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Tunnel wells, the traditional water harvesting structures of Kasaragod, Kerala: re-visited

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Tunnel wells or surangams are less common traditional groundwater harvesting structures of Kasaragod district in Kerala, southern India. These horizontal wells, structurally resembling Qanats, are driven into the laterite plateaus and hills for tens of metres. The status of tunnel wells of Kasaragod is synthesized, the problems and prospects examined to evolve a common strategy for sustainability. Functionally four different types of tunnel wells exist: (1) single tunnel, (2) single tunnel with branches, (3) tunnel system ending in a vertical well, and (4) tunnel system ending in a well with a horizontal outlet. The yield of tunnel wells has reduced over the years and 50% of them are now dry. Single tunnels (types 1 and 2) act as conduits for excessive draining of groundwater from the aquifer system during the rainy season, leading to wastage of groundwater and lowering the water table. The discharge estimates from the 24 tunnel wells indicate that 6653 m^3 of groundwater gets discharged from the aquifer per day. To prevent wastage, the mouth of the tunnel wells should be fitted with half shutter gate with a control valve at the bottom. There is an urgent need to create awareness to protect and modify these traditional water harvesting structures for sustainability of water resources.

Keywords: Discharge, groundwater, Kasaragod, traditional water harvesting, tunnel wells, surangam.

TRADITIONAL water harvesting structures generally provide time-tested solutions to water scarcity problems in many parts of India[1–6]. Tunnel wells or surangams are less well known and are gradually disappearing traditional groundwater harvesting structures of Kasaragod district, Kerala, southern India[6–11]. The word surangam is derived from a Kannada word for tunnel. It is also known as thurangam, thorapu, malayoottu, etc. These horizontal wells driven into the laterite plateaus and hills, structurally resemble Qanats[1] found in the arid regions of south-western Asia and North Africa, running several kilometres underground and are in use since generations. Probably the

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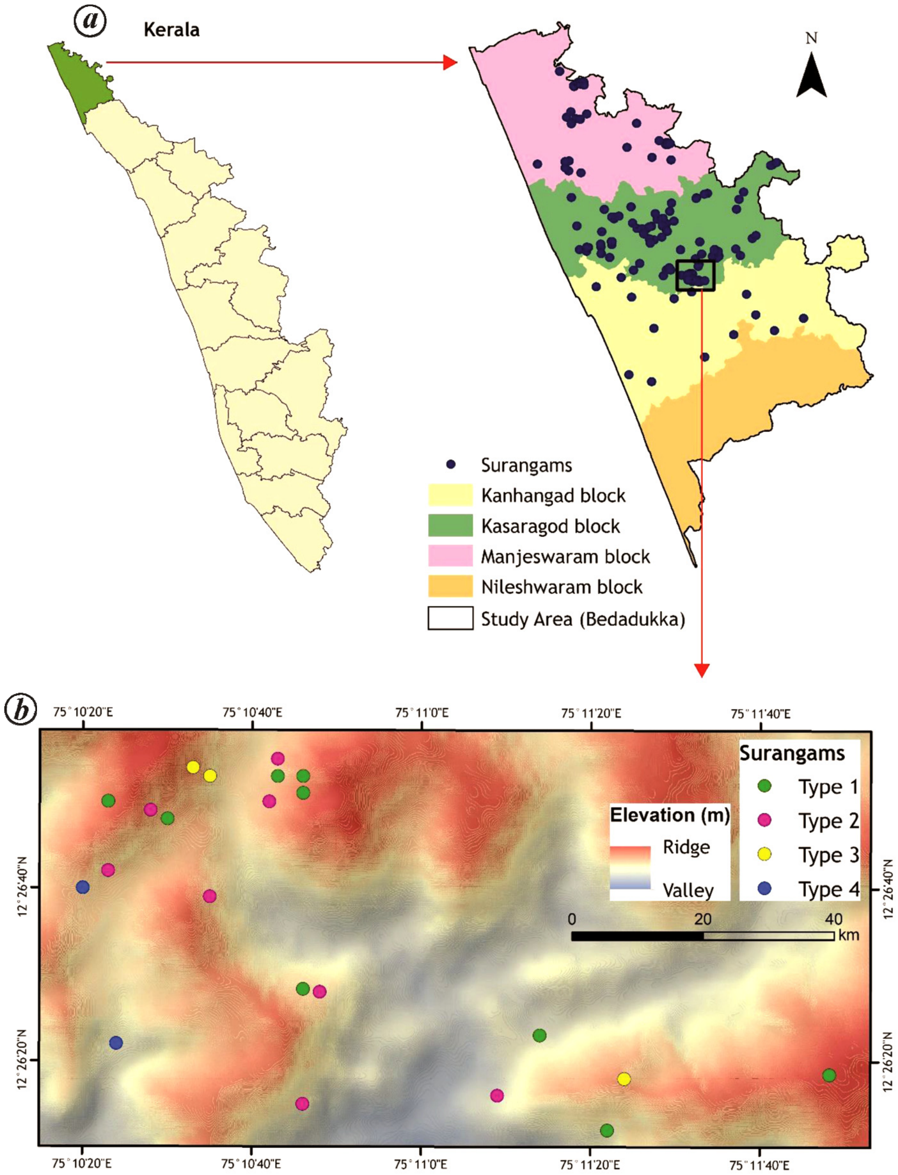

Figure 1. ***a***, Location map with the distribution of tunnel wells in Kasaragod district. ***b***, Study area, Bedadukka panchayat, shows the ridges and valleys and different types of tunnel wells.

expertise for these structures had come to India through Arabs who settled in the Malabar Coast at the end of 17th century[6,7,11,12]. Groundwater discharged through surangams is either directly used or collected in open ponds/ wells. Despite their declining use, they continue to be the lifeline for a large number of farmers in Kasaragod.

The present study examines the status of the tunnel wells in Kasaragod (Figure 1 *a*) with a case study from Bedadukka panchayat (Figure 1 *b*). The study area falls in the Survey of India toposheet number 49 Y/15+P/3, between 12°26′15″E and 12°26′55″E and 75°10′20″N and 75°11′50″N (Figure 1 *b*). The topography depicting the ridges and valleys and locations of the different types of surangams are shown in Figure 1 *b*. The Bedadukka area is a hydro-geologically closed basin. This small basin (Figure 1 *b*) having 4.4 sq. km area with water level fluctuation (pre- and post-monsoon) of two metres and specific yield of aquifer of 0.03 may have a groundwater reserve up to 264,000 m^3. In the past, villagers depended on different types of tunnel wells for all their water requirements, both domestic and irrigation. However, now they depend on bore wells/dug wells and only partly on surangams.

The lateritic mount has a small flat terrace at the summit. This and the sloppy area of hills are the recharge areas for tunnel wells. Habitation is confined to the slopes, where the tunnel mouth opens out. Seven hundred and sixty surangams in Kasaragod, Kanhangad and Manjeswaram blocks were examined in this study (Figure 1 *b*). Thirty per cent of them were abandoned. Drastic and unscientific changes in the land-use pattern were noticed all along the laterite mounds. These age-old structures are ill-maintained, and the dumping of non-degradable waste inside the air vents chokes and restricts the flow of water.

The tunnel wells start as a trench across the slope of the hill and ends in the middle of the hillock. They are unlined horizontal structure in laterite and have the innate strength to withstand caving. The average width and height of the tunnel is 0.4 to 1.0 m and 1.5 to 2 m respectively. The length varies from 10 to 30 m depending on the availability of groundwater. Most of their outlets are at lower elevations, so that water flows under gravity. The different types of tunnel wells are shown in Figure 2 *a–c*. There were mainly four types of tunnel wells in the study area.

Type 1 – Single tunnel wells: They are the simplest structures as shown in Figure 2 *a*. They are commonly seen in areas with homogeneous lateritic cover along the slope. They are mostly used for domestic and irrigation purposes.

Type 2 – Single tunnel with branches: It is a tunnel system with several tunnels arranged in different orientations, which are interconnected. If the surangam is very long, a number of vertical air shafts are provided to ensure ventilation within the tunnels. It is commonly seen in areas with heterogeneous laterite and often ends in boulders of massive crystalline rocks. Tunnels are driven in different directions to tap more groundwater (Figure 2 *b*).

Type 3 – Tunnel system ending in a vertical well: This works as a dug well to store the groundwater tapped by tunnels from different directions from the hill. Generally, it is located at a higher elevation and little away from habitations. This type is the most suitable and sustainable type of structure. But most such structures in the area are now becoming dry during summer (Figure 2 *c*).

Type 4 – Tunnel system ending in a well with a horizontal outlet: This is same as type 3. However, the dug well has an outlet in this system to drain the water downstream (Figure 2 *c*). These types are mostly used for irrigation purposes.

The rainwater captured by the entire sub-watershed gradually and steadily seeps out through these tunnel wells. The discharge (yield) from a tunnel well depends on its length and the thickness of the saturated lateritic zone. The groundwater yield of tunnel wells will be maximum and minimum during rainy season and peak summer respectively. The discharge from a tunnel at a particular time can be calculated by using the following formula with the assumption that the tunnel face has a rectangular notch.

$$Q = 3.33\ (L - 0.2H)H^{1.5},$$

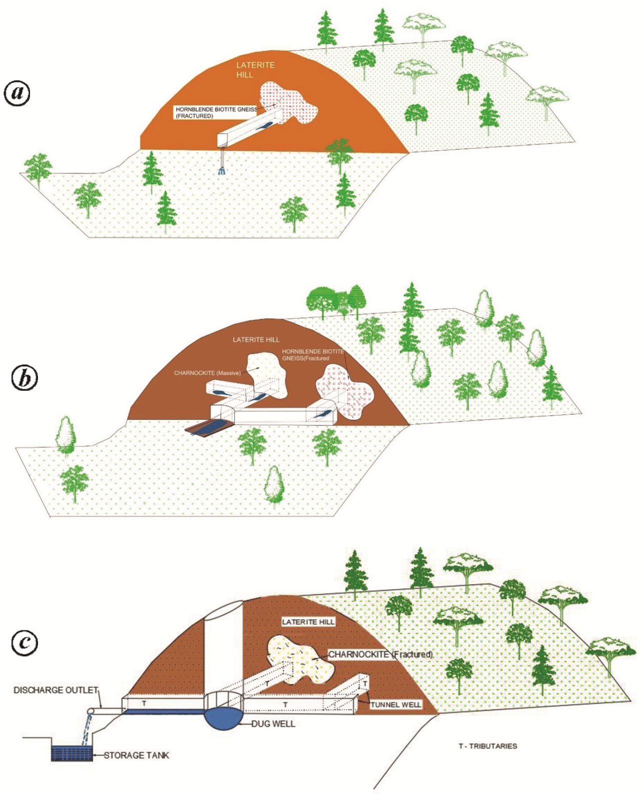

Figure 2 *a–c*. Diagram of different types of tunnel wells of the study area.

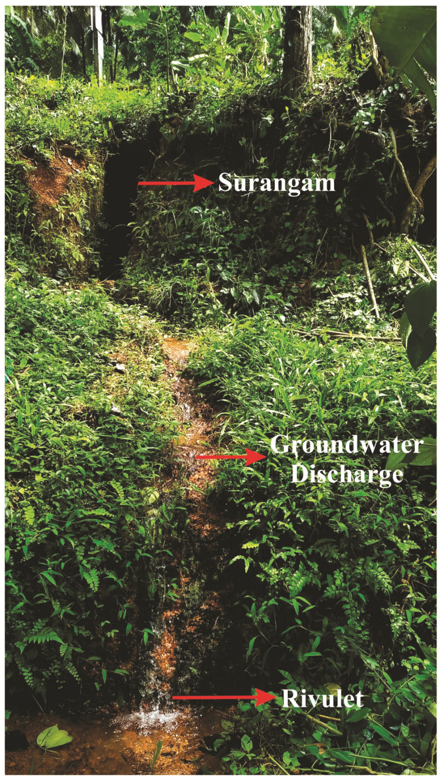

Figure 3. Groundwater discharge from tunnel wells to the rivulet during monsoon.

Table 1. Yield details of tunnel wells in different periods with GPS readings

Tunnel well no.	Latitude	Longitude	Discharge litre/day (May 2001) (ref. 8)	Discharge litre/day (May 2019)	Discharge litre/day (August 2019)
T1	12.445	75.1730	17,280	280	345,600
T2	12.4469	75.1744	25,920	Dry	172,800
T3	12.4466	75.175	172,800	2,187	691,200
T4	12.4483	75.1758	86,400	3,323	518,400
T5	12.4480	75.1763	129,600	463	432,000
T7	12.4480	75.1786	8,640	214	172,800
T8	12.4475	75.1794	No flow	Closed	Closed
T9	12.4486	75.1786	8,640	13,292	172,800
T10	12.4480	75.1794	8,640	Closed	Closed
T11	12.4472	75.1783	8,640	659	172,800
T12	12.4441	75.1763	17,280	No flow	345,600
T14	12.4472	75.1730	8,640	Dry	172,800
T15	12.4444	75.1722	64,800	Dry	172,800
T16	12.4375	75.1794	8,640	79	172,800
T17	12.4411	75.18	17,280	Dry	345,600
T18	12.4411	75.18	17,280	Dry	345,600
T19	12.4583	75.1875	17,280	No flow	345,600
T20	12.4383	75.19	8,640	Dry	345,600
T21	12.4205	75.1733	Dry	Dry	172,800
T22	12.4366	75.1894	8,640	Not in use	172,800
T23	12.4394	75.1733	17,280	2,400	345,600
T24	12.4397	75.1872	8,640	178	172,800
T25	12.4377	75.1858	17,280	Not in use	345,600
T26	12.4384	75.1967	86,400	199	518,400
	Total		764,640	23,274	6,652,800

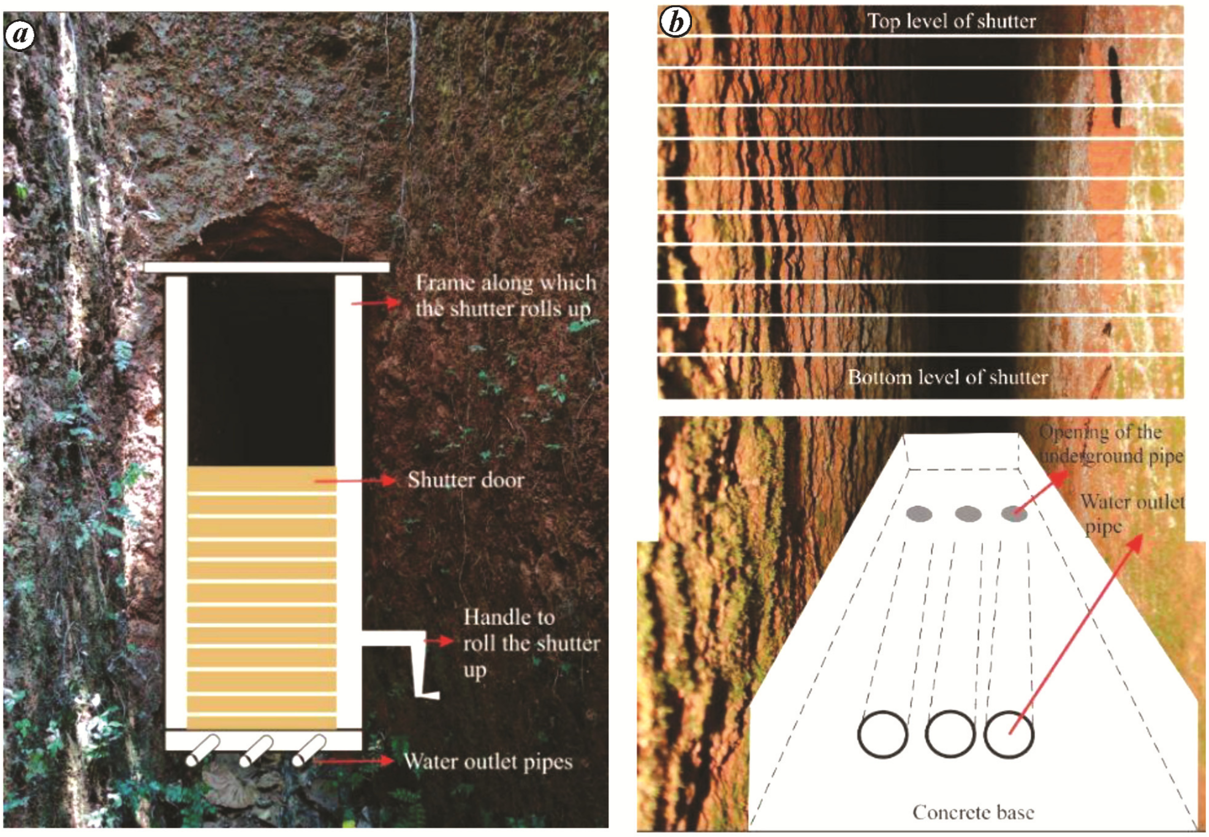

Figure 4 ***a***, ***b***. Design of the shutter gate proposed in the study to close/regulate the discharge of groundwater from tunnel wells.

where Q is the flow of water (discharge) (m^3/sec), L the width of the tunnel face (m) and H is the height of the flowing water above the base of the tunnel (m).

Detailed inventory of 24 tunnel wells was made during May and August 2019 (Table 1). Historical data of 2001 is also given in Table 1. The present yield of these wells was compared with the data of 2001 (ref. 8). The data showed that the yield of the tunnel wells had reduced considerably over the years. The total discharge during 2001 (summer) was 756 m^3 whereas during 2019 it reduced to 23 m^3. However, during monsoon (August 2019), these tunnel wells discharged large quantities of groundwater at the rate of 3 to 12 l/sec. A tunnel well with a yield of 8 l/sec discharges about 691 m^3 (691,000 l) of groundwater per day. Similarly, it was observed that all the single tunnel wells in and around the Bedadukka panchayat were discharging huge quantities of groundwater during rainy season and this water reached the *thodu* or rivulet (Figure 3), thereby escaping to the sea. The estimate done during August 2019, revealed that about 6653 m^3 of groundwater was being discharged from the aquifer per day (Table 1). Hence 50 to 60 such leaking tunnel wells may be sufficient to drain the whole aquifer in a short period.

To prevent undesirable loss of groundwater, we recommend that the mouth of the tunnel wells be blocked with half shutter gate, an engineering structure designed in this study, having a control valve at the bottom. This gate looks like a normal shutter with concrete frames on both sides (Figure 4 *a*). The handle attached to the frame can be used to roll the shutter up and down. The tunnel is floored with concrete. Three pipes may be installed in the concrete at the base, as shown in Figure 4 *b*, serving as outlets. The inlets of the pipes should have sieves to prevent leaves and other solids from entering. The outlet should have a control valve. With this kind of a stutter gate facility, the tunnel can act as a proper groundwater reservoir (Figure 4 *a* and *b*). To monitor the height of the impounded water, a pressure gauge can be fitted to the outlet pipe. The whole structure will act as a storage tank after modification.

Construction of new tunnel wells should be discouraged in the region. The panchayat authorities should collect details of all the existing tunnel wells in their respective panchayats, and the data should be brought to a digital (spatio-temporal) platform. There is a pressing need to create awareness about restoring and reviving these traditional water harvesting structures. These are not only far more sustainable in the long run than bore wells, but also carry with them the age-old wisdom of treating nature with respect and using natural resources wisely.

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