A strategy for drought mitigation using groundwater: a case study in Kolar district, Karnataka State, India

C. NAGANNA
School of Earth Sciences, Bangalore University, Bangalore 560 056, India

Y. LINGARAJU
Department of Mines and Geology, Government of Karnataka, Bangalore, India

Abstract Karnataka, one of the southern states of India, has an area of 192,204 km$^2$; of this nearly one third is constantly affected by drought. Based on various factors responsible for causing drought conditions, the Kolar district has been identified as one of the chronically drought prone areas. Reviewing different drought mitigation strategies that are in vogue in India, one finds that there is a dominance of irrigation and associated dryland agricultural programmes. These measures involve only the utilization of surface water. Through an analysis of the physiographic and geological conditions in the state, a new strategy is proposed to use the groundwater which is likely to be flowing along the east-west running lineament connecting the western water surplus areas to the water deficit areas of the east. To test this hypothesis a small basin in Kolar district was selected. Refining the lineament map already prepared by ground check within the basin selected, a number of sites were located along these lineaments. The average yield of these wells is 4 to 5 times higher than the average yield of the wells in the basin outside the lineament. Since some of these lineaments cut the water divide and extend up to the water surplus west, it is inferred that there is a flow of water across the water divide from the west and by properly managing the supply of water from these wells situated on the lineament, a permanent solution can be worked out for drought mitigation.

INTRODUCTION

The water resources in India depend on the monsoons, 70% of which occur during the monsoon season (June–November). Besides this, there are large tracts of land depending entirely on localized showers for their water needs. While there is sufficient shift in the period of the more dependable monsoons, the localized showers are totally undependable. This will completely upset the rather rigid agricultural programme of the Indian farmer resulting in situations coming under the definition of drought. Drought in
general may be defined as a "lack of rainfall" sufficiently large, and for a sufficiently long period, as to effect adversely plants, water supply for domestic purpose, operation of power etc. Drought, though essentially a meteorological phenomena, can be of three categories, (a) meteorological drought, a situation when the actual rainfall is significantly less than the climatologically expected rainfall; (b) hydrological drought, associated with the depletion of surface water, consequent drying up of lakes, river, reservoirs etc (a hydrological drought may result if meteorological drought is sufficiently prolonged); (c) agricultural drought, when soil moisture is inadequate to support a healthy growth of crops to maturity.

Past records show that drought conditions have existed in India since the eleventh century, some of which were very severe. Bhatia (1967) has systematically worked out drought periods in India since 1799. From this study it is evident that fairly severe drought conditions have occurred in India in some parts of other, once in two to five years. In Karnataka, the south-eastern and middle interior are the regions which are often affected (Fig. 1).

A review of the action of the Government for the past 30 years can only indicate some major and minor irrigation projects coming into being in the chronically drought-prone areas. Except for the Tungabhadra project, whose waters can flow into less than 5% of the chronically drought affected areas of Karnataka, the other projects are not designed to overcome the drought conditions. The minor irrigation projects in the area appear to have been undertaken more by way of providing employment to the local population during drought, rather than as a real mitigation strategy. Consequently, recurrence of drought has become a regular feature. The present study is intended to focus the attention of the planners on the possible mitigation strategies which are more permanent in nature by selecting an area for the case study (Fig. 1).

DROUGHT PRONE AREAS KARNATAKA

Drought prone areas of Karnataka have delimited on the basis of annual rainfall, rainfall variability, soil moisture characteristics, annual potential evapotranspiration, water surplus and index of aridity (Barai & Naganna, 1978). The drought-affected, north–south zone comprising 111 taluks in Bijapur, Belgaum, Gulbarga, Raichur, Chitradurga, Tumkur and Kolar districts with less than 700 mm annual rainfall lie in eastern part of the State (Fig. 1). This zone can be further delimited into four zones of drought intensity as, moderate, large, severe and disastrous drought conditions.

STUDY AREA

The Kolar region covering Kolar district was selected as the study area, mainly because according to the classification of drought in Karnataka it has moderate drought, with semi-arid conditions and is subjected to dryness. Kolar, Gulbarga, Raichur and Bijapur districts in Karnataka are the only
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drought-affected areas which do not have an assured supply of water by an of the means of surface irrigation. While the contemplated massive river valley projects in the Krishna River basin can bring some relief to the drought affected areas in the northern districts of Karnataka, there appears to have been no major attempt made to mitigate the drought condition in Kolar district. Kolar in 1980 had only 2–3% of the normal annual rainfall of 730 mm. In such a drought-affected area, an effective drought mitigation strategy needs to be evolved so that some assured supply of water is made available. Kolar district is situated between 12° 46' and 13° 58' N and 77° 21' and 78° 35' E, with an area of 8236.5 km².

GEOLOGY

Geologically the area is composed of crystalline complex of Precambrian age.
The rock types are gneisses of varying grain size and gneissosity, intrusive granites, various types of schists formed by metavolcanics and metasediments, younger basic dykes etc. The areas has suffered repeated tectonic disturbance and the famous gold mines which are known to be the deepest in the world are situated at the contact between the granitoids and the schists. Due to tectonic disturbance there are fractures, joints, faults, shear zones, and lineaments are very well developed. A prolonged weathering has created a thick mantle of soil representing A, B, C horizons in many places sometimes extending to tens of metres.

PHYSIOGRAPHY

The Kolar district is dotted by numerous hills and peaks of varying heights, particularly in the north. The principal chain of mountains is Nandidurga Range with the peak at 1617 m. Other peaks include Kalauardurga, Bharmagiri, Harahereshwarabetta and Divigiri. Further east is another range of hills of lower elevation forming a chain to the west of Kolar town. A third low line of hills lies to the south of Bangarpet.

There are no perennial rivers in Kolar. Most channels are small and carry water only in the rainy season. Three important rivers are the Palar, South Pennar and North Pennar. Several of the tributaries to these rivers have their origins in the district and flow in different directions.

CLIMATE

The average rainfall of the district is 730 mm, about 70% of its occurring during the southwest monsoon. September–October usually records the highest rainfall; which is also associated with thunderstorms. These were wide variations in rainfall recorded over a 50-year period. In 11 out of 50 years rainfall was less than 80% of the normal. Though the district as a whole did not record two consecutive years with rainfall less than 80% of the normal, such occasions are known at individual stations.

Temperatures indicate a rise from March to May, recording the highest of 40°C. With the advance of the southwest monsoons, temperature decreases till September–October. The withdrawal of the southwest monsoon records the lowest temperatures in December with 25°C (maximum) and 20.6°C (minimum). Relative humidity is high in the southwest monsoon period.

STRATEGIES FOR DROUGHT MITIGATION

A number of strategies have been suggested for drought mitigation in India, many of which are sociological. However, Bali (1979), Rao Ranganathan (1979) and Ramamurthy (1979), have suggested some physical methods. Mr K. L. Rao, who as the Minister for Irrigation, Government of India in 1971,
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had plans to bring the surplus waters of the River Ganga to be linked with rainfed rivers of the south by pumping the water over a head of 550 m using $7 \times 10^6$ kW of power. This has remained only as a plan. The other methods suggested are very general in nature, suggesting interbasin transfer of surface water and no one has considered the possibility of using the groundwater except the author (Naganna, 1979), who proposed a hypothesis which required testing.

![Average annual rainfall (in mm) in Karnataka State, southern India.](image)

**Fig. 2** Average annual rainfall (in mm) in Karnataka State, southern India.

**UTILIZATION OF GROUNDWATER FLOWING THROUGH DEEP SEATED LINEAMENTS : A HYPOTHESIS**

Naganna (1979) has hypothesized that there is a western belt lying along the western coast of Karnataka comprising of high mountains of the Western
Ghats. This region receives very heavy rainfall ranging from 1000 to 4000 mm and this Ghat forms the water divide for the east and west flowing rivers (Fig. 2). Further, as confirmed by the exploratory work in Kudremukh, Bababudan and Kemmangundi, and further north in Belgaum, there is a thick weathered mantle providing sufficient media for the formation of a subsurface water reservoir. During the non-rainy season water from the subsurface water body through effluent seepage is discharged and flows as baseflow in all the rivers. This accounts for the discharge of groundwater wherever the water table intersects the surface.

![Fig. 3 East-west major lineaments in Karnataka State, southern India.](image)

The existence of east–west running lineaments in Karnataka is established by the study of Landsat image though their exact location on the ground is yet to be established in many places. These lineaments are found to exist all along Karnataka from north to south (Fig. 3) and must be transporting groundwater from the surplus western region to the east.
CASE STUDY

In order to verify the above hypothesis, the Palar basin in Kolar district was selected. By a close examination of the satellite imageries, the lineaments present in the basin were demarcated on the map. Location of these lineaments on the ground was made by a detailed geological and geophysical investigations involving resistivity profiling across the suspected lineaments on the ground. The linear extent of each one of these lineaments was traced by both geological and geophysical investigations. Further, by depth probes through electrical resistivity, sites were located along the lineaments. Bore holes were sunk to depths ranging from 50 to 80 m. Yield tests were
conducted in all the wells located along the lineaments. These details are indicated in Fig. 4. In this, there are wells yielding 2 to more than 12 l/s. A number of bore holes also exist outside these lineaments and yield tests were conducted in these wells and the average yield was noted to 4 to 5 times less than the minimum yield noticed in the wells sunk along the lineaments, with lower rate of recuperation. Further, it is also noticed that these lineaments cut across the water divide of the basin and some of them can be traced up to far western region of the State, where there is a surplus water storage in the subsurface.

CONCLUSION

From this it could be concluded that the best drought mitigation strategy would be to located the deep seated east–west lineaments which connect the water surplus of the Western Ghat region to the eastern chronically drought-stricken belt on the ground by detailed geological investigation and to sink deep boreholes to tap the water flowing along the lineaments. Yield tests conducted in these wells show a fair degree of consistent supply of water with a steady rate of recuperation. Therefore, proper management of this water can serve as a permanent drought mitigation strategy.

Acknowledgements The second author is indebted to the Director of the Department of Mines and Geology, Government of Karnataka, and the Karnataka Government for providing deputation to undertake this study.

REFERENCES


