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Developing protocols for river rejuvenation using drone technology: a case study from Central India

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Abstract

Protocols for rejuvenation of large to moderately-sized rivers using remote sensing data is well established in different parts of the world. With the advent of commercially viable drones, highresolution imageries in sub-centimetre level can be generated, and this has made the assessment of degradation of small rivers a reality. The Sakri is a small river in the state of Chhattisgarh, central India with a basin area of 410 km , channel width $<$ 30m. Even with an average rainfall of 1232 mm, and a perennial source feeding the river, the river remains dry in most stretches. People from 23 villages and the town of Kawardha are mostly dependent on this river, and therefore, an attempt to rejuvenate this river was taken up using an innovative technology of drone surveys coupled with

Developing protocols for river rejuvenation using drone technology: a case study from Central India

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1. Introduction

⇒ Rejuvenation of large to moderately- sized rivers using remotely sensed data is well established in different parts of the world. However, the small rivers remain neglected due to limitations in data resolution.

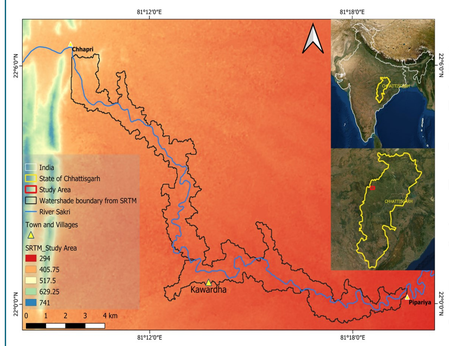
⇒ With the advent of commercially viable drones, high-resolution imageries in sub-metre level can be generated making the assessment of degradation of small rivers a reality.

⇒ Sakri - a small river in Chhattisgarh, Central India remains dry round the year, though the region receives 1232 mm of average annual rainfall & fed by a perennial stream.

⇒ A commercially available quadcopter, DJI Phantom 4 Pro, was used to collect imageries, supplemented with Real Time Kinematic (RTK) survey to generate Digital Elevation Model (DEM) and orthoimages of the river at a Spatial resolution of 8cm.

⇒ The data from orthoimage, Digital Surface Model (DSM) and ground inspection were combined to locate the intervention, evaluate their purposes and quantify the degradation to propose remedial measures for rejuvenating the River Sakri.

2. Study Area



⇒ River Sakri, is a small tributary of Mahanadi, in district of Kabirdham, Chhattisgarh, India with basin area of 410 square kilometres.

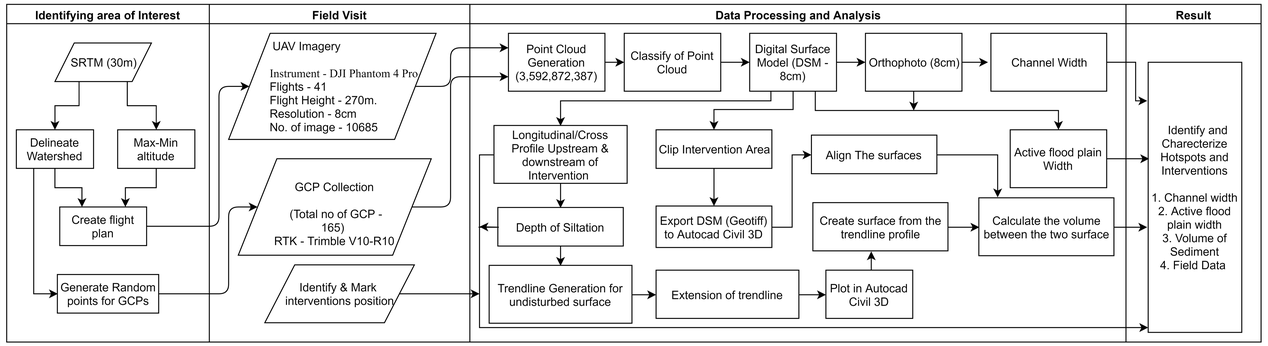
⇒ Channel width less than 30 m

⇒ The river stretches for 52km between Chourah to Pipariya.

⇒ The district headquarter, Kawardha and 23 villages depend on the river.

Fig.1 : The River Sakri flowing through parts of Chhattisgarh, Central India

3. Methodology



4. Results

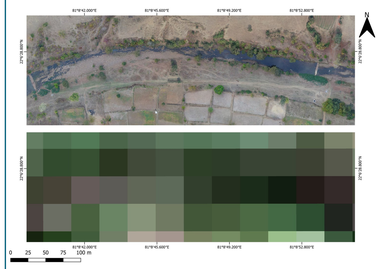


Fig 2: Comparison between Orthoimage from DJI Phantom 4 Pro (Top) & Sentinel 2 (Bottom) - Spatial resolution - 8cm & 10m respectively.

⇒ River Sakri is less than 30 meter in width. It hardly constitute 2-3 pixel in the sentinel image

⇒ Sentinel imageries from European Organisation of Space (EOS) are the highest resolution - freely available imageries.

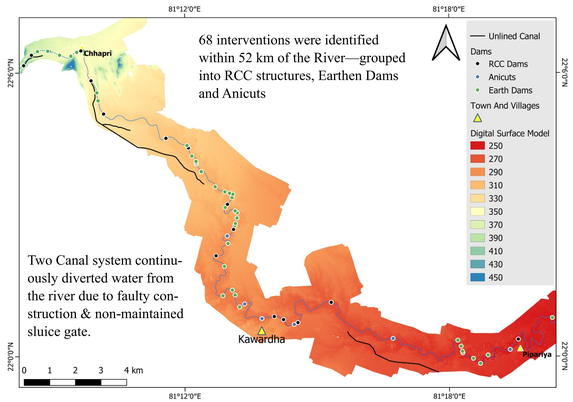


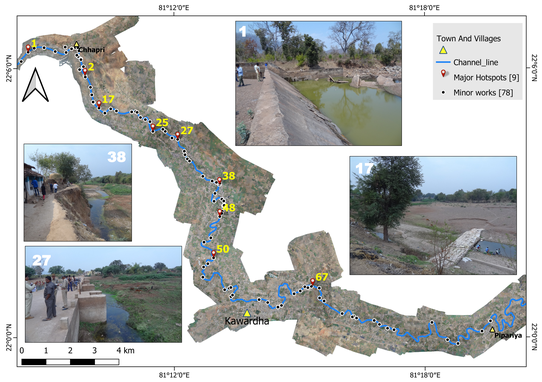
Fig 3: (Left) The Digital Elevation Model (DEM) is the first product of the point cloud processing from the UAV data.

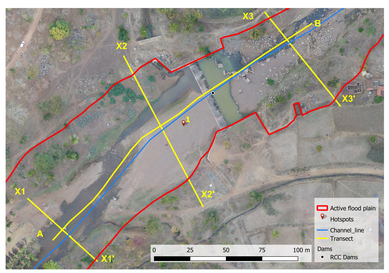
⇒ A Digital Surface Model (DSM) was also generated by classifying the point cloud and separating the ground.

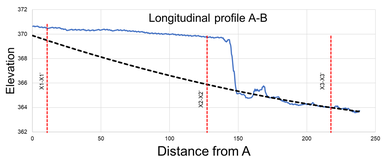
⇒ DSM was used for volumetric calculations of sediment.

Fig 4: (Right) The ortho imagery generated from the point cloud has a resolution of 8cm .

(Inset) Field photographs of the identified hotspots.







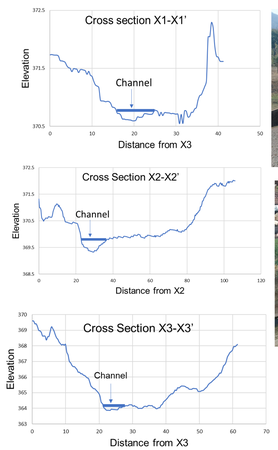
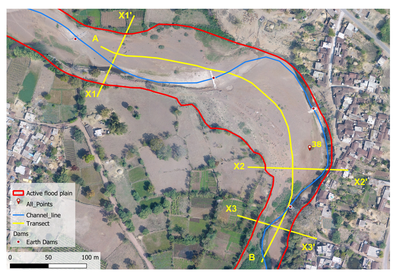
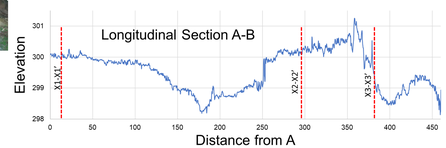


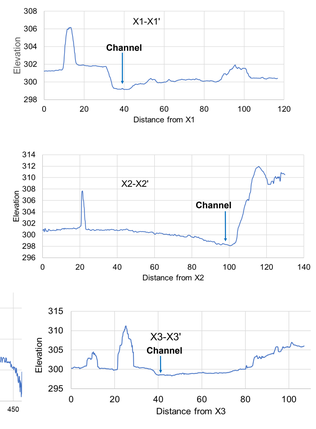
Fig 5 & 6 : (Left and top) This is first RCC structure on the river which used to serve as the primary water storage.

Fig 7 & 8 :(Right & bottom) Human lives are at stakes in this area as the river meander is eroding through the village.

⇒ These two sites are classic examples of the damaged state of the river due to anthropogenic activity and is in immediate need of river management.







Channel Characterisation	Problems observed	Proposed Remedial measures
• Channel Width = 9m • Active flood plain width= 15m • Max Depth of siltation = 4m • Sediment volume= 30,228.5 m^3	•Heavy siltation in upstream •5m fall in water level, leading to severe erosion downstream •Irrigation gate not maintained •Water leaking through left bank	•Desiltation in upstream •Irrigation gate needs to be redesigned and maintained. •Base floor need repairment

Channel Characterisation	Problems observed	Proposed Remedial Measure
• Channel Width = 8m • Active flood plain width= 90m • Depth of siltation = 1-1.5m • Sediment volume=20,720m^3	• Non-functional Earthen Dam • Large deposition of Silt. • River meandering sharply toward right – eroding the left bank with a 14 meter high cliff • Shallow channel	• The Earthen dam must be removed unless washed away in monsoon. • Immediate channelization required. Silt from river bed need to be used to provide left bank protection. • Boulder pitching, plantation of trees and removal of houses on the cliff is also advised.

5. Major findings

⇒ Siltation was identified as the primary problem in the River Sakri. Several hotspots have been identified where large volume of sediments have accumulated creating convexity in the longitudinal slopes.

⇒ River Sakri is longitudinally disconnected through a series of Man-made structures like anicuts, check –dams and sand Bags resulting in high siltation

⇒ The structures lack sediment management—sluice gates are either non-existent or non-functional.

⇒ The banks lack vegetation cover due to encroachment of agricultural farms, enhancing bank erosion, especially at the meanders.

⇒ Severe bank erosion was documented near few villages , endangering resident life.

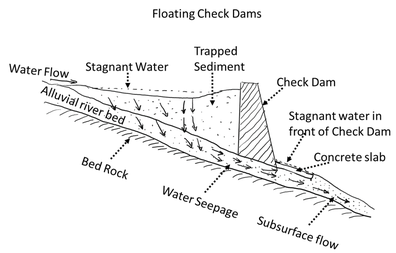
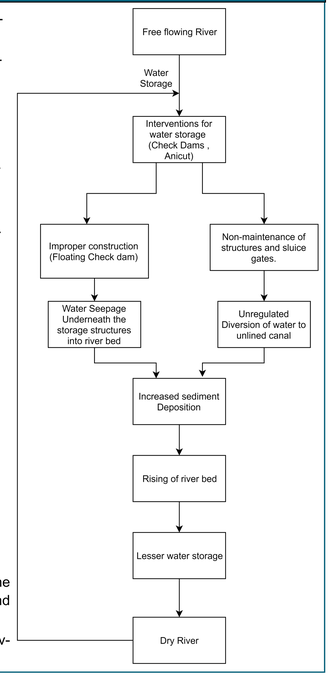


Fig 9: (Top) Most structures are poorly designed. They float on the sandy-alluvium bed of the river and do not reach the bed rock, and hence forcing subsurface flow.

Fig. 10 : (Right) A schematic describing the degradation process of River Sakri



6. Proposed Remedial Measure

⇒ Several reaches identified as siltation hotspots need to be excavated in a scientific manner so as to achieve the natural slope of the channel.

⇒ Several intervention, such as anicuts and bridge are recommended to be demolished as they are totally non-functional and are degrading the river further.

⇒ Some of the anicuts need to retrofitted:

- (a) must be extended down to bedrock to serve the purpose,
- (b) fitted with sediment bypass structures or sluice gates.

⇒ River training works are needed around meanders , suffering from excessive erosion, involving realignment of river course and channelization.

⇒ Bank protection using the excavated sediments may also be carried out using standard procedures including plantation.

⇒ Treatment of catchment area in the upper mountainous hinterland and high slopes along the river to reduce sediment production may also be required.