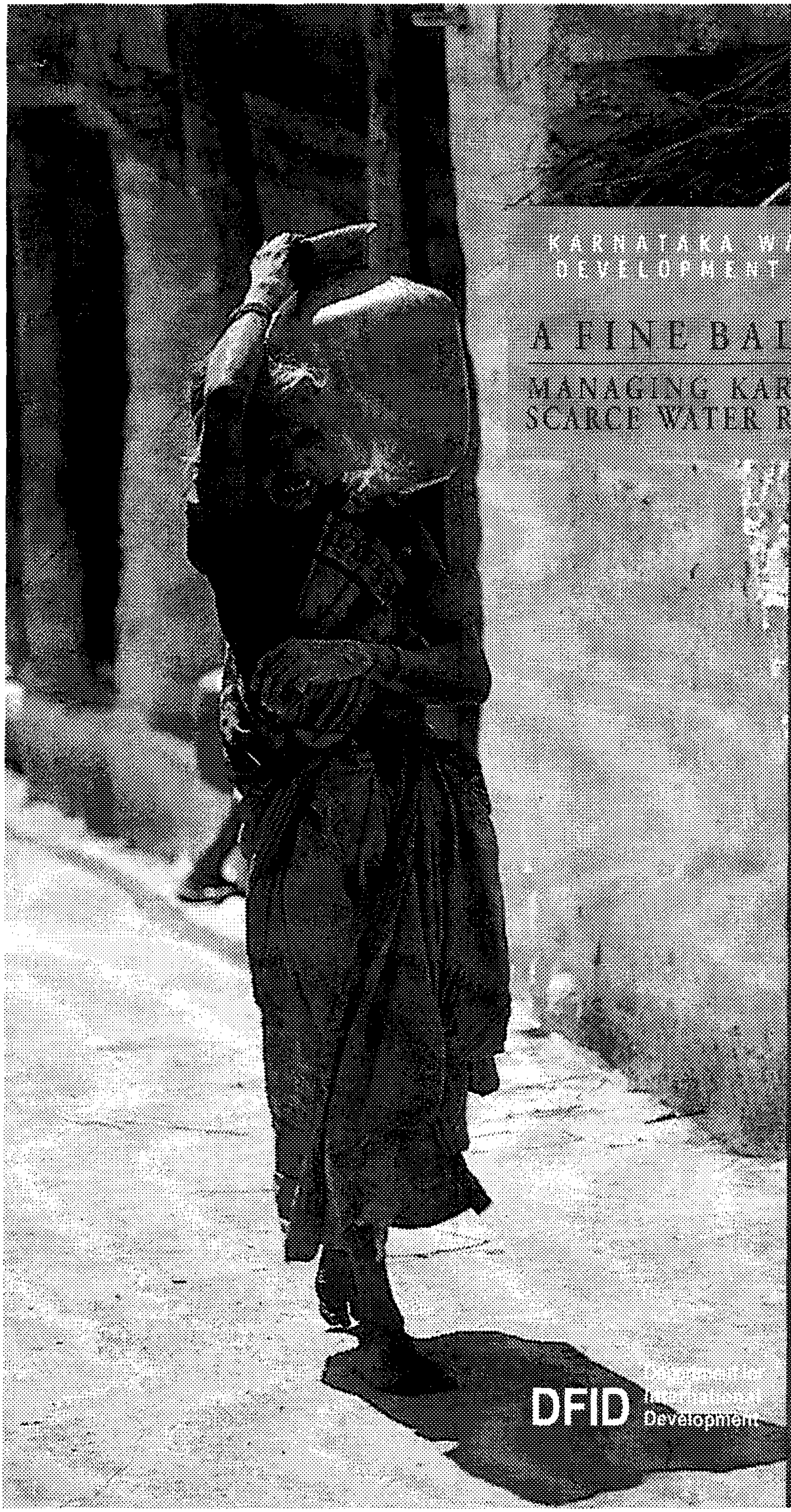

KARNATAKA WATERSHED DEVELOPMENT PROJECT

# A FINE BALANCE:

## MANAGING KARNATAKA'S SCARCE WATER RESOURCES

MARCH 2001

DFID Department for International Development

KARNATAKA WATERSHED DEVELOPMENT SOCIETY

KARNATAKA WATERSHED DEVELOPMENT PROJECT

# A FINE BALANCE:

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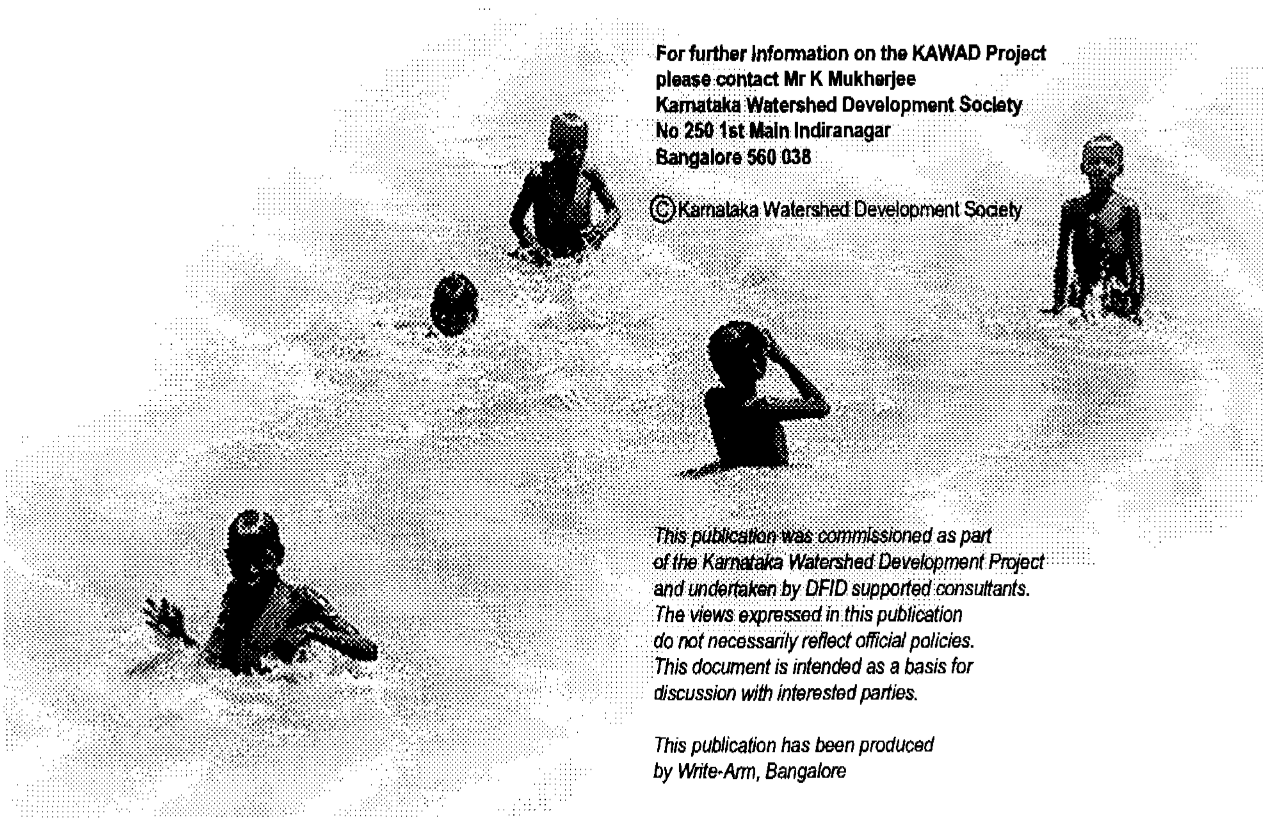

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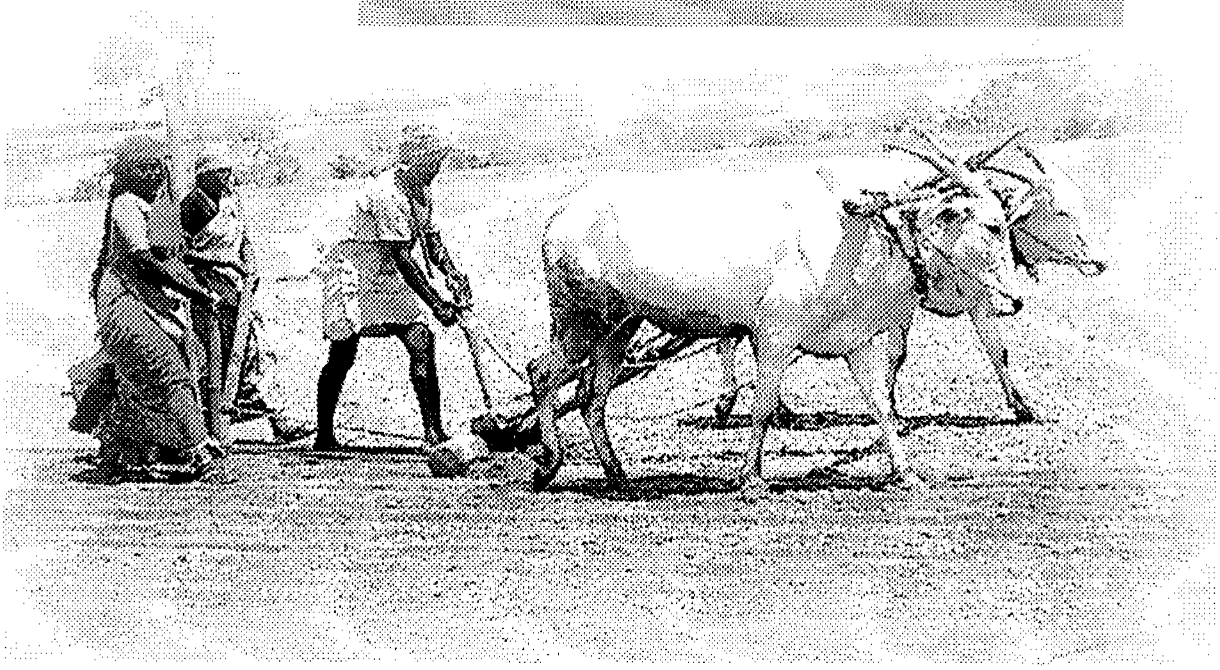
*This publication has been produced by Write-Arm, Bangalore*

Safe drinking water is the priority need in most semi-arid areas of India

# FOREWORD

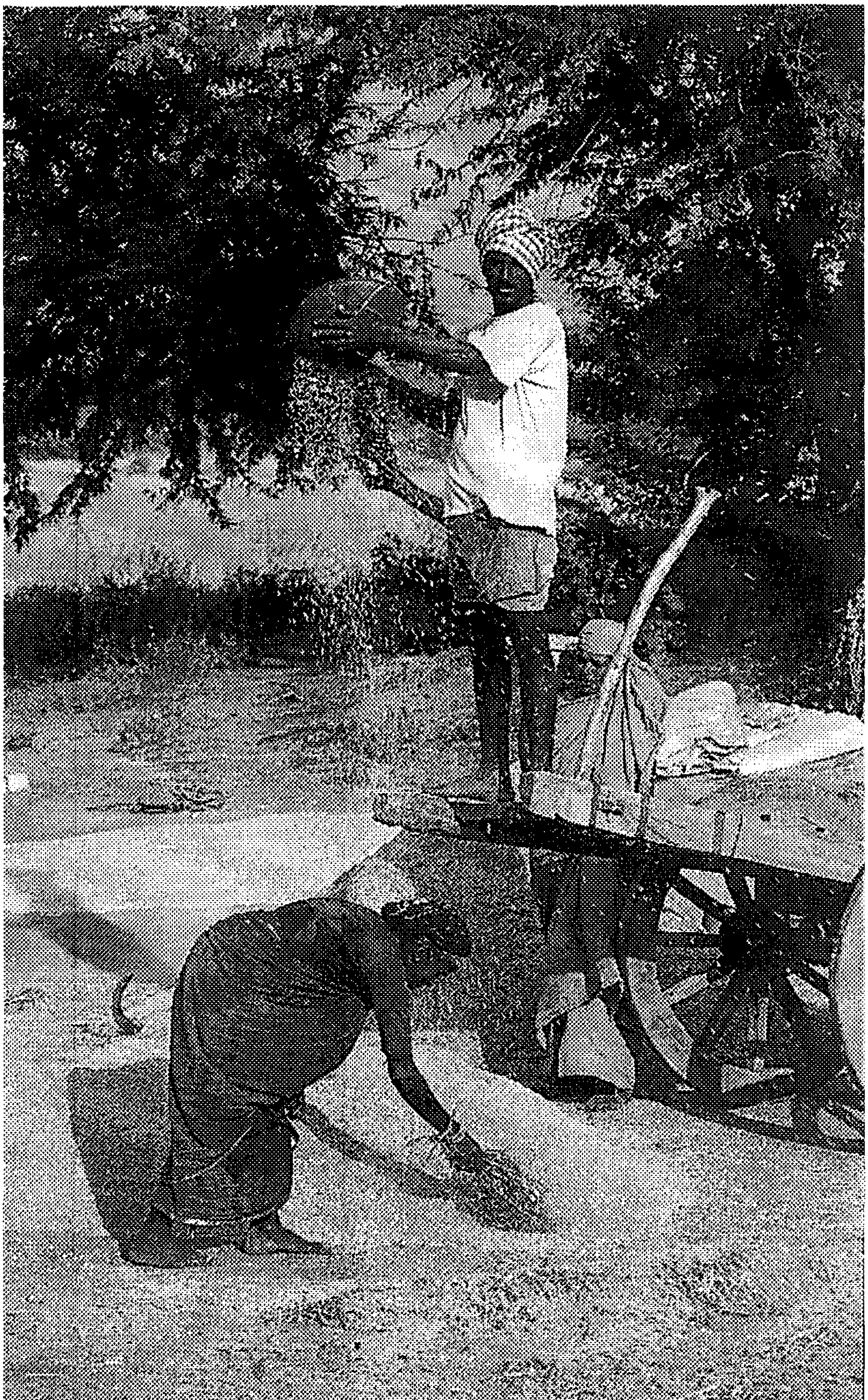


Many areas of Karnataka are vulnerable to drought. Where the average rainfall is in the region of 500 mm, "water", without question, is the most valuable resource. Farmers in these areas perceive a watershed project as one which increases the availability of water to them. It is very easy for any watershed project to fall into the trap of being a "developer of new sources of water" and the project administrators see the dream of a lush green landscape. Unfortunately, such tracts cannot be transformed into tropical forests. Projects must be capable of discovering as to what can be sustained in the long run without jeopardising the livelihoods of the future. Underground water reserves are like bank accounts which can be thoughtlessly depleted by the farmer by resorting to heavy irrigation which can be likened to issuing a series of cheques without depositing anything!

The DFID funded KAWAD project in Karnataka is perhaps the first one in India which has carried out an audit of water as a resource in its watersheds. This "Water Resource Audit", published as a book has been extremely well received and has set many policy makers thinking. This monogram goes over the same issues yet again but this time, without the burden of details, which ironically, sometimes cloud the issues they seek to highlight. I am sure this monogram would ultimately get the message of "more crop per drop" across to all the stake-holders of a wide range of watersheds in rain-fed areas.

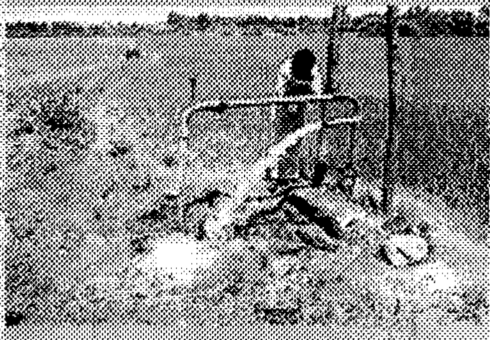
**Kaushik Mukherjee**
**Executive Director**
**KAWAD Project**

**March 5, 2001**



*Many farming practices involve all the family members*

# 1 WATER - A LIMITED RESOURCE



*Irrigation is the first step on the way to improved profits for farmers in many parts of Karnataka. Here, groundwater is being pumped for paddy irrigation*

India's semi-arid areas are today more vulnerable than ever to the ravages of drought. Some rivers that were once perennial sources of water are now dry for long periods of the year. In all but the wettest years, many village tanks[1] no longer receive enough runoff to reach capacity. People's livelihoods are under threat as water supplies for agriculture, livestock, manufacturing and service industries diminish and/or as competition for these supplies escalates. Most alarming, though, is the increasing unreliability of supplies of drinking water to many of the affected towns and villages. The shrinking supply of water for domestic use has given rise to seasonal markets for water; selling water is now a common dry-season business.

Inappropriate management of water resources is to blame. A recent audit of water resources in three Karnataka watersheds[2], Doddahalla, Chinnahagari and Upparahalla, shows that the amount of water used in each year approximates the amount replenished by rainfall. The groundwater 'buffer' that people normally relied on in dry periods has disappeared in many areas, leaving them much less able to withstand the shock of drought.
At the same time the demand for water is increasing. Farmers are improving their livelihoods by cultivating the more profitable irrigated crops, whilst the ever increasing demand for domestic water in northeastern Karnataka is predicted to double in the next 25-30 years.

The effect of this thirst for water on the communities of northeastern Karnataka is alarming. It is only a matter of time before these areas are visited by catastrophic droughts. As farmers collectively chase the water table to the limits of the aquifers, the poorest of the communities are literally left high and dry. The worst hit will be those who can barely afford to purchase water, lack the resources to switch to alternative livelihoods until the drought recedes, mortgage their futures in order to survive the enforced unemployment that prolonged

*[1] Tanks are earthen-bunded reservoirs that have been constructed to store rainwater. Many tanks are hundreds of years old and it has been estimated that there are around 800,000 tanks in India.*

*[2] Batchelor, C.H., Rama Mohan Rao, M.S., James, A.J., June 2000, Water Resources Audit, Karnataka Watershed Development Project, Report 17*

droughts bring with them and, as a result, fall into debt. The immediate impacts will be felt by women and children as they are primarily responsible for collecting water for cooking, cleaning and washing.

To some extent, such problems can be addressed by collecting and storing more rain water and, to these ends, great efforts have been made by communities to construct appropriate structures for harvesting and storing runoff, in some cases with spectacular success. This seemingly simple solution has, to some degree, also influenced governmental responses to tackling water shortage and its negative impacts on people's livelihoods. Governments in many parts of the world have perceived the development of water resources as a key constraint to development and have therefore focused efforts on increasing the supply of water. In India, watershed development has consistently boosted agricultural production; facilitated the development of village-level institutions and substantially improved the livelihoods of some groups. These are considerable achievements and the approach has enjoyed not only widespread public and political support in India but has also served as a model for other countries.

However, these visible successes have encouraged an unrealistic expectation of what watershed development programmes are able to achieve in dryland areas. If appropriate water management were simply a matter of setting up appropriate village-level institutions and installing appropriate small-scale structures to capture runoff, there would be no shortage of water, regardless of a person's social status, caste, economic class and so on, nor would droughts affect people's livelihoods as much as they do.

Data collected and analysed as part of the KAWAD water resources audit suggest that there is very little scope for further development of water resources, at least in the three watersheds surveyed. The same is likely to be true for many other semi-arid areas. The reality is that watershed development is not the panacea it is commonly held to be. Water is simply *not* an unlimited resource.

Whilst it is true that measures can be taken within a watershed development programme to increase the amount of water available, that increase is finite; once the measures have been implemented, very little can be done that is economically feasible to capture more. This booklet sets out to show some of the positive and less positive aspects of current approaches to watershed development and to highlight some of the options available to address the problems outlined above. The information comes mostly from the aforementioned water resources audit; however the findings and conclusions have wide relevance to other semi-arid areas of India.

*Village tanks like this one traditionally harvested rainfall in dry areas of India. However, inflows to most tanks are now much reduced as a result of groundwater extraction and water harvesting in the tank catchment areas*

*NGOs working in the watershed development programme have successfully established village-level institutions*

The most important conclusions of the KAWAD Water Resources Audit are:

**Northeastern Karnataka will experience a catastrophic drought if steps are not taken to reestablish ground water reserves, particularly, in aquifers that are important sources of domestic water.**

**It is likely that the same is true for Western Andhra Pradesh and other areas of India with similar hydrogeological characteristics and similar levels of water utilisation.**

**People living in northeastern Karnataka may improve their livelihoods and avoid the potentially disastrous effects of drought only if they shift their emphasis from the development of water resources to improving the management of the resource.**

**There is probably insufficient water available to sustain the intensity of irrigated agriculture that farmers would naturally opt for. Hard political decisions will therefore have to be made as to what constitutes the wisest use of a limited resource for today and for the future.**

The study showed also that watershed development programmes could be promoting a much wider range of activities and management practices than is currently the case. If selected, these options would have the potential of improving the livelihoods of poorer social groups as well as making more productive and sustainable use of water resources.

Children help to fetch and carry water

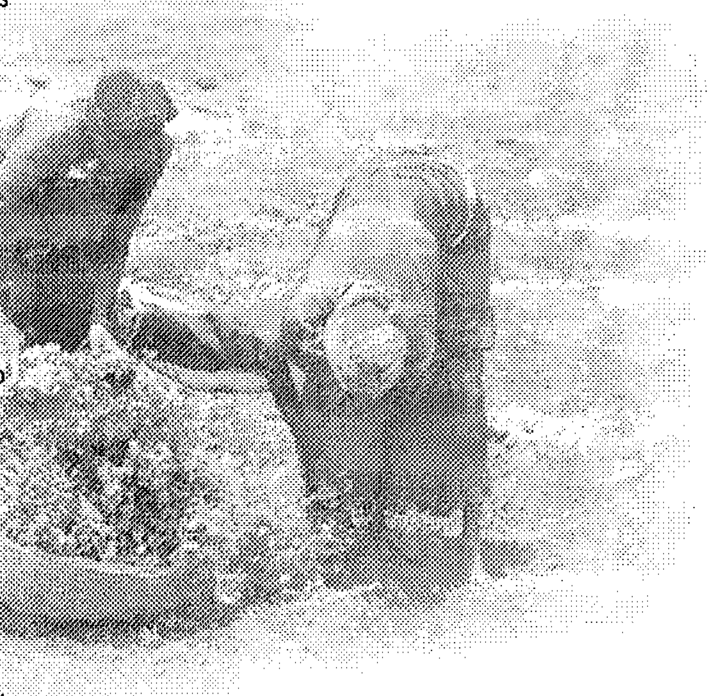
# 2 WHERE HAS ALL THE WATER GONE?

Water vending from a tanker is now a common dry-season business in north-eastern Karnataka

A sustained increase in the regular extraction of ground water for irrigation is the single largest contributor to the present-day scenario, but several factors drive this trend.

### Irrigation and productivity

Wherever resources permit, the farmers' first step towards improving their livelihoods is to irrigate their fields. The reason for this is that the productivity of any crop will increase if the crop is provided its optimum requirement of water, but also because certain crops that require irrigation, such as mulberry, onions, cotton and groundnut are 300-500 per cent more profitable per unit area than rainfed crops (see Figures 2 and 3). Although tank-based irrigation was the most common method of irrigation in much of semi-arid India, increasingly water for irrigation is pumped from wells. Farmers who can afford the costs of constructing wells and installing pumps (or are able to take out loans for such work) understandably opt to do so.



Farmers used to rely on shallow, open or hand-dug wells to supply water for irrigation. Around 1990, two things happened which, taken together, radically changed the way water was used in the area, with serious implications for the economy of the region, the divide between rich and poor and the ability of people living in northeastern Karnataka to withstand the potentially disastrous effects of drought. These were: first, that the type of well favoured by farmers changed from shallow or open wells to deep borewells and, secondly, those farmers able to drill deep borewells began to do so in earnest. The rate of construction of deep borewells began to rise sharply, as did the use of submersible pumps. So, not only did the number of wells multiply, but the volume of water extracted per well also increased.

Figure 1. Well construction in the Chinnahagari Watershed

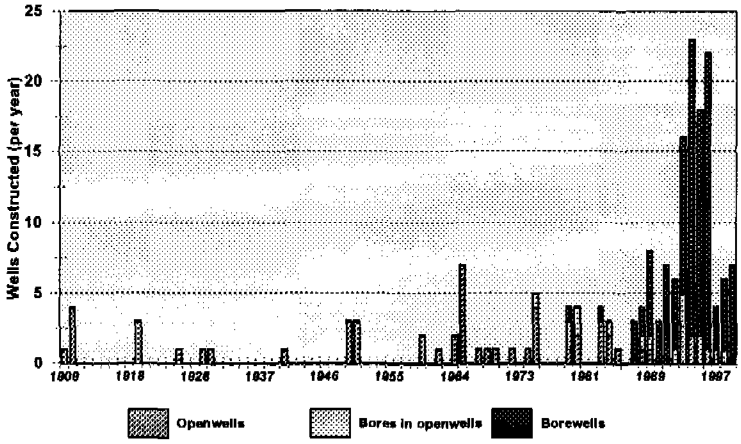



Figure 2. Net revenue of rainfed crops

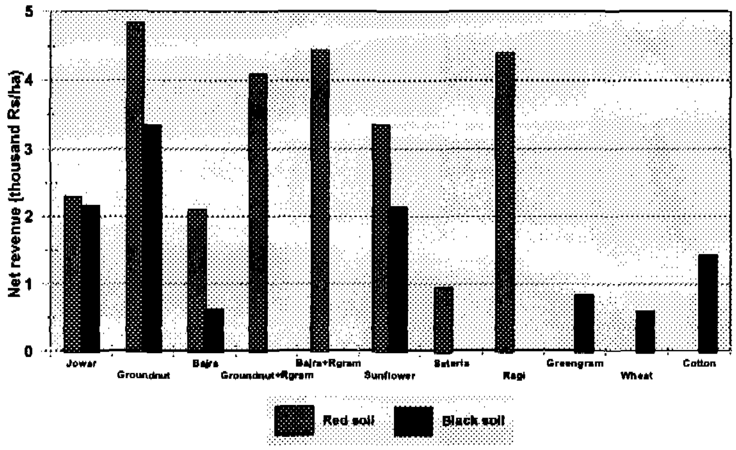
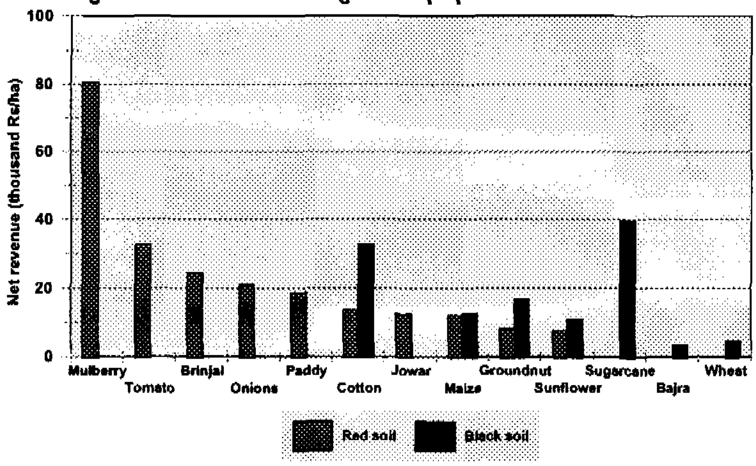
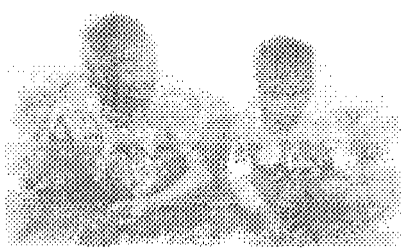



Figure 3. Net revenues of irrigated crops per unit area

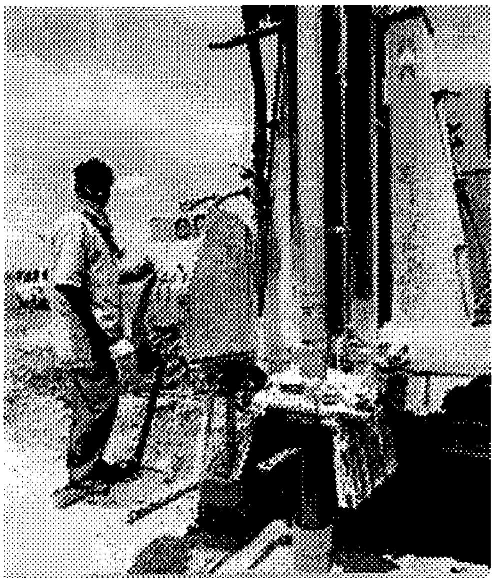


These changes in rates of ground water extraction and the type of well constructed are due in part to various incentives, such as:

- **government provision of grants that wholly or partly fund the construction of wells;**
- **provision of free electricity for pumping ground water for irrigation using pumps of less than 5 HP and electricity at a nominal annual fee for larger pumps;**
- **the relative reduction in cost of constructing borewells as a result of new drilling rigs and competition between contractors offering drilling services;**
- **electrification of villages and the availability of submersible pumps, which permit the extraction of water from greater depths than is possible with pumps located at the ground surface.**

Prior to 1990, the largest number of wells constructed in Chinnahagari watershed in a single year was seven; the average for 1909 to 1989 was two new wells constructed every three years. After 1989, however, the rate of construction changed radically; in 1994 alone, 21 deep borewells were drilled in the Chinnahagari watershed (see Figure 1).



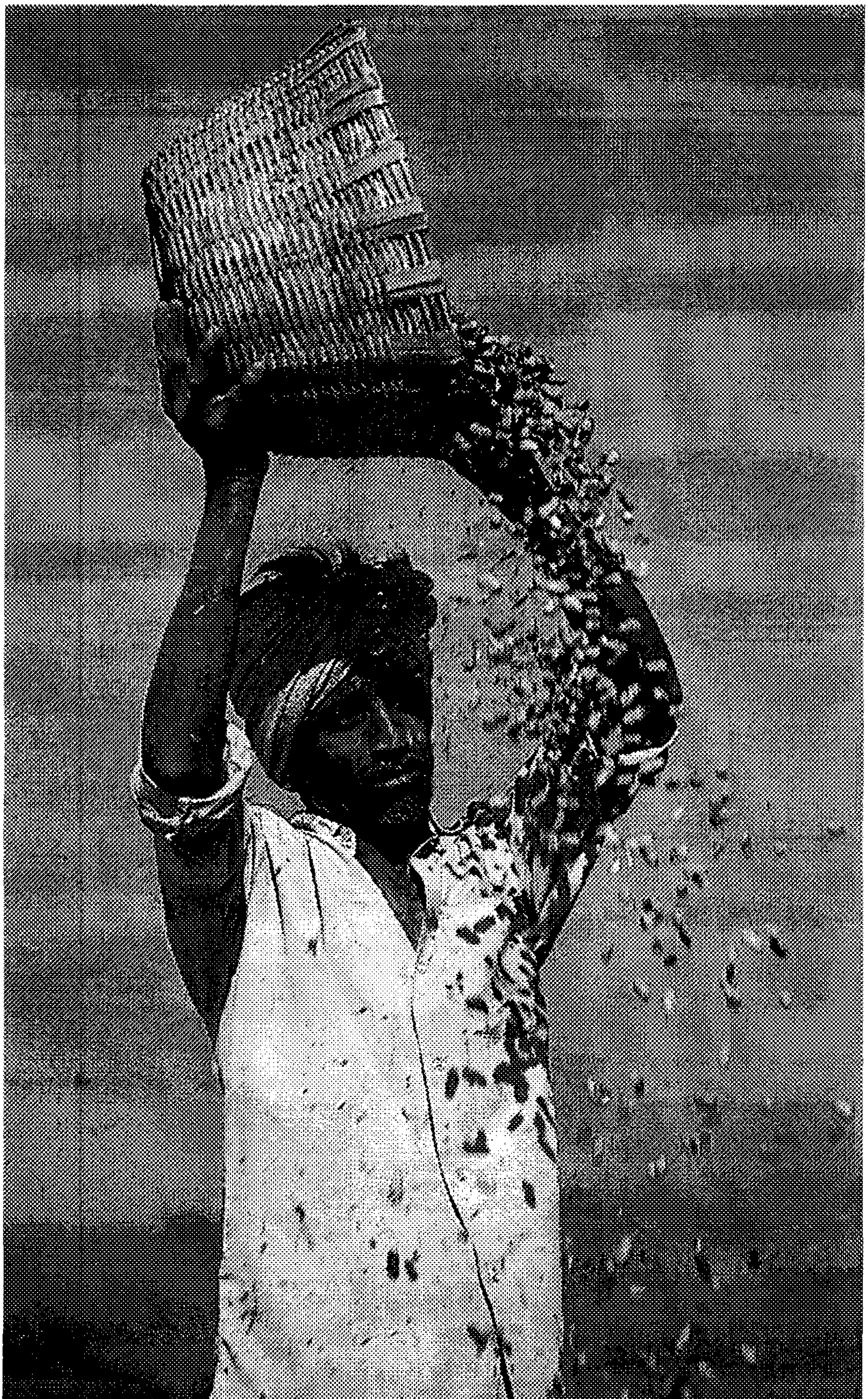
*Improvements in drilling technology in recent years have brought down the real cost of borewell construction. Rigs like this one are an increasingly common sight*

Largely as a result of these changes, the intensity of ground water extraction has significantly lowered the water table. In many hard rock areas, the water table is now too low for the shallow aquifer to re-establish in all but the wettest years. As a consequence shallow or open wells are almost permanently dry and farmers living in areas where neighbours have drilled deep borewells have found that their shallow wells have become unreliable or rendered defunct. They presently have no choice but to construct their own deep borewells in order to reclaim a share of the ground water resource. This, in turn, drives the process quicker and further to establish a vicious circle; the more deep borewells are drilled, the more water used, the lower the water table recedes, the more shallow and deep wells fail, the more farmers drill deeper or additional borewells and so on.

## Groundwater and drought protection

People living in semi-arid areas are, of course, no strangers to drought. Not only is the amount of rainfall highly unpredictable, but the climatic conditions are such that more of it evaporates away than would be the case in more temperate regions. People in northeastern Karnataka generally believe that, in every decade, there will be five droughts of differing severity; two of these will be moderate, two will be severe and one will be catastrophic.

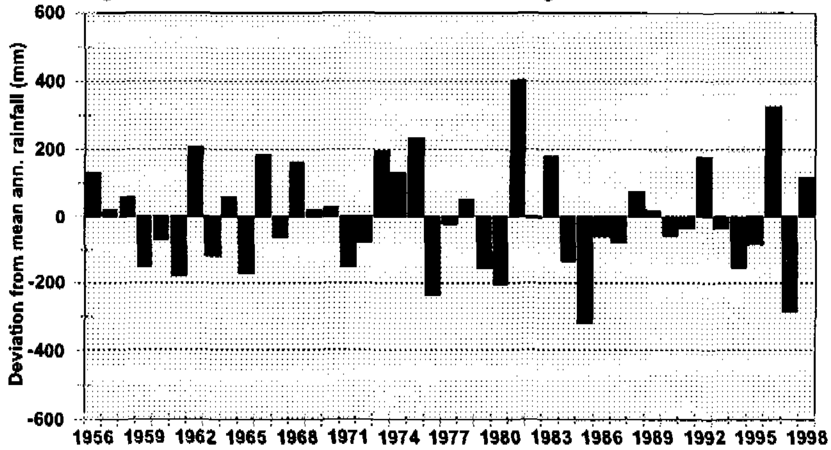
In the extreme, drought preparedness can therefore mean the difference between life and death. In general, lack of drought preparedness is a major cause of poverty. For many people, drought has a major impact on their livelihoods. It is a simple fact that the shock of droughts and other natural disasters has a relatively greater and a longer impact on the livelihoods of the poor. Having sufficient reserves of ground water is the only long-term way in which people living in semi-arid or arid areas can protect themselves against drought. In theory, these reserves should be large enough to meet basic human and livestock needs for a period of at least 18 months so that communities can survive a year in which groundwater recharge is insignificant. However, in practice, the potential amount



Most farming practices are based on significant labour inputs of ground water available varies according to the geology of the area and the pattern and intensity of groundwater extraction. Secondly, extraction of ground water for irrigation has reached such intensity that the ground water buffer has all but disappeared. Whilst the first factor is environmental and cannot be changed by the actions of people living in the area, the second is very much within human control.

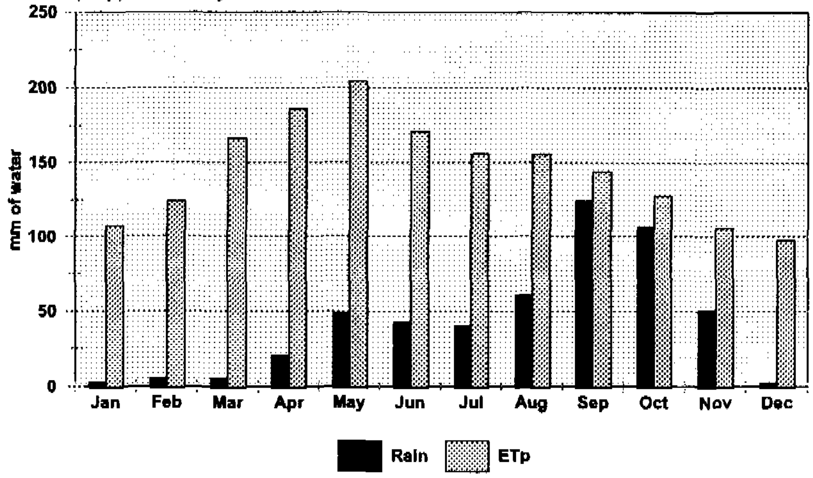
Just as the rains can be shortlived, they can also be torrential. The challenge for people living in these areas therefore, is how to adapt their agriculture to cope both with low rainfall as well as to make the best possible use of rain when it does fall abundantly. It should be noted also that floods in dryland areas can cause major shocks to livelihoods by destroying crops, houses and infrastructure. Again awareness and preparedness are crucial.

**Figure 4. Deviation in annual rainfall from the long- term mean**

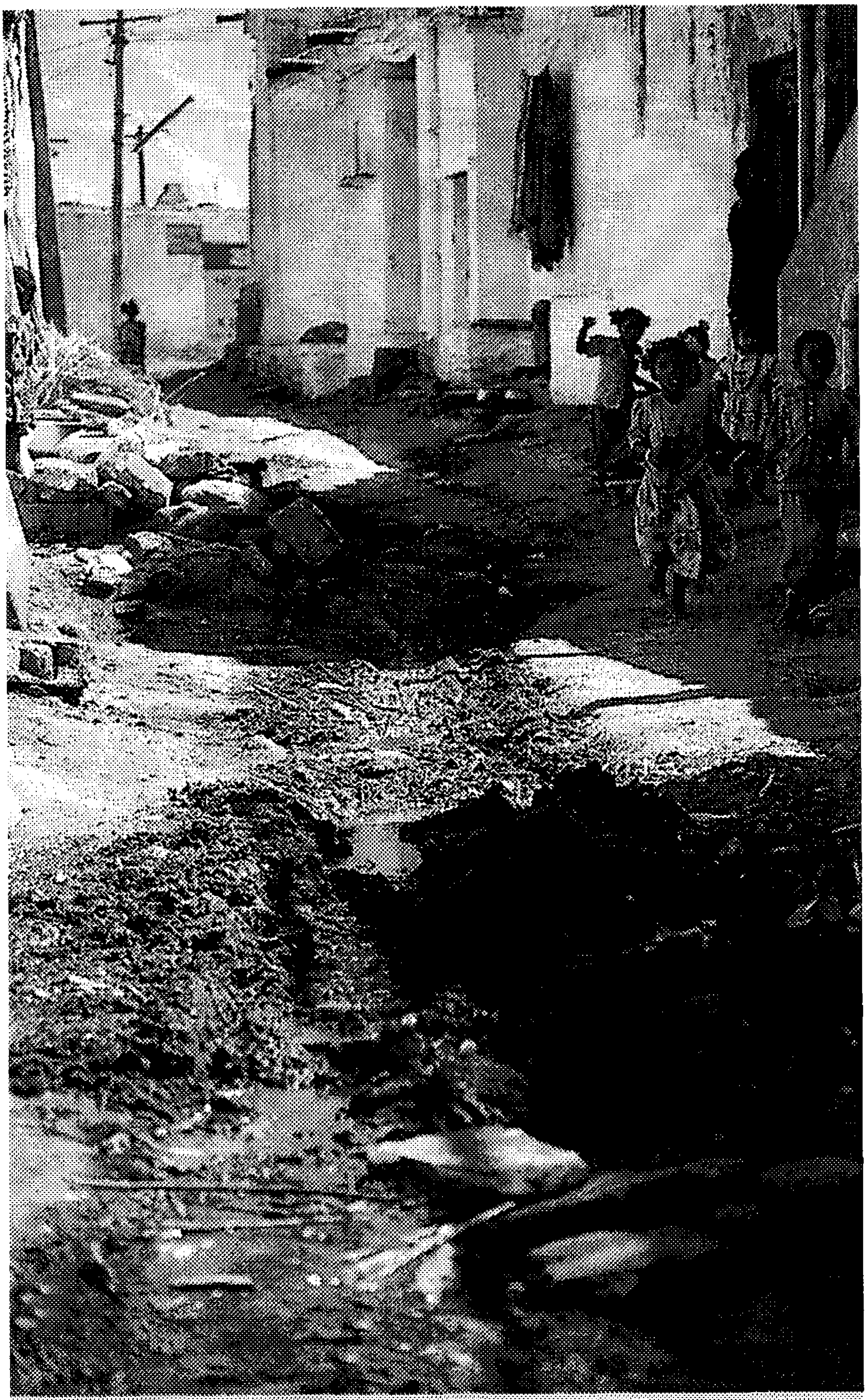



( Figure 4) Rainfall in the three KAWAD project watersheds, although seasonal in nature, is unpredictable during the rainy season. This graph shows how each year's rainfall differed from the average over a period of 42 years. The horizontal line running across the middle of this graph, at point zero on the vertical axis, represents the average rainfall that KAWAD project areas had between 1956 and 1998. The coloured bars show how much the actual rainfall in any given year deviated from the average. The actual rainfall was within 25mm of the average for only 11 of the 42 years. For 24 of the 42 years, actual rainfall exceeded or fell short of the average by more than 100mm.

**Figure 5. Monthly mean rainfall and Penman potential evaporation (ETp) for Bellary. Source: FAO CLIMWAT**

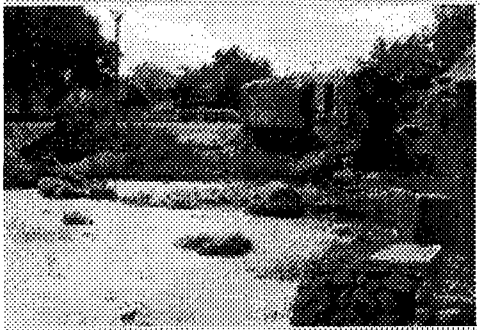



( figure 5 ) On average, there is no month during the year when the amount of rain falling on the land is more than the amount that potentially can evaporate from it. To fulfil their maximum growth potential, crops need an optimum amount of water to be available at all times. The widely fluctuating levels of soil moisture available to plant roots prevent crops from achieving their growth potential.



*Poor drainage in village areas poses a significant health risk*

# 3 ASKING FOR MORE



*Village tanks are becoming increasingly polluted as a result of poor drainage and sanitation systems*

There are two main ways of meeting the challenge: increase the amount of available water, or reduce the demand for it. To date, much more effort has been made by government and the private sector to improve the supply side of this equation by constructing new wells, by de-silting tanks, by building dams or canals to transfer water from one basin to another, by harvesting rainfall, and so on. However, a much wider range of policies and actions could be adopted, particularly on the demand side of the equation.

**Policies for promoting more efficient use of water (After Winpenny, 1994)**

| Category | Actions and instruments |
|---|---|
| 1. Enabling conditions | Institutional and legal changes<br>Macro-economic and sectoral policy changes |
| 2. Demand management incentives and disincentives | *Market-based:*<br>Active use of water and/or electricity tariffs<br>Groundwater markets<br>Surface water markets<br>Auctions<br>Water banking<br>*Non-market:*<br>Restrictions and/or zoning<br>Quotas, norms, licenses<br>Exhortations, public information |

## Water conservation

Whilst there are incentives to exploit ground water there are no incentives for people with access to large volumes of water to conserve water or to use it more efficiently and productively. This applies both to agricultural and domestic use. Water is used efficiently only when farmers or households have access to limited amounts of water, when they have to put considerable effort into fetching and carrying it. Interestingly in the case of domestic water use, water is often used efficiently only once it has been carried from the water point to the house. Large amounts of water are often wasted around the water point itself. This suggests that very little value is put on the commodity.

For all three watersheds for which data have been analysed, on average, evaporation accounts for around 95 per cent of the water balance, with average run-off from these watersheds amounting to only 5 per cent and 2 per cent of rainfall for the watersheds that are underlain by Deccan basalt and crystalline basement geologies respectively. Hence, the fate of around 95 per cent of rainfall is evaporation either from water bodies, from vegetation or from bare soil or rock.

So far, the greatest efforts of the watershed development programme have been made in reducing runoff and increasing storage by constructing additional soil and water harvesting structures (e.g. gully checks, gully plugs and nala bunds etc. Tree planting and improving certain agronomic practices have also been promoted as a means of reducing the amount of rainfall lost to runoff.

The rationale behind these measures is that, although rainfall is erratic, there is enough water reaching the area annually to meet the demand for both farming and domestic use. The problem is perceived as a loss of water as runoff, due to lack of vegetation cover, lack of structures to conserve water, lack of sufficient storage capacity and poor management of common lands. If rainfall could be captured where it falls and stored for later use, the argument goes, aquifers could be kept sufficiently recharged and people could protect themselves against the worst effects of drought as well as enjoy ample supplies of water for domestic and economic purposes. However, the story is not as straightforward as it is often made out to be. The success of the current approach depends crucially on two factors:

1. **The demand for water is less than the supply.**
2. **Appreciable quantities of water are being lost as runoff.**

For the KAWAD project area, however, neither of these factors apply.

### Demand is set to double in the next 30 years

In the three watersheds studied, on average, the amount of groundwater extracted each year for domestic and farming uses is roughly the same as the amount of water being replenished through groundwater recharge. Demand for water, however, continues to rise as irrigation increases and the aquifers in the three watersheds continue to be depleted. There is no evidence that the trend for drilling deep borewells is slowing, nor is there currently any suggestion that the incentives for doing so are to be discontinued or weakened in any way. However, estimates can be made of the likely future demand for water supply and sanitation and for watering livestock. Based on an estimated growth rate of 2.5 per cent for the human population of the three watersheds, a growth rate of 1 per cent for livestock population and an estimated consumption of 40 litres of water per capita per day, it is likely that the demand for water will double in the next 30 years. (see Table 1).

**Table 1. Current and future demand for water for domestic water supply and sanitation (WSS) and for livestock as percentage of average annual rainfall and groundwater recharge**

| Watershed | Domestic water supply and sanitation & livestock demand | | | |
|---|---|---|---|---|
| | Year 2000 | | Year 2030 | |
| | % rainfall | % recharge | % rainfall | % recharge |
| Doddahalla | 0.7 | 3.2 | 1.3 | 6.2 |
| Upparahalla | 0.6 | 9.8 | 1.1 | 19.0 |
| Chinnahagari | 0.9 | 11.6 | 1.8 | 22.3 |

Water for drinking, sanitation and livestock is met by pumping groundwater either by hand or by electrically operated submersible pumps. In years of normal rainfall, the current demand for water for domestic and livestock use in Upparahalla and Chinnahagari watersheds is 9-12 per cent of the ground water recharge, already a fairly high proportion. By 2030, this is estimated to rise to 19-23 per cent.

### Runoff is low

The drive to build rainfall-harvesting structures is partly fuelled by a widespread misconception that runoff accounts for about 30 per cent of annual rainfall. However, data from Central Water Commission gauging stations indicate that there is far less runoff available for harvesting in the Doddahalla and Chinnahagari watersheds. The average annual percentage runoff for Doddahalla and Chinnahagari rivers, for 1985-1995, was 5.9 per cent and 1.8 per cent respectively.

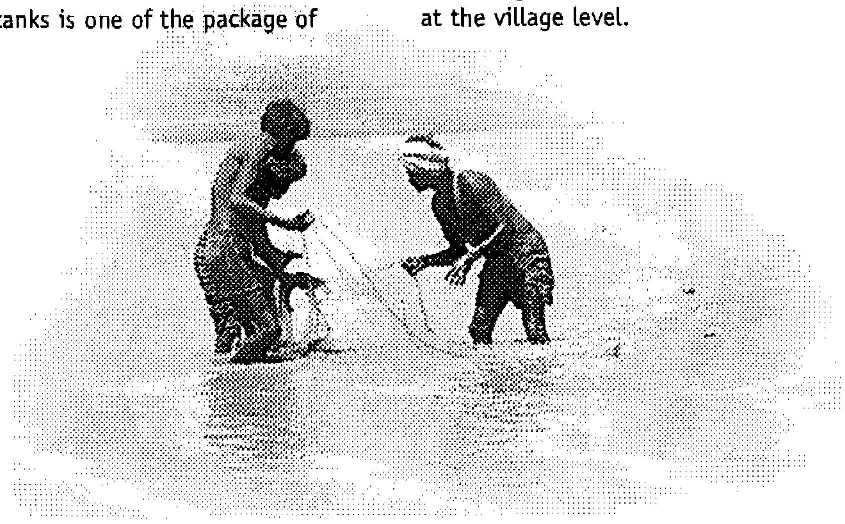
These very low figures are probably less surprising given the low rainfall, well-drained soils of Chinnahagari and Upparahalla and the existence of large numbers of runoff-harvesting structures.

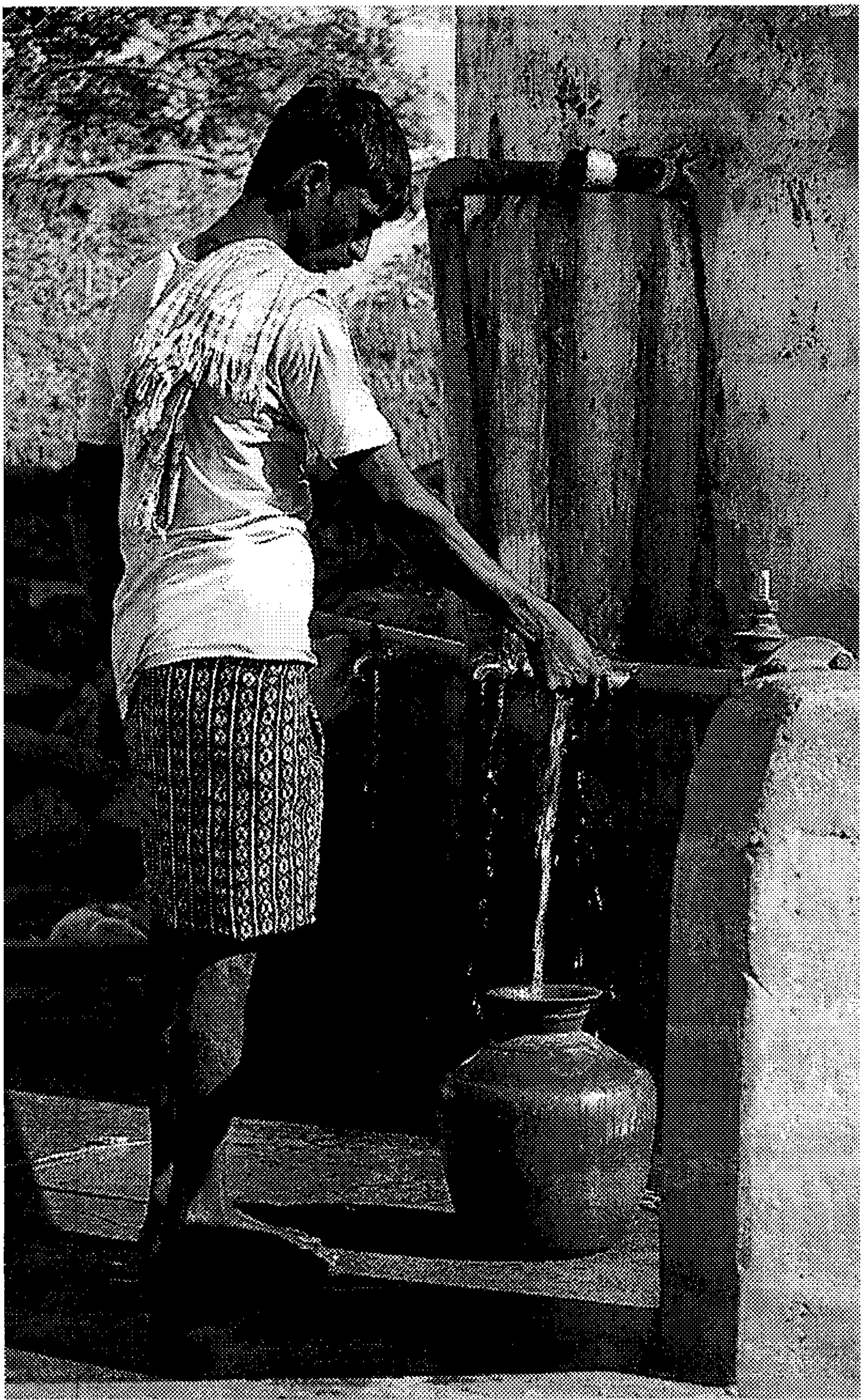
Tanks that are still capable of storing water help to reduce the amount of runoff reaching rivers. Although tanks are still used for activities such as fish farming and watering livestock, the majority of tanks are no longer used directly as sources of irrigation water. It is often the case that de-silting tanks is one of the package of measures implemented to increase the capture of surface water, the assumption being that runoff is available to replenish the tanks. However, in areas where the groundwater table is no longer high enough to allow streams to flow perennially, inflows into tanks have decreased.

### The other side of the equation

Given the effort already expended, there is little scope for increasing water supply by further development of the resource and attention must focus on the 'demand' side of the equation. The stark truth is that unless steps are taken soon to re-establish the ground water reserves in areas close to villages, there will be a catastrophic drought in the KAWAD project areas. Given the similarity in the hydrogeology of the rest of northeastern Karnataka and Western Andhra Pradesh, the poorest people living in these areas cannot expect to see long-term improvements in their livelihoods unless this problem is tackled.

The good news is that the situation is not hopeless. There is much that can be done to ensure the sustainability of adequate supplies of water for domestic and livestock use, and the equitable exploitation of the surplus. In order to achieve this, however, hard political decisions must be taken and awareness of the true nature of water resource challenges needs to be enhanced at all levels. It is also clear that institutions and organisations that have been involved in watershed development have the capacity to promote and initiate the changes that are needed, in particular, at the village level.





A lot of water is wasted as a result of poorly maintained water supply systems

# 4 NO QUICK FIXES

*Livestock are an important part of farming systems in semi-arid India*

*Transplanting paddy*

As we have seen, there is very little scope for further development of water resources in the three watersheds studied. It is certainly the case that trends of water availability and patterns of use are sufficiently complex to prohibit the blanket prescription or 'off-the-shelf packages' of measures for watershed development. 'Quick fixes' ignore the stark reality that, on a watershed scale, less than 2 per cent of runoff is available for capture. This matter of 'scale' is crucially important to appropriate management.

At the scale of one village, clusters of villages, or perhaps even slightly larger units, community-led initiatives for small-scale water development may yield the desired results; one or more villages may benefit
but only at the expense of other villages. Success at the micro level certainly does not necessarily predict success at a watershed level or at larger scale.

In the light of this and other findings of the Water Resources Audit, KAWAD should shift its focus to appropriate management of water resources of the three watersheds for which it is responsible. By extension, the same is likely to be true for other semi-arid areas with similar hydrogeological characteristics. Whilst the logic behind this shift in focus may be appreciated, it is much more challenging to find acceptable management solutions. It is instructive to consider the types of options identified by the KAWAD Water Resources Audit for the three watersheds and then to turn to broader recommendations for semi-arid areas in general.

*[1]Batchelor, C., Rama Mohan Rao, M., Mukherjee, K., Watershed development - or should it be watershed management?, Case Study 12. FAO E-Workshop: "Land-Water Linkages in Rural Watersheds", 18 Sept - 27 Oct 2000 (http/www.fao.org/ag/aglwatershed/)*

'Lessons' for KAWAD

The results of the Water Resources Audit clearly show that KAWAD should[1]:

**Shift its focus to water resource management as opposed to water resource development;**

**Choose from the many alternative water management options identified (and others yet to be identified), all of which have the potential to increase the productivity of water use and/or to improve equitable access to water resources;**

**Consider the tradeoffs associated with changing patterns of water use and select options that maximise the social and economic value of water in any given setting at the watershed scale. (In most cases, this means giving drinking water the highest priority.)**

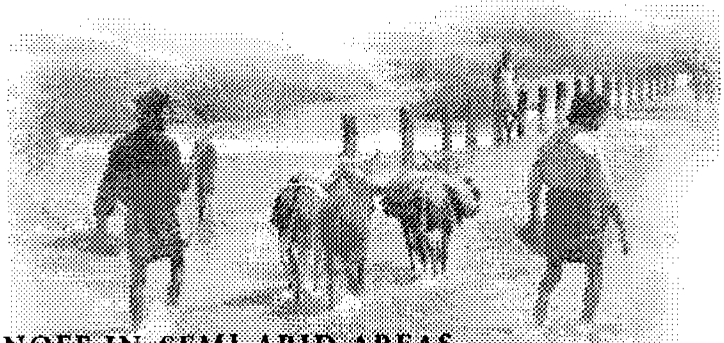
**Develop and facilitate a participatory decision making process amongst stakeholders such that they decide which lower-priority uses are of the highest social and economic value.**

# MYTHS ABOUT WATER

Below are some of the more common misconceptions about groundwater, runoff and crop water use. Subscription to myths such as these can lead to poor decision-making and wastage of human and financial resources.

## 1 AQUIFERS ARE UNDERGROUND LAKES

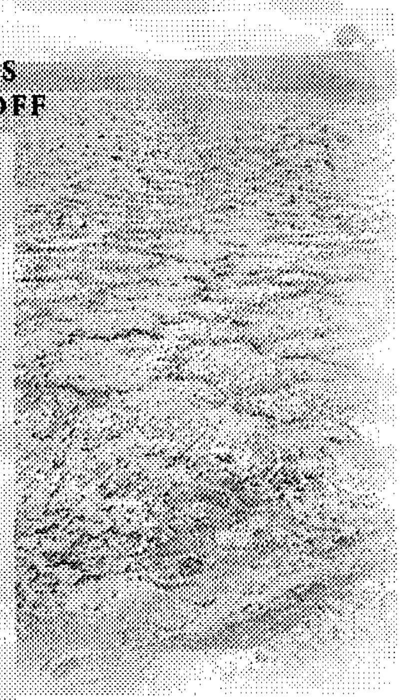
**The observation that water tables have risen in wells that are immediately adjacent to check dams is often recounted as an indicator of success of watershed development programmes. Unfortunately, many such reports fail to recognise the fact that, in semi-arid areas that are underlain by hardrock aquifers, structures such as check dams, even in the absence of increased groundwater extraction, rarely lead to regional rises in groundwater water levels. The reality is that check dams and other such water-harvesting structures usually have only localised impacts on the water table and aquifers rarely behave like underground lakes (i.e. that localised recharge in one place leads to an immediate rise in groundwater levels at another place many hundreds of metres away). Aquifers are geological formations that contain groundwater. In simple terms, groundwater is water that accumulates underground and is stored in the pore spaces that exist in sediments or weathered materials and/or in the fractures in rocks such as granites or basalts. Groundwater is in continuous slow motion in the direction of potential gradients that are created by gravity and capillary forces. In areas of permeable subsoil, excess rainwater travels through the soil and the unsaturated layer below. When it reaches the water-table and joins the aquifer, it begins a slow underground journey, typically at rates ranging from a few millimetres to a few metres per day. Eventually it finds outlets, such as riverbeds, wetland seepages, natural springs etc. Drawing groundwater from wells can have a big impact on groundwater regimes and availability. Cones of depression in the water table are created around wells and these influence potential gradients and, hence, the speed and direction of water movement.**



## 2 RUNOFF IN SEMI-ARID AREAS IS 30-40 PER CENT OF ANNUAL RAINFALL

**Although localised runoff, and runoff from individual storms can be high, annual runoff in semi-arid areas - at scales larger than the micro-watershed - tends to be much lower than 30-40 per cent. In large areas of semi-arid India, mean annual runoff is lower than 5 per cent of annual rainfall. Groundwater extraction, soil water conservation and construction of water harvesting structures have all contributed to a further reduction in mean annual runoff. This fact explains why, in the areas surveyed by the KAWAD Water Resources Audit, inflows to tanks are significantly reduced and why rivers that were once perennial are now seasonal.**

## 3 PLANTING TREES INCREASES LOCAL RAINFALL AND RUNOFF

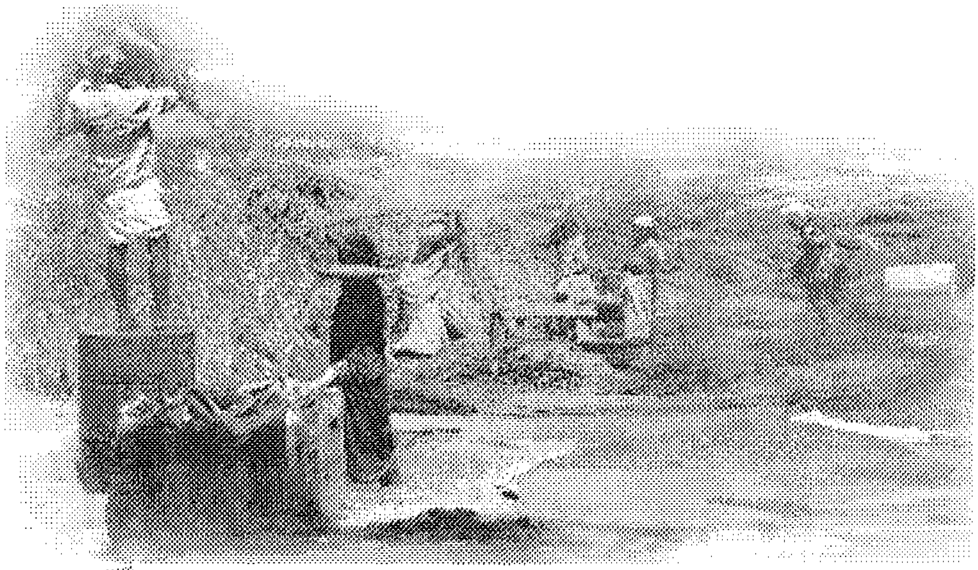


**The worldwide evidence that high hills and mountains usually have more rainfall and more natural forests than do the adjacent lowlands has historically led to confusion of cause and effect (Pereira 1989[1]). The reality is that forests exert a small, almost insignificant, influence on local rainfall (Calder, 1999[2]). Notwithstanding a small number of exceptions, catchment experiments generally indicate reduced runoff from forested areas as compared with those under shorter vegetation (Calder, 1999).**

*[1] Pereira HC, 1989. Policy and practice in the management of tropical watersheds. Westview Press, Colorado, USA.*
*[2] Calder IR, 1999. The Blue Revolution: Land use and integrated water resources management Earthscan, London*

## 4 RAINFALL HAS DECREASED IN RECENT YEARS

**Studies of long-term rainfall records have, to date, shown no systematic trends in annual rainfall in semi arid areas of India, despite widespread reporting to the contrary.**



## 5 WATER USE OF CROPS DEPENDS MAINLY ON CROP TYPE

A common misconception is that the daily water use of crops is directly related to the crop type and that the evaporation rates from certain crops are many times higher from some crops as compared to others. The reality is that, assuming that a crop is well supplied with water, the evaporation process is driven primarily by the meteorological conditions (e.g. radiation, wind speed, dryness of the air).

## 6 AQUIFERS ONCE DEPLETED STAY DEPLETED

A pessimistic view of aquifer depletion is that this is an irreversible process. The reality is that, in most cases, aquifers can be reestablished or replenished as long as the balance between recharge and extraction is swung towards recharge. This can occur as a result of higher than average rainfall or a reduction in groundwater extraction. There is nothing inherently wrong in extracting groundwater. So long as supplies of drinking water, water for domestic use and wildlife are not endangered, extraction of groundwater for agriculture and other livelihood uses is sensible. Moreover, there is some evidence to suggest that optimum use of groundwater resources is good for the long-term 'productivity' of aquifers.
For example, in certain areas of the watersheds surveyed, it appears that increased extraction of groundwater has actually led to an increase in annual recharge. This is because groundwater extraction has a direct influence on the potential storage volume of the aquifer, particularly at the beginning of the rainy season.