

Scientific approaches for non-monsoon flow revival in Kanari river

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Groundwater (GW) is the dominant source of fresh water. Over exploitation of groundwater at a faster rate has resulted in sinking water tables. In coastal areas, the intrusion of saltwater from the sea is degrading the groundwater. Most groundwater can no longer be used for domestic consumption or irrigation because of saline intrusion, and the country has resorted to desalination. Sinking water tables also affect rivers since many river flows are maintained in the dry season by springs that dry up when water tables fall. The real challenge for river revival is maintaining the continuous discharge of GW into the river. Discharge takes place only because the lowest point of the regional water table is above the river's bed (which is the lowest point in the area). The moment it drops below river bed level, the discharge stops and flow in the river ceases. Therefore the challenge of a perennial river is to keep the water table above the bed level till the next monsoon. Measures for reviving Kanari river originating from Ghutehi hill region located at Ghutehi village have been taken. Estimate of the groundwater storage volume was calculated by considering the saturated thickness and specific yield. The identification of groundwater recharge zone as well as locations for artificial recharge structures within the Kanari river system was carried out by integrating satellite derived various thematic maps in GIS platform. Taking this in consideration the pumping overdraft of Kanari river watershed was calculated through which it can be concluded that if over drafting through pumping is considered then this additional recharge can fulfil the requirement and maintain the flow in the river.

Keywords: Groundwater, Monsoon flow, Water table

INDIAN rivers are monsoon rivers that have deep and wide floodplain aquifers that run for thousands of kilometres and are enormous natural storage for water. They get recharged by the river flow and floods, especially during the monsoon and feed groundwater aquifers in their environs. Given the increasing scarcity of water, they are likely to be one of the few perennial water resources of the future. The river flow regime widens considerably in the monsoon months and the flow regime can be segregated through the main river channel and areas adjacent to the main river channel. But for flow in the river throughout the year, we must try to understand the relation between the water table and the non-monsoon flow of rivers. Based

on the understanding, a flow revival movement may be initiated.

Kanari river is a river of Madhya Pradesh state in Central India. The river originates at Ghutehi hill at an elevation of about 490 m, whose latitude is 23.56441 and longitude is 80.11622, which is situated in Ghutehi village, Sihora, Jabalpur, Madhya Pradesh. Kanari river is a fifth-order river functioning as a tributary of the Hiran and Narmada rivers.

Preserve and use

In the present circumstances of water scarcity due to rising populations, agriculture demands and urbanization, the question that is assuming immense importance is how to use river water resources in a non-invasive way—Preserve

and Use. The maximum sustainable water use from a river that will maintain the ecological integrity of a river as a perennial resource is also an important aspect.

Like any other living being, the river needs to cleanse itself. This happens when the rain makes the river somewhat fast and furious, flushing out pollution, silt and still water algae. For Indian rivers this happens during the monsoon, when 80% of all rainfall occurs each year. It is during these periods of heavy rain that the river performs many essential functions. The much higher discharge during the monsoon markedly increases the velocity and depth of flow. This is essential for soil transport to avoid siltation of the river bed—a dire need for our rivers today.

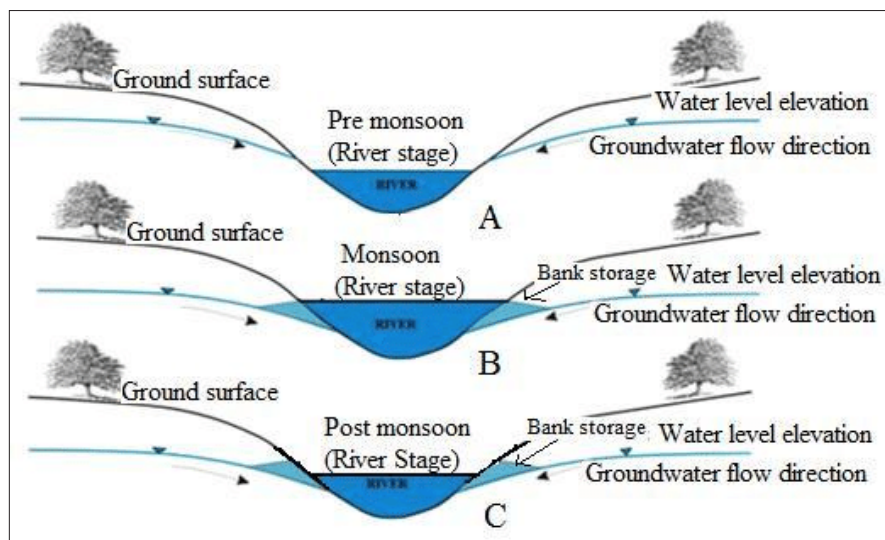
Recharge flows

The clayey soil in the Kanari river plain has aquifer parameters conducive to recharging the aquifer during a normal monsoon season. The water flowing through the river, the groundwater in river bank storage (flood plain just by the side of the river) and the other water bodies are in dynamic equilibrium. It is, thus, important to assess the desirable monsoon flow in river required for proper recharging of flood plain aquifers.

Besides, the wetting of the soil is also important as the good bacteria that can break down nitrates function only in the presence of water. These are strong reasons to maintain such ecological flows to preserve the recharge and quality of the water provided by the river, as aquifers are getting significantly impoverished.

Causes for declining non-monsoon flow in Kanari river

- **Groundwater overexploitation:** As water is pumped from a well, the adjacent water table will experience a drawdown, or become lower, if the rate of pumping exceeds the horizontal flow of water in the aquifer. Like any renewable resource, groundwater can be tapped indefinitely as long as the rate of extraction does not exceed the rate of replenishment.
- **Deforestation:** The effects of deforestation such as soil erosion, increased runoff, sedimentation and siltation caused rivers to swell out of their banks. Excessive tree-cutting also leads to siltation of reservoirs, reduces hydroelectric power capacity and thereby reduces electricity output, i.e. one of the gains that justifies the building of large multipurpose dams. Furthermore, tree removal also affects groundwater recharge by affecting infiltration capacity and reducing the baseflow of the river. The drainage basin of a river is an open system with inputs and outputs. The gains from interference with a river's natural flow may not outweigh the multiple intersecting



Dynamics of river flow

problems produced that often create snowballing conditions. Changing rainfall and weather patterns associated with climate change will only exacerbate these existing problems.

- **Mining:** In the process of mining, when digging is undertaken, and when such activity extends below the water table, the working areas experience an inflow of water so much, that in some cases inundation takes place extending the danger of loss of life and property. Thus pumping becomes an integral part of mining. In a normal process, the water table represents a rest-level surface with some hydraulic gradient depending upon the disposition of various types of rocks, their porosity, frequency of occurrence of breaks and bedding planes, and the rainfall preceding the period in question. This level of water will fall in the vicinity of a shaft through which pumping is undertaken. This will occur equally in all directions from the shaft, assuming similar ground conditions. The level of water in the shaft is then known as the depressed or pumped water level, from the plane joining the water level in the ground around it is referred to as the cone of depression. Such pumping operation in various points due to mining in the region will cause resultant depression of water level. This is the cause of the

lowering of the water table.

Scientific approaches for non-monsoon flow revival in Kanari river

The present study based on suggesting measures for reviving Kanari river uses topographic map F44C2, F44C3 and F44B15 of scale 1:50,000, purchased from Survey of India Office, Jabalpur. DEM data provided from U.S. Geological Survey Earth Science Data Interface, SRTM data of spatial resolution of 30 m have been used. For land use land cover (LULC) change detection study, satellite image of Sihora Tehsil, Jabalpur District, covering Kanari river watershed were acquired for four Epochs: 1990, 2004, 2009 and 2019 from Global Land Cover Facility (GLCF) an Earth Science Data Interface. Multi-temporal Landsat-5, Landsat-7, Landsat-8 Thematic Mapper (TM) imageries of 1990, 2004, 2009 and a high resolution cloud free Sentinel 2A Multi Spectral Sensor (MSS) Level-1C image of 2019 was used for mapping LULC classes of Kanari river watershed from 1990 to 2019. Various locations were traced during the ground truthing for validating the major part of the river and finding out the core points. A door-to-door survey was conducted because of the perceived low literacy rates in the area. To recognize the sample's point of view, visions, needs and memories, the research followed two simple field methods; holding interviews and distributing

a questionnaire form. Google Earth Pro was used to analyse historical imagery to browse through past air photos to easily detect changes through time. In order to study the urban built-up and cultivated land change detection of the study area, Google Earth Pro high resolution satellite imagery based on 1.00–1.50 km eye altitude was considered. Google Earth historical imagery facilities provide a fast and efficient way of analyzing study area change, different time period imagery was considered for change detection study. The study attempts to assess the LULC and their effects on the hydrological regime of Kanari river watershed. Mapping of present and historical LULC conditions in the river watershed were carried out for assessing the changes that have taken place mainly due to human induced activities. The integration of GIS and Soil Conservation Service-Curve Number method was used to estimate the surface runoff. The appropriate area-weighted curve number for the study area was computed using overlaying tool of ArcGIS, then the daily rainfall database was incorporated in the analysis to estimate the direct runoff.

Groundwater recharge rate and runoff was estimated coupling the Soil & Water Assessment Tool (SWAT) model with meteorological data. Watershed delineation was done through SWAT using Digital Elevation Model. In SWAT the entire area was divided into sub-basins and HRU's using LULC map, Soil map. The threshold for creating HRU's was zero and 18 HRU's were generated. The weather data, precipitation data and temperature data were given to run the SWAT model to get recharge values i.e. percolation to shallow aquifer and deep aquifer values. The current GW recharge was 1758.2 MCM. Aquifer capacity from pumping test was 1901.4 MCM. The possible surplus recharge was 143.04 MCM. Fluctuation of depth to water level was studied on the basis of long-term water-level record at observation wells located at Kanari river watershed, to estimate the long-term high, medium and low

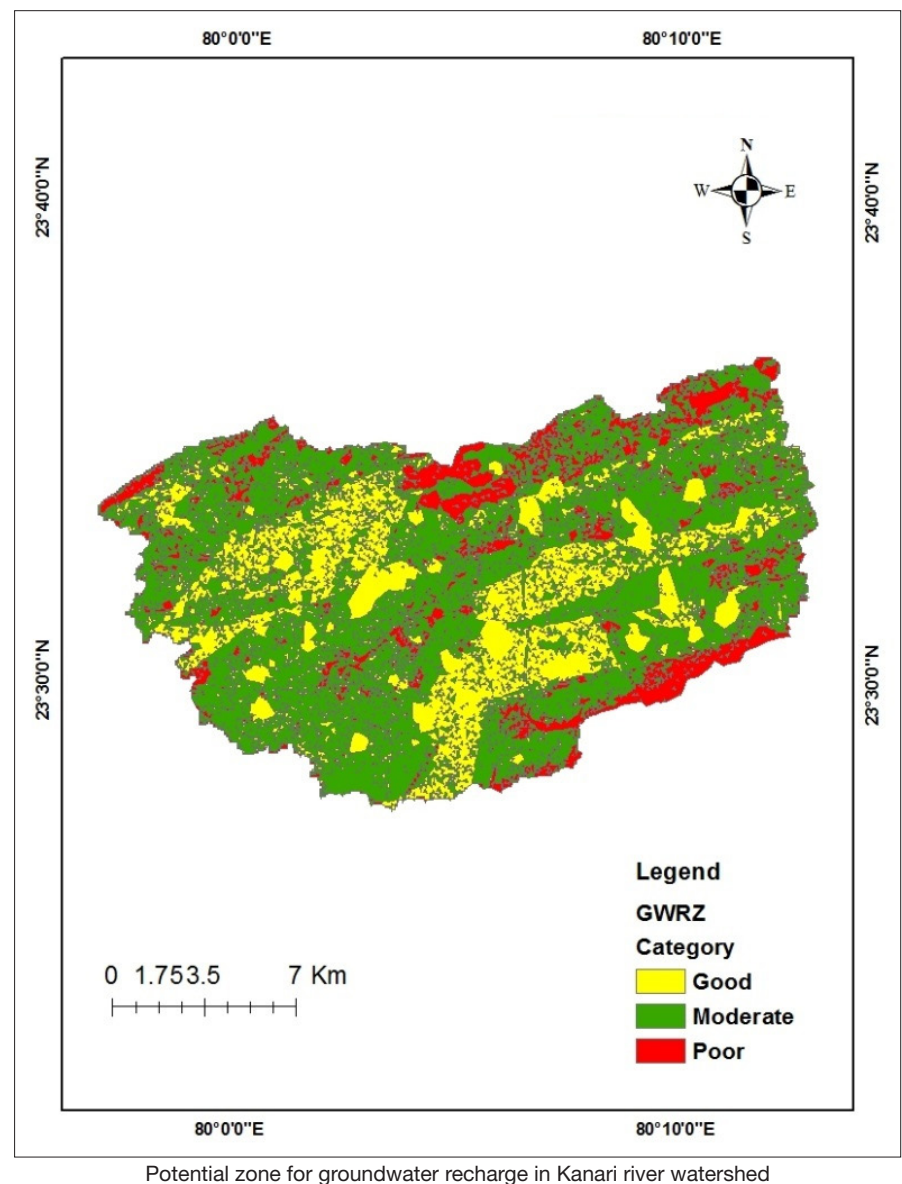
water levels at the site interest. It also covered water level fluctuations in the future as they have in the past, water level fluctuations seasonally, pre monsoon and post monsoon water level fluctuations. The National Atlas on Aquifer Systems of India on 1:250,000 scale, compiled by Central Ground Water Board in 2018 was used as the base for the current study area. The National Atlas on Aquifer Systems of India was geo-referenced and the types of aquifer were extracted for the Kanari river watershed using various tools of ArcGIS. Estimate of the groundwater storage volume was calculated by considering the saturated thickness and specific yield. The identification of groundwater recharge zone as well as locations for artificial recharge structures within the Kanari

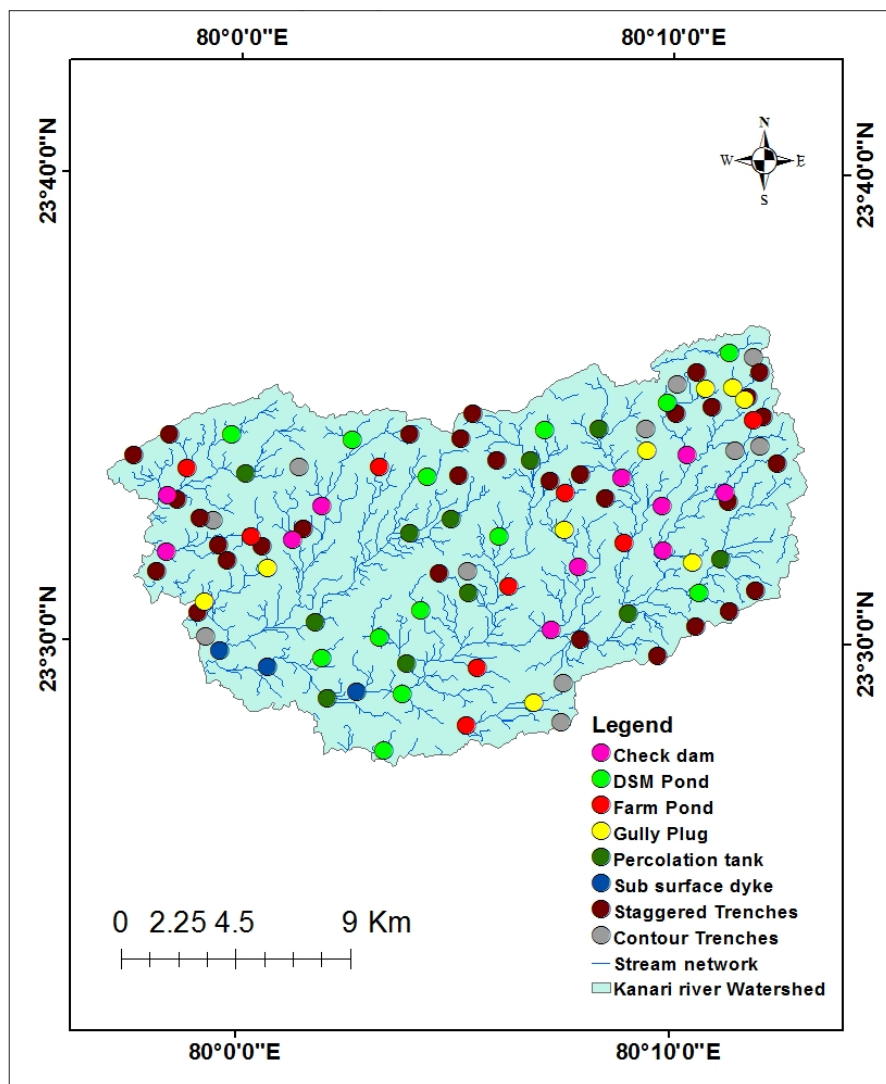
river system was carried out by integrating satellite derived various thematic maps in GIS platform.

The water demand of Kanari river watershed was estimated as 731.83 MCM. Taking this in consideration the pumping overdraft of Kanari river watershed was calculated and was found to be 423.192 MCM. Thus, the proposed additional recharge through planned conservation structure is 858.8 MCM through which it can easily be concluded that if over drafting through pumping is also considered then this additional recharge can fulfil the requirement and can maintain the flow in the river.

Additional strategies for non-monsoon flow revival in Kanari river

- Use of existing storage for stream rejuvenation.





Potential zone for groundwater recharge in Kanari river watershed

- Development of continuous stream storage along the streams.
- Identification of storage locations and potentials (ArcGIS, HEC-RAS).
- Development of simulation model for integrated operation of existing reservoirs for various water uses.
- Model simulation for stream rejuvenation with continuous stream storage with environmental flows and its effect on other water demands.
- Continuous Stream Storages (CSS) filled with minimum environmental flows is an easily implementable approach for stream rejuvenation.

- Rivers with upstream storage can be rejuvenated without much impact on the other water demands.
- Upstream storages need to release environmental flows.
- It can be rejuvenated using environmental flows from existing storage.
- Slight increase in irrigation efficiency (10%) or by changing the present cropping pattern substantial water can be saved which is useful for stream rejuvenation.
- Without productive land submergence and continuous groundwater recharge, CSS is a very cost-effective solution for river rejuvenation for all rivers in the country.

SUMMARY

The long term consequences of overexploitation of the river and cutting flows affect a river and its surroundings. In this context, the river Kanari is already overexploited. Our suggestion is that since the lean season use is mainly for agriculture, therefore restoration of flow in water through short rivers can be accomplished by water harvesting, more efficient agricultural practices like drip irrigation and by moving more water-intensive agriculture (for example for rice and sugarcane) to water surplus areas.

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