23.1	21.8	23.8	22.9	20.4

Source: Kustagi district Panchayat office Raichur.

Appendix 3: Impacts of major irrigation schemes

Canal irrigation programmes are extremely costly and crop yields from existing irrigated areas are near their maximum potential (total net irrigated area in India is currently about 48.8 million ha). Although there are many plans for further development, including the construction of a national water grid, it is estimated that there is a maximum potential for irrigation of 50% of India's cultivated area in the immediate future. Such options are costly and plagued with administrative, technical and political problems. There are also the associated problems of poor water management: Seepage from irrigation schemes has lead to increased salinity, alkalinity and water-related disease.

Costs of many state irrigation projects have risen to 8-10 times their original estimate due to the chronic financial and physical slippage in targets and performance. Examples include the Ghataprabha project (Belgaum district), the Malaprabha Project (will irrigate Belgaum, Bijapur and Dharwad), the UKP project (see below) and repairs to the Tungabhadra project (The Hindu, May 1998).

Misappropriations of funds and interstate political wrangles over water allocations have been the main causes of delay. The sharing of river waters is a major issue in interstate politics and is often used to divert attention from internal state problems. Within Karnataka the Cauvery and now UKP projects are major examples. Both the Andhra Pradesh and Kerala Chief Ministers have initiated water disputes and then approached central government for a quick solution or other concessions. Because rivers are not considered as national assets, there is no national policy for sharing of river waters.

The Upper Krishna Project (UKP) and the Tungabhadra scheme are two major irrigation projects with substantial command areas in the North and South of Raichur district respectively. The Upper Krishna Project is scheduled for completion in the year 2000.

The Upper Krishna Project and Raichur District

The World Bank aided Upper Krishna irrigation Project (UKP) was conceived in 1963, work finally commencing in 1976. It was conceived to follow the initial success of the TB scheme in the irrigated belts of Raichur and Bellary. The project has been dogged by delays including a long running dispute over whether to complete the project with World Bank aid or invite Global tenders.

The relevance of this project to two of the project areas became apparent during the fieldwork of the current project. When complete the UKP will provide waters to Belgaum, Bijapur, Gulbarga, Raichur and Andhra Pradesh. In Raichur the scheme will supply 72,000ha of Deodurg Taluk and 12,000ha of Lingsugur Taluk. This will lead to the rehabilitation of 46 villages of the two taluks. Although the provision of flood irrigation was originally envisaged, the canal will now only be flooded during drought periods to supply water for five to six emergency irrigations of semi-dry crops per year, and will be depleted by February (Mr Pai, Technical Assistant to Superintendent Engineer of the Naryanapur Right Bank Canal, pers. com.). Accordingly the UKP Board is recommending the production of white sorghum, cotton and millet rather than the rice paddi now characteristic on the southern irrigated belt. If funds are made available, the canal will be lined during the second phase of the project. This lining would almost double the amount of irrigation water available by reducing seepage losses. Land prices have increased four-fold to over Rs 2 million per ha during the last year (Mr Pai, Technical Assistant to Superintendent Engineer of the Naryanapur Right Bank Canal, pers. com.). Some Andhra Pradesh farmers are beginning to speculate although there are restrictions on the sale of potentially irrigated land. Neither of the two study villages in these districts (Mallapur and Pai Doddi) will receive direct benefit from the project due to their location in upper catchment areas.

The project incorporates two successive dams on the Krishna at Alamatti and Naryanapur. These each have a 'left' and a 'right' bank canal, which supply Gulbarga to the North and Raichur to the south respectively. An additional canal emanating from the Alamatti, the Mulwadi, will supply Belgaum district. A total of 353km of canal is envisaged. There are two phases to the development. Phase 1 covers the construction of the Alamatti to a partial height, construction of the Alamatti left bank canals (will irrigate 20,235ha in Bijapur) and the Naryanapur LH canal (will irrigate 409,000ha in Belgaum) and lift irrigation structures on both reservoirs. The cost of Stage 1 has now reached Rs. 10.7 billion against the original estimate of 2.8 billion in 1978.

The Indian Irrigation Minister, Nage Gowda, announced that another Rs 36 billion would be spent to complete the project by the year 2000. This includes Rs 10 billion for the rehabilitation of 93 villages. However the government has failed to spend the targeted amount for the last three years, during the last financial year spending only Rs 7.7 billion against a target of Rs 12.5 billion. In 1998 work had allegedly almost ceased for six months due a dispute over the fixing of land value for acquisition. The Irrigation Minister stated in press that the civil works were still on target, but according to engineers working on the project, poor quality work and misappropriation of materials and funds are commonplace. Similar allegations made by retired engineers were also reported in the press. The opposition is currently calling for a CBI (Criminal Bureau of Investigation) inquiry into irregularities in the awarding of piecework contracts.

As well as 43 villages so far rehabilitated, the town of Bagalkot (administrative centre for the newly formed Bagalkot Taluk) will also require rehabilitation, affecting 70,000 families. Farmers are demanding Rs 115,000 per acre for irrigated land but the government is offering a maximum of Rs. 54,000-100,000 per acre (dry and irrigated land respectively) exclusive of any depreciation.

The state government has initiated a public saving bond called Krishna Jala Bhagaya Nigam to cover some of the overrun in project costs. So far this has raised Rs 14.8 billion and applications for a fresh tranche of Rs 8 billion have just been invited. However there has been criticism of the high interest rates offered to attract investors to this scheme. Mr Patel, the current Minister of state, announced in the spring of 1998 that the government intend to float a similar bond to expedite execution of the Malaprabha, Ghataprabha and the upper Tunga basins. He asserted that recent economic sanctions imposed by the United States, Japan and Denmark after the Pokarhan nuclear tests will directly effect funding of irrigation projects within the state and there would be a greater need for self dependence.

Phase 1 of the canal will irrigate 72,000ha and a total of 26 villages in Deodurg, and phase 2 will cover 12,000ha and a total of 20 villages in Lingsugur. Under a prospective phase 3, Raichur taluk would also receive irrigation water. The total (phase 2) length of the Right Hand canal is 95km at a projected cost of Rs 4.8 billion (Mr Pai, technical assistant to superintendent engineer of the Naryanapur RB bank canal at Naryanapur Dam, pers. com.). Neither of the two study villages in this area (Mallapur and Pai Doddi) will receive direct benefit from the project.

Although originally the provision of flood irrigation was envisaged, the canal will now only be flooded during drought periods to supply water for five to six emergency irrigations of semi-dry crops per year and will be depleted by February. Most of the Naryanapur water will flow north to Gulburaga through the extensive left-hand canal. Accordingly the UKP board is recommending the production of white sorghum, cotton and millet rather the paddy that is now characteristic on the southern irrigated belt. If funds are made available the canal will be lined during phase 2 of the project. This is predicted to almost double the amount of irrigation water available by reducing seepage losses.

Land prices have increased four-fold to over Rs 2 million per ha during the last year (Mr. Pai, pers. com.).

There has been a long running dispute between Karnataka and Andhra Pradesh over their allocation of the Krishna waters. Both states allege that they are adhering to the award of the 1976 Krishna water disputes tribunal but Andhra Pradesh claims that Karnataka has unsanctioned plans to raise the height of the dam by another four metres to store an additional 100tmcft[9] of water. Karnataka State insists it has advanced planning permission for this (under stage 2 project sanction) and the additional water will be used for non-consumptive hydro power use and not irrigation. In the past Karnataka has deviated twice from planning commission sanctions. Subsequently both deviations were approved by central agencies in 1990 without details previously being made available to Andhra Pradesh. Once developments have been sanctioned there is no central regulatory authority to check for deviations. The situation is further complicated by the fact that the previous United Front government (a weak coalition) was headed by Mr. Deve Gowda, the ex chief minister of Karnataka. Mr Gowda had previously been accused of accepting bribes whilst allocating UKP works. To avoid any further accusation Mr. Gowda distanced himself from the issue and in 1996 the Andhra Pradesh chief minister Mr. Naidu used this weakness to delay sanction of the Phase 2 works (including the proposed dam elevation. He also delayed sanction of Rs 2 billion allocated under the then new Accelerated Irrigation Development Scheme. At present the issue is being resolved the Supreme Court.

Currently only Andhra Pradesh is impounding its full share of 800tmcft of Krishna waters and is also utilising surplus waters. Karnataka is not yet able to impound its share of 729tmcft. These allocations were decided under the 1976 Bachawat Tribunal award, which is due for review in the year 2000. If Karnataka does not utilise its share of Krishna waters by this time there is a danger it may loose entitlement to surplus waters in favour of Andhra Pradesh.

---

[9] Tmcft: thousand million cubic feet

The Tungabhadra project

The Krishna Water Disputes Tribunal ruled on the allocation of Tungabhadra waters by Andhra Pradesh and Karnataka in 1953. The Tungabhadra board was constituted by the central government to manage the common parts of the project. It ensures equitable distribution of irrigation waters, hydropower generation and other uses on the right bank canal. The chairman of the board is appointed by central government, and two other members represent the states. The project irrigates 250,000ha in Raichur and Bellary and another 250,000ha in Kurnool and Ananthapur Districts in Andhra Pradesh. Karnataka has an allocation of 139tmcft and Andhra Pradesh has 73tmcft. Siltation has reduced the TB dam capacity by approximately one third and the actual delivery has dropped to 99 and 55tmcft respectively.

The state opposition is accusing the Janata Dal State government of being bankrupt with Rs 7.5 billion of unpaid public works bills. As a consequence development and maintenance works have come to a halt on many projects.

The left bank canal irrigates about 243,900ha of land in the Southern taluks of Raichur and Koppal. Every year there is a scheduled shutdown period of the canal to carry out repairs, the duration of which has increased as the condition of the canal has deteriorated. In 1998 year it commenced on April the 25th and is scheduled to last for nearly two months. Prior to 1984 this shutdown lasted only one month (Kale Pada Mindel, pers. com). The irrigation minister promised to release Rs 160 million for canal repairs this year but the funds are yet to be released. Contractors have refused to take up the repair works until their outstanding bills of Rs 50 million have been settled.

In addition to scheduled shutdowns the frequency of emergency shut downs has increased as breaches of the ageing canal (nearing the end of its estimated 50 year life span) become more common. 206 such incidents have been recorded to date. One such breach occurred on the main left bank canal on the 1st Febuary 1998. Farmers that had used their emergency irrigation tanks for integrated aquaculture had to assess whether the repairs would be carried out on time before making a decision whether to use their remaining water to preserve their fish stocks or their crops. Such crop losses have resulted in desperation amongst farmers, and in April 1998 one farmer in Koppal and three in Sindhnur taluk (all tail-enders) committed suicide.

The worst recorded incident occurred in September 1996 when an aquaduct on the eleventh mile breached causing around Rs 400 crop losses (India Express 26/4/98). Due to financial constraints only the first phase of this repair work has been completed and a temporary diversion canal is still in operation. As a result of indecision over the sanction of this repair, farmers still do not know when waters will be released for them to sow their kharif crops. Government engineers state that repairs are required along the entire 146 mile length of the canal. All of the sections of the drained main canal and tributaries observed in the current project had extensive damage to the stone or concrete canal lining every 50-100m. Because of this deterioration the canal can now only carry a maximum 3,500m^3 s^{-1} of water compared to the design capacity of 4,100m^3 s^{-1}.

The net result of siltation and canal deterioration is a loss of forty and seventy days irrigation to primary and tail end farmers respectively. Farmers are appealing for the construction of further balancing reservoirs in the high-level command area to store floodwater (an estimated 150tmcft of floodwaters are lost every year). One such reservoir, the Ganekal, currently exists to supplement tail-enders in Bellary district.

Several sugar factories in the area are on the verge of closure as water available for sugar cane production is reduced. Siltation has diminished the area available for sugarcane cultivation in the area by one third to one quarter (at least 10,000ha of cultivation are required to run a factory profitably). The government is now unwilling to finance further expansion of this industry. At the same time the government recommends a switch to commercial crops (including fruit and floriculture) other than paddy and sugarcane which have high water consumption. The possibility of discontinuing the release of waters for a rabi crop is also being considered.

Other state irrigation programmes

The World Bank providing Rs 600 million of funding towards the Karanja irrigation project, the only major irrigation project in Bidar district. Estimated at Rs 9 million in 1972, completion is planned for 2001 at a revised cost of Rs 3.2 billion. Two dams are being built across the river Karanja at Marakal bridge and Bagadal bridge. Bagadal bridge will impound 7.6tmcft of water.

Appendix 4: Remediation of silted tanks in Karnataka State

De-silting of derelict tank can increase the potential availability of water resources to co-operative fisheries groups. The NGO PRARAMBHA is currently managing a de-silting programme within the state.

There are 36,790 minor and major (> 10ha water spread) tanks in Karnataka state. The Minor Irrigation Department estimated that Rs 150 million is required to clear the large number of tanks that have become silted in the state. They have allocated Rs 100 million to this end. Phase 1 has begun in Tumkur, Kolar and Chitradurga Districts. Along with construction of check dams, the main purpose of this initiative has been to improve groundwater recharge in these districts. The Minor Irrigation Minister stated in press that there were insufficient government resources to clear all the tanks and the government would only pay the cost of the de-silting machine (fixed at Rs 475 per hour). Farmers would have to meet the costs of ferrying the mud to their fields. He said each tank would cost around 5 million (minor tanks) to Rs 10 million if the Government carried out the entire operation alone. He also commented that the state utilises only 10tmcft of water to irrigate 20,000 acres of land while 2000tmcft flows into the sea and the feasibility of diverting these waters should be investigated.