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Will the flow end?

Artesian wells of Uttarakhand's Tarai

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A preliminary study in the *Tarai* region of Uttarakhand has revealed a depleting water flow in the artesian wells used for agricultural purposes, due to over exploitation of the aquifers. This coupled with deforestation, global warming and unpredictable weather patterns could damage an otherwise sustainable and eco-sensitive agricultural practice.

Human beings have traditionally built settlements near the source of water - ancient civilizations' presence near major rivers of the world bears proof of this. For fulfilling the ever increasing demand for water by domestic, agricultural, and industrial sectors, human beings learnt to extract groundwater. Probably the open wells are the ancient structures that were developed for abstracting groundwater from unconfined[1] aquifers and the water from these wells was raised to the surface level by man or animal power using indigenous techniques. Later on, the advancements in mechanisation in the 20th century made it more convenient to abstract groundwater even from deeper aquifers. The introduction of diesel-engine/electricity operated centrifugal pumps has completely changed the irrigation scenario of agriculture. Depending on the depth of aquifer and the quantity of water required, pump size in terms of its horse power (hp) is selected. Increased input of energy has also increased the production cost of the crops.

A sustainable agricultural practice

However, there are regions all over the world where abstraction of groundwater does not require a pump. Once the drilling of bore-hole to the specific aquifer (essentially artesian[2]) is completed, the pressure within the aquifer forces the groundwater to rise above the ground surface naturally without using a pump. These types of wells are known as flowing artesian wells. Flowing wells are an uncommon manifestation of geological activities (Swamee et al: 2000). Expansion of water due to release of pressure and compression of aquifer formation material are responsible for the water flow from such wells (Jacob: 1940). In Uttarakhand, such type of wells - of width up to 25 km and having a general slope less than 1%, is restricted only to the *Tarai* zone. .

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The formation of the *Tarai* region is dependent on the evenly sorted finer material that was washed away by the streams from the hilly tracts. The northern limit of the *Tarai* belt is in contact with the *Bhabar* zone which is bound by the lower *Shiwalik* range of Himalayas in the north. The *Bhabar* zone can also be referred as piedmont alluvial terrain that comprises ill-sorted sediments ranging from big boulders to silt. Since this zone is very porous and permeable it forms the recharge area of the artesian aquifer system in the *Tarai* zone. Moreover, the region between *Bhabar* and *Tarai* belts forms the spring line (the landmass with marshy conditions). This spring line is of the source of various perennial streams in the region. Since the slope of *Bhabar* zone varies from 1-2%, the elevation difference between the recharging area in *Bhabar* zone and water withdrawing position (i.e. well) in *Tarai* zone creates the artesian head in the aquifer which is directly responsible for the existence of flowing wells.

Tarai soils are rich in clay and organic matter and that is why this belt is considered one of the highly productive agricultural areas in India. Availability of irrigation water from flowing wells without spending any energy on its withdrawal is one of the factors that could reduce agricultural costs.. The introduction of highly mechanised agricultural practices since the last two to three decades has encouraged the farmers to adopt the intensive cultivation in the region. Consequently, the demand for irrigation water has increased significantly. The trajectory of water resources development has thus been following a simple principle of "developing", which in the case of groundwater means extracting more water to produce more grain (Kulkarni and Shah: 2013). Other than this, the rising domestic and industrial needs for water have further stressed the existing groundwater resources. Collectively, it has resulted in the development of more number of bore wells which has increased the density of flowing wells in the *Tarai* belt. As expected, the discharge rates of these wells have drastically decreased and are declining further with time.

Overexploitation and environmental damage

A preliminary study on the thermal characteristics of water sampled from the seven flowing wells located in a radius of more than 15 km has revealed that all the wells are installed in the same aquifer. Definitely, the installation of more wells in this stretch will directly affect the yield of other wells. It can be judged from the fact that in year 1970, the water pressure of these flowing wells at the ground surface was over 2 kg/cm^2 (Michael: 2006) which now has dropped to ~ 0.2 kg/cm^2. Moreover, the figures mentioned are for the monsoon season only which would be lesser than this value during the dry season. Presently, the flowing behaviour of wells in certain pockets of the region have become seasonal (see Figures 1) and few others are completely dried (Figure 2a) and are abandoned now.

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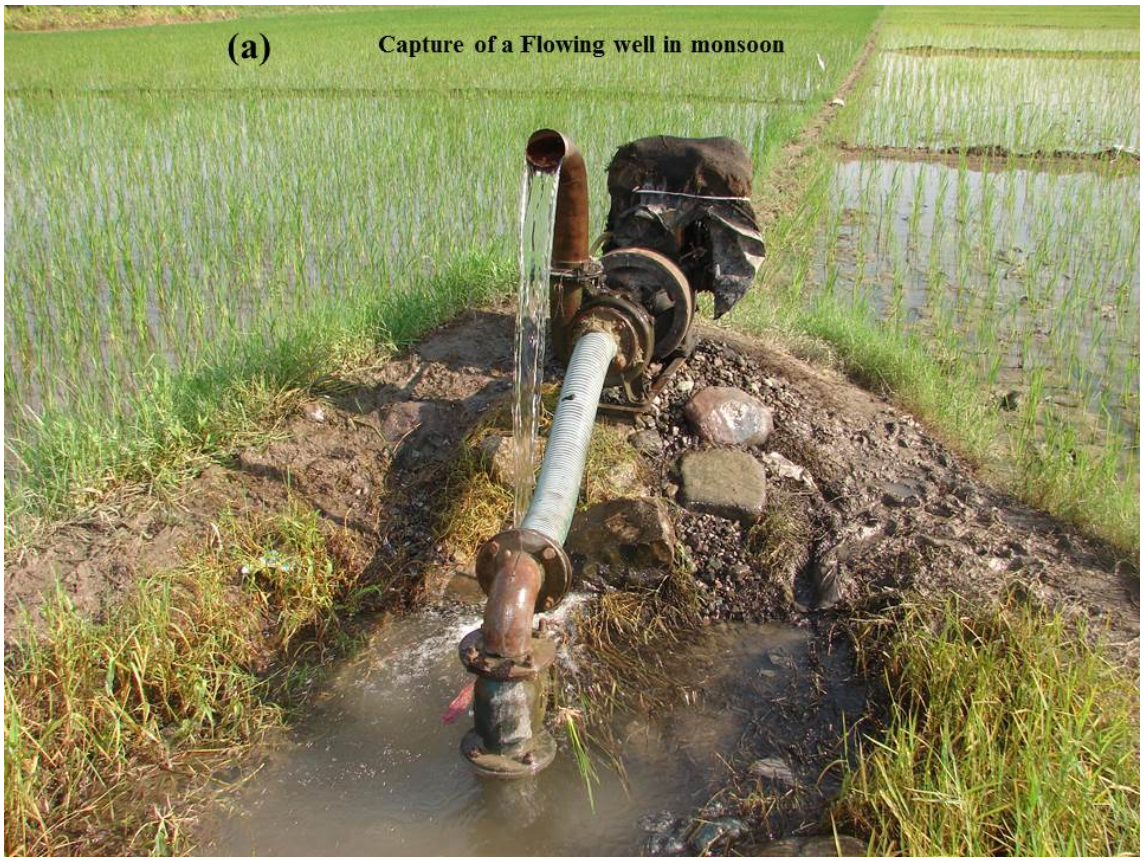

Figure 1a: Capture of a flowing well in monsoon

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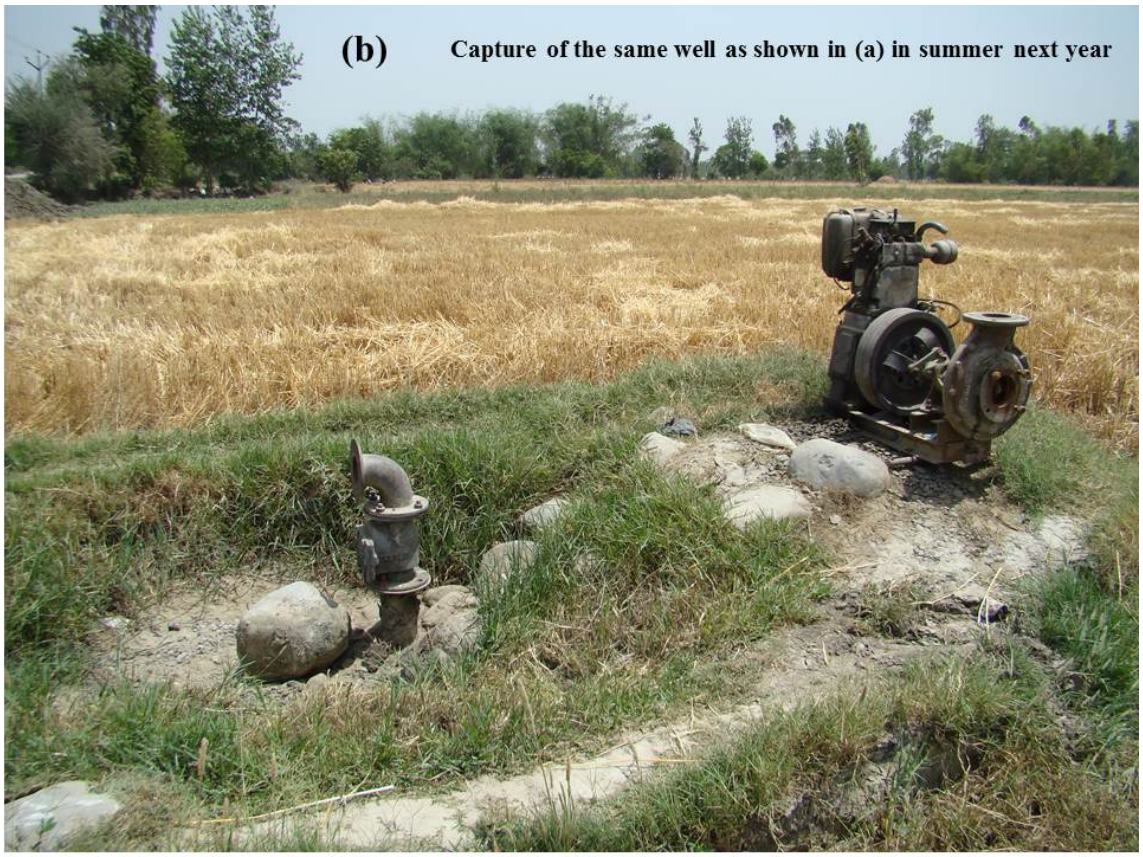

Figure 1b: Same well in 1(a) shown in summer.

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Figure 2a: Well completely dried up.

Other than the over exploitation of groundwater due to overall development and industrialisation in the *Tarai* zone, haphazard felling of trees for converting forest land into industrial/agricultural land, reduction of water pressure in the artesian aquifers due to increased leakage of water from confined to unconfined aquifers through the increased number of bore-holes for developing tube wells, and unattended flowing of these wells without any beneficial purpose (Figure 2b below) are the additional causes for their changed behaviour. The current scenario will further worsen with the reduction in recharging of these artesian aquifers in *Bhabar* zone due to changed rainfall pattern in Himalayan (Vashisht and Bam: 2013) and *Shiwalik* foothill regions. For proper recharging of the aquifers, rainfall intensity should be less than the water intake capacity of the land surface.

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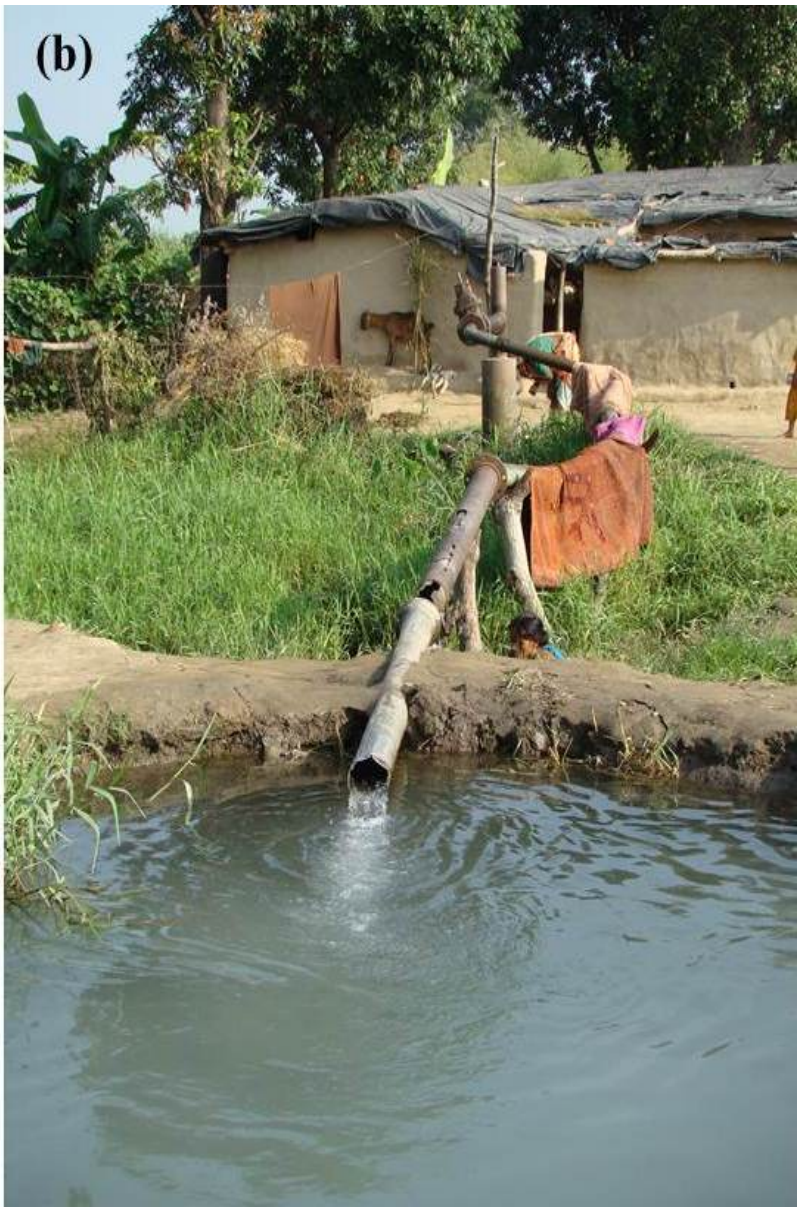

Figure 2b: Unattended flow of well without any beneficial purpose

According to a World Bank report, global mean warming is approaching 4°C. This will result in a 10% increase in annual mean monsoon intensity and a 15% increase in a year-to-year variability of Indian summer monsoon precipitation is projected compared to normal levels during the first half of the 20th century (World Bank: 2013). The report further emphasises that these changes imply an extreme wet monsoon. This is projected to occur every 10 years by the end of the century compared to the currently probability of it occurring only once in 100 years. These extremes of weather conditions are likely to affect flowing wells adversely. With the number of flowing wells dwindling, abstraction of water will be dependent on the diesel engine or electric motor operated pumps. This increase in the energy cost will be added to the production cost of the crops. To equalise the profit margin, it is likely that food

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prices will be increased which will affect the end consumer adversely.

Nevertheless, the impact of the above mentioned factors can be drastically reduced by strengthening the farmers' knowledge regarding the groundwater hydraulics with special attention on the groundwater movement from the recharging zone to flowing artesian wells in their fields. But, the immediate action that is required at this stage is to increase awareness so that the farmers in the region can install control valves on the flowing wells to avoid water loss. The farmers who are aware of the consequences of this water loss have already adopted these measures by using end plugs or end plates for the purpose. However, these measures are not so effective in completely controlling the water loss (see Figure 3 below). Lack of general maintenance of control valves, non-replacement of end-plug gaskets at appropriate intervals, and improper tightening of the nuts and bolts of the pipe are the main reasons of this major water loss.

Figure 3: Instances of water loss from the wells

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Additionally, there is a need to demarcate the major recharging zones in *Bhabar* belt and any kind of development other than the construction of water conservation/harvesting structures should be restricted on it. Environmental isotope techniques can be efficiently used for the purpose (Shivanna et al: 2008). Conserving groundwater resources at this stage is crucial in the *Tarai* and *Bhabar* belt before it's too late.

Notes

1. Underground water bearing formation that is not bounded between impermeable confining layers. Unconfined aquifers are also called water table or phreatic aquifers, since their upper boundary is the water table or phreatic surface.

2. An aquifer lying between two impermeable layers and containing water under positive pressure is known as artesian aquifer. If well install a well in such aquifer, water in the well rises above the top of the aquifer, but does not necessarily reach the ground surface.

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