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Groundwater Prospects of Shahbad Tehsil, Baran District, Eastern Rajasthan : A Remote Sensing Approach

K V RAVINDRAN* and A JEYARAM°
*Regional Remote Sensing Service Centre, Dehradun
°Regional Remote Sensing Service Centre, Nagpur

ABSTRACT

The relevance of satellite remote sensing in groundwater exploration stems from the utility of satellite images in identifying and delineating various features that may serve as direct or indirect indicators of the presence of groundwater. This paper presents the results of hydrogeomorphological mapping using IRS-1B LISS II data and evaluation of groundwater prospects of each hydrogeomorphologic unit on the basis of lithology, structure, landform and available aquifer data in the Shahbad tehsil, Baran district, Eastern Rajasthan. The study has shown that in the western parts of the area the Vindhyan sandstones (Lower Bhander) in which groundwater occurs under unconfined to confined conditions along bedding planes and fracture zones have vast potential for groundwater development through deep bore-wells or dug-cum-borewells, while in the eastern parts where shales dominate, large diameter dug-wells are suitable to tap the limited groundwater resources. Infiltration (or recharge) tube wells have been proposed to augment the sandstone aquifers.

Introduction

Remote Sensing technology has already been accepted as an effective complementary tool in natural resource mapping the world over. Satellite images are increasingly used in groundwater exploration because of their utility in identifying and outlining various ground features that may serve as direct or indirect indicators of the presence of groundwater. While the groundwater investigations in small areas can be tackled by field methods, a regional evaluation of groundwater potential requires data on a regional scale which is provided by satellite images. The common approach adopted is to visually interpret the images and prepare a

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hydrogeomorphological map in which various geomorphic units and landform features are delineated and evaluated in terms of their groundwater potential on the basis of underlying lithology, structural features, topography and available data on aquifer characteristics. This paper deals with the results of hydrogeomorphological investigation carried out in Shahbad Tehsil of Baran district, Eastern Rajasthan using satellite data and the recommendations for development and management of groundwater resources in the area. This study forms part of the nationwide project, the Integrated Mission for Sustainable Development (IMSD) which was taken up with the objective of generating site specific action plans for land and water resources management in selected districts/watersheds/ blocks, using remote sensing and conventional methods (RRSSC, 1994).

Study Area

Shahbad tehsil is situated in the south-eastern corner of Rajasthan and covers about 1470 sq. km. Physiographically it forms the extension of the Malwa plateau of Central India comprising low hills and gently undulating uplands made up of Vindhyan formations. The study area can be distinctly divided into two physiographic zones separated by a north-south escarpment. The eastern zone constitutes a highly irregular terrain with undulating surfaces and dissected hills carved out in the soft lithology (shale) by the river Kuno and its tributaries, while the western part consists of an almost flat or gentle westerly sloping surface that forms the dip slope of the Vindhyan sandstones which continue below the alluvium of Parbati river further west.

The area has dry sub-humid climate with an average annual rainfall of 800-900 mm. Nearly 50 per cent of the geographical area of Shahbad tehsil is under forest, 24 per cent under agriculture and 8 percent is wasteland (RRSSC, 1994).

Data Source and Methodology

IRS-1B LISS II geocoded FCCs of two dates (October 1992 and January 1993) on 1:50,000 scale, the corresponding SOI topographical maps of the area and the available data on depth to water table, aquifer parameters and groundwater quality were used for the study.

The methodology used consists of the following steps:

- Visual interpretation of satellite images to delineate various geomorphic units and landform features.
- Field verification of interpreted units and assessment of hydrological conditions.
- Finalization of hydrogeomorphological map and suggestions of action plan for groundwater development.

Geology of the Area

The predominant rock types that occur in the entire district belong to the Bhander group of the Vindhyan supergroup. A small area in the southern part exposes Deccan traps and along the river courses Quarternary alluvial deposits occur. The general stratigraphic sequence of the study area (after Raj and Reddy, 1976 and Jethra, 1984) is given in Table 1.

The Vindhyans in Shahbad area form the western extension of the great Vindhyan Basin of Central India. The lithology in the area belong to the lower part of Bhander group which consists mainly of sandstone, limestone and shale. Ganurgarh shale the lower most formation occurs as the dominant lithology in the eastern part, east of Shahbad escarpment. It is overlain by limestone, which is exposed as thin capping in the eastern parts and as 20-30 m thick beds along the escarpment. The most extensively exposed rock type in the area is the Bhander sandstone which occurs as homogenous, horizontal to gently dipping monotonous plateau

Table 1. Stratigraphy of the area.

Quarternary	:	Alluvium (Sand, Silt, Clay)	
.... Unconformity			
Cretaceous to Eocene	:	Deccan traps (basalt)	
.... Unconformity			
Upper Proterozoic to Lower Palaeozoic	:	Vindhyan Super group (Bhander group)	Lower Bhander sandstone Lower Bhander limestone Ganurgarh shale

surface to the west of the escarpment. The presence of patchy exposures of basalt over the sandstone surface indicates that this surface was once covered by Deccan trap which is still preserved in the form of residual hills and inselbergs. Quarternary alluvium and colluvium conceal the underlying Vindhyan formations along major rivers and streams.

Structurally, the Bhander formations are almost flat to gently dipping towards west in the western parts and show gentle flexures, warps and local folds. A number of major and minor lineaments traverse the area. The present Shahbad escarpment represents a prominent N-S trending fault. Two prominent lineaments along NW-SE and NE-SW directions intersect at Shahbad. Other lineaments follow major joint directions i.e., E-W, NW-SE and NE-SW, most of which control the drainage pattern in the area.

Hydrogeomorphology

The geomorphology of the area is highly influenced by the lithology and structure of the underlying formations. The horizontal to gently dipping sandstone exposed in the western part forms a plateau surface which stands out over the Shahbad escarpment and further west this surface gently slopes and merges with the alluvial plain of Parbati river. This dip slope which represents an undulating erosion surface with a veneer of residual and colluvial soil in the area is termed as pediment/pediplain. The depressions on this surface filled by alluvial and colluvial materials are termed as buried pediments (RRSSC, 1994).

Shahbad escarpment which forms the eastern edge of the plateau is deeply dissected and incised. A number of alluvial and colluvial fans and talus cones have developed at the foot of the escarpment, giving rise to an apron of piedmont slope. One such large fan is developed at Shahbad where two regional lineaments intersect. Further east, the Kuno river and its tributaries have carved out a broad irregular valley in the shale formation.

Based on visual interpretation of IRS-1B LISS II image (Fig. 1), the following units have been delineated and hydrogeomorphological map prepared (Fig. 2).

Units of fluvial origin: Valley fill, alluvial/ colluvial fans; piedmont.

Units of structural origin: Plateau (on sandstone and shales), dissected plateau (on shale and limestone).

Fig. 1. Colour Composite (Ba 342 - RGB) of IRS 1B LISS II of Shahbad Tehsil, Baran District, Rajasthan (29 January 1994)

Units of denudational origin: Pediment/ pediplain (over shale and sandstone), buried pediment, ravinous land, escarpment and residual hills.

Detailed description, the underlying lithology and groundwater prospect of the hydrogeomorphologic units are presented in Table 2.

Table 2. Hydrogeomorphology and groundwater prospects of Shahbad.

Map Symbol	*Geomorphic Unit*	*Description*	*Groundwater Prospects*
VF	Valley Fill	Unconsolidated alluvial and colluvial materials consisting of sand, silt, gravels, pebbles etc. deposited along valley. Underlain by sandstone and shale.	Good to very good depending on the thickness of deposits. Normally shallow suitable for open wells in shale region and for dug-cum-bore wells or bore wells in sandstone region.
BP(Sh)	Buried Pediment in shale	Depressions in the eroded pediment surface of shale are filled by unconsolidated weathered rock materials or alluvial/colluvial materials, mostly cultivated or vegetated. Thickness varies.	Good to moderate, depending on the thickness. Suitable for deep dug wells to tap bed rock aquifer.
BP(SS)	Buried Pediment in sandstone	Irregularities on the sandstone surface are filled by unconsolidated alluvial/ colluvial or weathered materials. Mostly vegetated or cultivated. Normally shallow. Underlain by sandstone.	Good to very good. Very good when fractures or lineaments associated. Suitable for borewells to tap water in sandstone aquifer.
P(Sh)	Pediment/Pediplain in shale	Irregular erosion surface in layered, horizontally bedded shales of Vindhyans. (Ganurgarh shales). Very thin layer of soil at places.	Poor to moderata depending on fractures/joints. Not suitable for ground water except along fractured and weathered zones.
P(SS)	Pediment/Pediplain in sandstone	Flat gently dipping sandstone surface with joints/fractures. Very thin cover of soil.	Good to moderate along wide fractures and fracture intersections where shallow borewells are suitable.
DP(Sh)	Dissected pediment in shale	Highly dissected irregular surface in shale with steep slopes and valleys. Run-off zone.	Generally poor. Unsuitable for groundwater exploration.

(Contd. ...)

Table 2 Continued..

Map Symbol	*Geomorphic Unit*	*Description*	*Groundwater Prospects*
Pt(Sh)	Plateau in shale	Horizontal beds of shale developed into plateau surface with irregular steeply sloping edges. No recharge to groundwater.	Generally poor. Larger diameter – wells may be dug for drinking water and irrigation.
Pt(SS)	Plateau in sandstone	Almost horizontal or gently diping sandstone bed for plateau with irregular edges and steep escarpment. Local depressions filled in thin layer or soil and lateritic material. Joints and fractures are present.	Good to moderate. Fractures and their intersections and bedding planes can yield good amount of water. Suitable for bore wells.
DPt(Sh)	Dissected Plateau in shale	Highly dissected plateau surface in shale.	Poor. Not suitable for groundwater development.
DPt(Lst)	Dissected plateau on limestone surface	Highly dissected plateau on limestone, forming as capping.	Poor. Not suitable for groundwater development.
BL	Ravinous area	Deep gullied ravinous area in silt or alluvium underlain by shale.	Poor. Unsuitable for groundwater.
SC	Scarp slope	Steep to vertical escarpment of irregularly edged plateau exposing various lithology.	Poor; but springs which occur where fractures interesect along this slope may form a source of water.
Pd	Piedmont	Zone of gently sloping surface made of talus or scree material often forming talus fans. Recharge zone.	Good recharge zone when the piedmont is wide. Not suitable for groundwater development.
RH	Residual hill	Isolated hills or mounds on pediment or plateau surface. Basalt/laterite cover.	Poor for groundwater.
	Colluvial fan	Comprises of scree of rock fragments along slopes.	Suitable for dug wells in the toe-zones.
	Lineaments	Fractures in sandstone/shale.	Very good in sandstone region. Moderate in shale. Deep bore wells in sandstone may give high yield.
	Springs	In joints of sandstone	Spring water may be harnessed: Continuously flowing water is a perennial source.

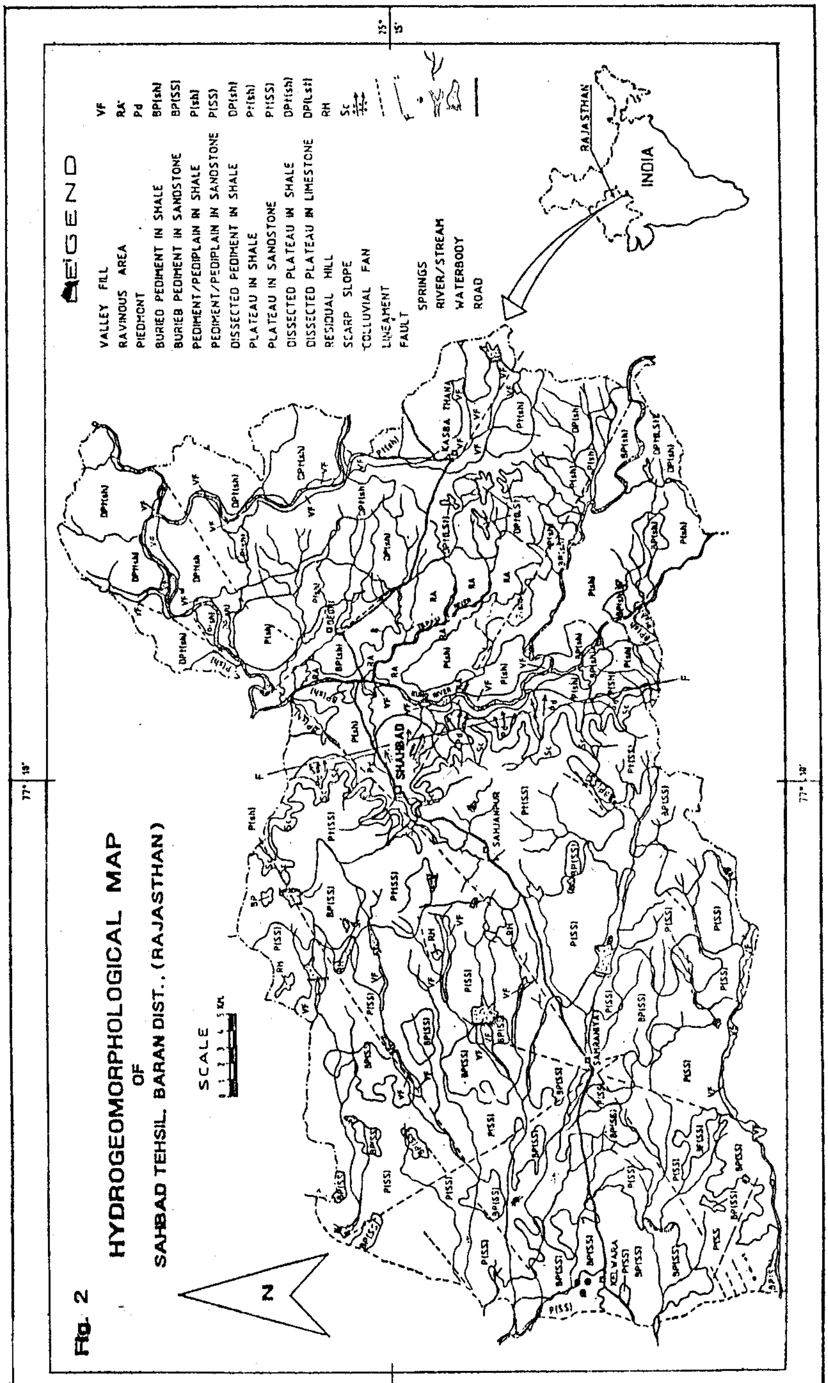
Fig. 2
HYDROGEOMORPHOLOGICAL MAP
OF
SAHBAD TEHSIL, BARAN DIST., (RAJASTHAN)
SCALE
N
LEGEND
VALLEY FILL VF
RAVINOUS AREA RA
PIEDMONT Pd
BURIED PEDIMENT IN SHALE BP(sh)
BURIED PEDIMENT IN SANDSTONE BP(SS)
PEDIMENT/PEDIPLAIN IN SHALE P(sh)
PEDIMENT/PEDIPLAIN IN SANDSTONE P(SS)
DISSECTED PEDIMENT IN SHALE DP(sh)
PLATEAU IN SHALE Pt(sh)
PLATEAU IN SANDSTONE Pt(SS)
DISSECTED PLATEAU IN SHALE DPt(sh)
DISSECTED PLATEAU IN LIMESTONE DPt(Lst)
RESIDUAL HILL RH
SCARP SLOPE Sc
COLLUVIAL FAN
LINEAMENT
FAULT
SPRINGS
RIVER/STREAM
WATERBODY
ROAD
RAJASTHAN
INDIA
SHAHBAD
KASBA THANA
SAHJANPUR
KELWARA

Fig. 2

Hydrogeology

Groundwater potential of the area has been evaluated on the basis of geomorphology, lithology, structure, surface drainage, location of springs, depth of weathering, lineaments and data on depth and fluctuation of water table and ground water yield. Based on the hydrogeological characteristics Shahbad can be broadly divided into two zones, viz., sandstone and shale zones.

Lower Bhander sandstone, which assumes a thickness of 100 to 130 m is invariably hard, compact and quartzitic in nature and forms the main aquifer zone in which groundwater occurs under unconfined to semi-confined (at places even confined) conditions along bedding planes, fractures and joints. The nature, size and extent of these openings control the quantity of groundwater and yields. Vertical fractures and horizontal bedding planes provide favourable opening for groundwater movement and storage. The wells tapping the sandstone aquifers give high yields ranging from 40,000 to 1,50,000 litres per day. Depth of water table varies from 2.3 to 23 m bgl. The NE-SW regional lineament passing through Shahbad, Mamoni and Samraniya is found to be highly productive as indicated by a tubewell drilled near Samaraniya along this zone. This well acts as an artesian well with the piezometric surface about 2 m above the ground level (RRSSC, 1994).

Ganurgarh shale that underlies the eastern zone is fractured and splintery in nature and acts as poor aquifer. Borewells and open wells yield water only in limited quantities. Many of the borewells go dry in summer. Some of the open wells yield 10,000 to 35,000 litres per day.

Unconsolidated sediments of buried pediments, valley fills and alluvium form shallow aquifers, with the depth to water table ranging from 4 to 13 m.

Groundwater Exploitation : Suggestions

Groundwater balance estimation carried out by Groundwater Department, Govt. of Rajasthan (1992) in Shahbad indicates that out of the total recharge of about 83 MCM, the utilizable ground water reserve comes to 73 MCM. Of this, only about 6 percent is being utilized at present, leaving another 69 MCM awaiting proper exploitation in the area. On the basis of the present study, the following structures have been recommended for development and management of groundwater in Shahbad.

a) *Tube wells and dug-cum-borewells:*

The sandstone terrain in the western part of Shahbad is recommended for tube-wells and dug-cum-borewells. Experience has shown that the tubewells of 60-80m depth can tap the aquifers in the bedding planes and fractures. Zones of prominent lineaments and lineament inter-sections are suited for such tubewells. In the buried pediments, open wells normally yield fairly good amount of water after monsoon. If these dug-wells are converted to dug-cum-borewells to tap the underlying sandstone aquifer, they will serve as additional source of irrigation during summer.

b) *Large diameter dug-wells:*

In the shale zone of eastern Shahbad, the existing borewells yield water just sufficient for drinking purposes. Dug-wells are mostly shallow and yield only limited quantity of water. Deeper wells with 10-20 m depth and 5 m diameter are recommended for storage of water from the slow yielding fractures and bedding planes of shale. Such wells are suggested to be located along the fracture zones and lineaments and in buried pediment and valley fills in the shale zone.

c) *Infiltration tube-wells:*

The sandstone being compact and

quartzitic, only a small part of the rain water can infiltrate into this aquifer through fractures and joints. The groundwater resource can be augmented by inducing artificial recharge through 30-40 m deep infiltration tube-well dug within large tanks and water bodies. Part of the water collected in these waterbodies, which would have otherwise evaporated in summer can be inducted into the aquifer by this way. Similarly, abandoned wells and other depressions can also be used for artificial recharge.

Conclusions

The study has shown that there is vast potential for groundwater exploitation in the Vindhyan sandstones of western Shahbad, in which groundwater occurs under confined to unconfined conditions along bedding planes, fractures and joints. Deep tubewells and dug-cum-borewells have been suggested in this region for groundwater development. On the other hand in the eastern part where the shales dominate large diameter dug-wells are recommended to tap the slow yielding aquifers. In addition, infiltration tube-wells are proposed in the waterbodies to enhance the recharge into the sandstone aquifer.

The study has also demonstrated the utility of satellite images in hydrogeomorphological mapping and groundwater prospecting in sedimentary basins of semi-arid regions.

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