Hydrogeological assessment in upper Vientiane Plain, Lao PDR: implications for sustainable groundwater development in data-scarce regions

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INTRODUCTION

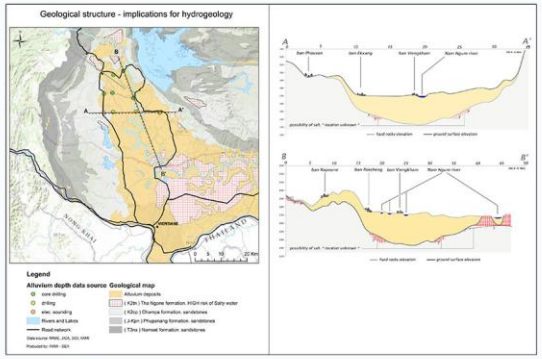
In Lao PDR, there is an emerging interest in developing groundwater supplies for irrigation to increase food production. Lack of knowledge on the groundwater resource availability is a major constraint.

This case study provides a first step towards addressing this knowledge gap by assessing the water balance and providing recommendations for management.

STUDY AREA

The upper Vientiane Plain which extends over 650 km² in the central part of the country was selected as a case study. The hydropower-controlled Nam Ngum River forms the N-S axis of the Plain. Rainfed-farming land dominates the landscape with wet-season rice paddies and grazing land. Some ponds and oxbow lakes are found locally. Groundwater is accessed through shallow wells and used mainly for domestic uses in the 188 villages located across the area.

The hills and mountains forming the edges of the plain comprise of thick deposits of sandstones and mudstones (T3ns, J-Kpn, K2cp). Evaporites can be found where the upper Tha Ngone (K2tn) formation has not been eroded. This whole rock sequence was folded and the resulting valley filled by alluvial deposits, providing a localized aquifer system.



METHODS

Data scarcity is a major constraint in Lao PDR. Thus there was a real need to apply pragmatic yet reliable methods for GW assessment.

A monitoring network was established after field surveys and identification of previous public supply wells in appropriate condition. A government agency (DWR) was trained to carry out monthly monitoring of water levels.

Aquifer characteristics were obtained from 7 slug tests in the sandstones and 4 slug tests and 1 long-term pumping test in the alluvium.

Water Budget & Water Table Fluctuation method
The WTFM has been selected as the most appropriate way to estimate (i) specific yield and (ii) groundwater recharge. Estimated recharge was compared with Chloride Mass Balance-derived recharge estimation to increase confidence in the results.

***Water Budget method** to estimate Specific Yield [with additional assumptions]:*

$$S_y = \frac{ET_{gw}^{dry} + Q_{bf}^{dry} + Q_{pump}^{dry} - Q_{inf}^{dry}}{\Delta h \; dry}$$

Each component has then been estimated using simple methods (remote sensing, surveys, literature).

***Water Table Fluctuation Method** to estimate recharge WTFM assumes that a rise in groundwater level during the wetseason in an unconfined aquifer is directly related to recharge and thus:*

$$R = Sy \; dh/dt = Sy \; \Delta h / \Delta t$$

Recharge was then calculated over the area using monitored Δh and calculated Sy. .

Chloride Mass Balance:

$$R=(P \times [Cl\ rain])/[Cl\ gw]$$

17 borewells were sampled using a bailer in march 2014. 5 rainfall samples were taken in 2014 and 2015

RESULTS

Transmissivity was estimated at 294 m²/day for the alluvium and 11,5 m²/day for the sandstone

Expected discharge of a borewell is up to 18 m3/h if suitable conditions in the alluvial plain. This is sufficient for farm-scale cash-crops irrigation.

The water table depth is shallow (usually 1.5m to 6m in the dry season) and seasonal water level variation is between 1 m and 5.5 m at different locations in the watershed.

The Specific Yield of the alluvium has been estimated using a Water Budget method to 0.15. This is a coherent value for a sand and gravel aquifer and similar to that derived by Perttu, (2011) using geophysical methods (0.13).

The annual recharge in the alluvium was calculated in the plain as 465 mm from the WTFM and 421 mm from the CMB method. This corresponds to approx. 20% of the 2340 mm annual rainfall.

Current use of GW is 12 mm/year or 2,5% of annual recharge, suggesting a important scope for increasing abstraction.

Pictures: (a) Typical dry season landscape of Vientiane Plain; (b) farmer dug-well and shallow water-table (dry season) (c) 'Tok-Tok' pump used for groundwater abstraction; (d) IWMI's pilot site with groundwater irrigation of cash-crops

IMPLICATIONS FOR AGRICULTURE AND MANAGEMENT

Small-scale, farmer-controlled GW-irrigation during the dry season (and dry spells in the wet season), if managed sustainably, could enhance food production and improve livelihoods.

Shallow aquifer and the possibility of underlying evaporites highlight the need for improved management to avoid over-exploitation and uplifting of saline water.

Drilling should not be deeper than 30 meters and the relevant government authority should implement a groundwater management plan for the upper Vientiane Plain to ensure sustainability of the resource (this is currently under development, led by DWR).

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http://gw-laos.iwmi.org/