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Photo: Gardens irrigated with groundwater in Southern Laos
Credit: M.Viossanges /IWMI

Research to support sustainable groundwater development and governance in Laos

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Research Highlight Report

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Overview

Lao PDR (Laos) is a landlocked country of around seven million people situated in the heart of the Mekong region (Fig. 1). Listed amongst the 47 UN-designated Least Developed Countries, its level of socioeconomic development is comparable to that of neighboring Myanmar and Cambodia but significantly lower than China, Thailand and Vietnam. Subsistence farming is the primary means of food security and income for nearly 80% of all households. Poorly developed, water-rich countries such as Laos have historically paid most attention to surface water resources, with limited consideration to groundwater.

The attention to groundwater in Laos received a much-needed boost through a four-year research project (2012-2016) funded by the Australian Centre for International Agricultural Research (ACIAR) and the CGIAR Research Program on Water, Land and Ecosystems (WLE). The project, '*Enhancing the Resilience and Productivity of Rainfed Dominated Systems in Lao PDR through Sustainable Groundwater Use'*, was the first multi-disciplinary research effort focused on groundwater issues in the country. With the project completed (ACIAR 2016), this article examines its contributions in the areas of science, policy and capacity development and highlights the main lessons learnt during its implementation. These learnings may resonate with those actors already involved in, or considering involvement in applied groundwater research under similar conditions.

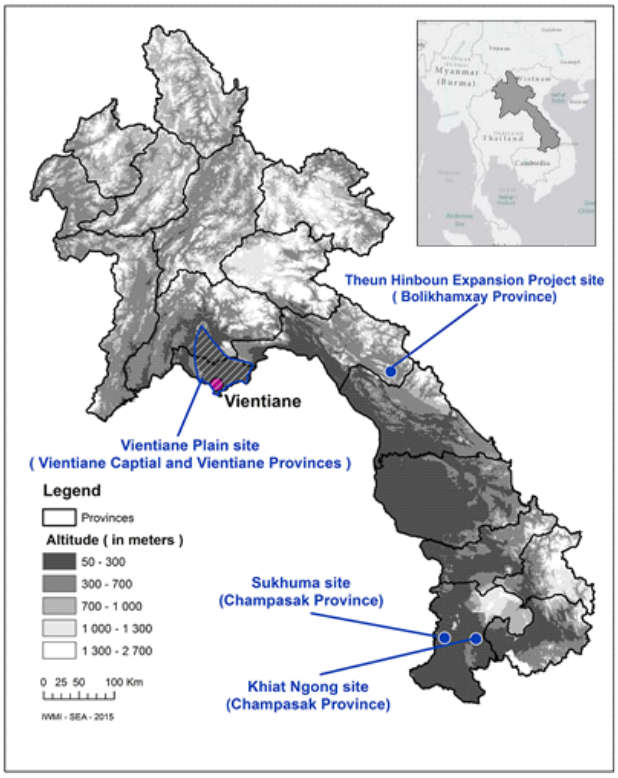

Figure 1. Focal areas of the research project

The implementation approach

The project consortium consisted of partners from government and academia: the Lao Department of Water Resources (DWR), the Natural Resources and Environment Institute (NREI) from the Ministry of Natural Resources and Environment (MONRE), the Lao Department of Irrigation (DOI) from the Ministry of Agriculture and Forestry (MAF), and the Faculties of Water Resources (FWR) and Environmental Science (FES) from the National University of Laos (NUOL). Other partners included Khon Kaen University (KKU) in Thailand, home to a national groundwater research center and the regional Institute for Global Environmental Strategies (IGES) in Japan. KKU's involvement in capacity development took advantage of high technical capacity of its personnel and the similarities in language between the northeastern dialect of Thai and that of Lao. IGES were involved in institutional and policy analysis and had earlier established a Knowledge Hub for Groundwater Management in the Asia-Pacific Region. The International Water Management Institute (IWMI), operating through its country office in Vientiane, Laos, provided overall project leadership and coordination.

A multi-disciplinary research approach was applied in two principal thematic areas: one focused on groundwater resources assessments and management, and the other on groundwater irrigation potential, technologies and practice. The main aim was to influence and strengthen linkages in policy and decision making processes within the water resources and agricultural sectors. Research activities included database development; well drilling and testing; hydrogeological mapping; monitoring the quantity and quality of groundwater resources; groundwater recharge estimation; establishment and testing of on-farm irrigation sites; and understanding community perceptions and perspectives on agricultural groundwater use and management. Work was carried out at four main locations within three provinces with different hydro-geological and socio-cultural settings (Fig. 1) at spatial scales ranging from individual farms or villages through to national (Fig. 2). Underpinning these activities was a firm commitment to capacity enhancement of the large project consortium as well as the wider group of stakeholders. Specific capacity development activities included intensive short courses on the fundamental aspects of groundwater, specialist training on groundwater modelling, provision of internships and postgraduate study opportunities for students and young/junior professionals, particularly those from Laos. When possible, students and interns from Laos were linked with international interns involved in the project (Fig. 3).

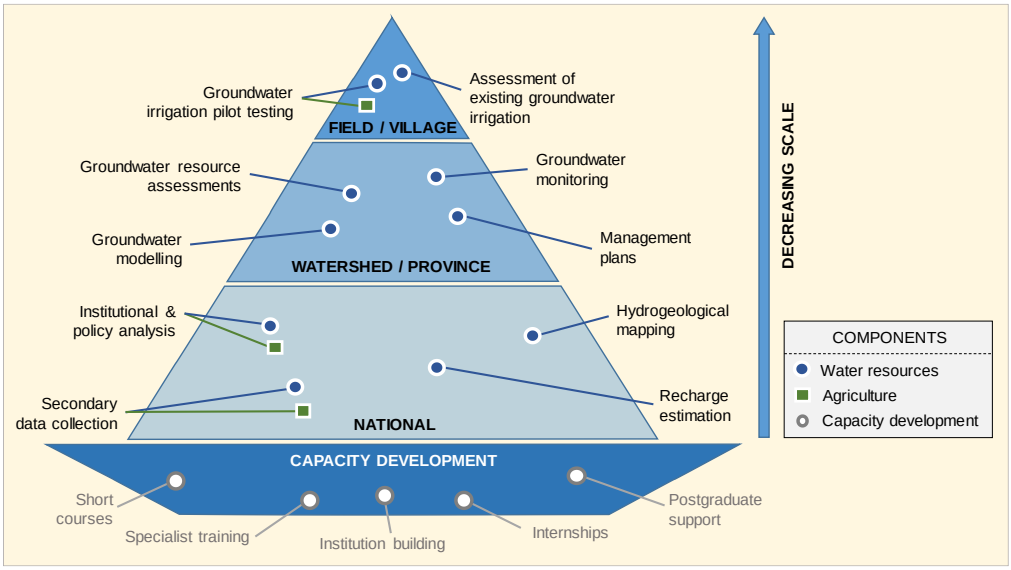

Figure 2. A representation of the multi-scale, multi-disciplinary approach adopted

Figure 3. Bachelor students from the National University of Laos and an intern from Australia interacting during training activities.
Credit: P. Pavelic /IWMI

Groundwater in a tropical water-rich country

Why should Laos, a small country with the highest per capita freshwater availability in Southeast Asia give priority to its groundwater resources? The rationale is found in at least three key socioeconomic development issues.

Diversifying and intensifying irrigated agriculture: Around 80% of the population depend on agriculture for their food security and livelihoods, but an eight-month dry season with very little rainfall makes access to irrigation a high priority for farmers. Outside the monsoon season and remote from perennial surface water irrigation schemes most fields lie fallow, limiting opportunities for farmers to grow crops. Groundwater could provide reliable irrigation for rural communities. Besides improving local food security, groundwater irrigation could support year-round production of diversified produce to help farmers advance from subsistence to market-oriented farming.

Responding to climate change: Drought risk and impact are worsening as temperature increases and precipitation patterns shift due to climate change. Due to the high dependence on rainfed agriculture, droughts present a major threat to rural populations. Tapping into groundwater could buffer against seasonal and multi-year droughts. If done sustainably, groundwater-dependent ecosystems could still thrive (Fig. 4).

Figure 4. The Ramsar-listed Beung Kiat Ngong wetlands in Champasak Province are known to be fed by groundwater.
Credit: K. Phommavong /IWMI

Safeguarding access to clean water: Rural water supplies largely depend on groundwater sourced from wells and springs. Yet a significant proportion of the population still lacks access to safe and clean water for domestic use and sanitation largely due to inadequate infrastructure development (Fig. 5). Groundwater using appropriate infrastructure, like protected wells, is a viable source for closing the gap in water supply and sanitation in rural areas. Increasingly, groundwater could also play a significant role in urban areas.

Figure 5. Improved water supply from groundwater in a Lao village ensures the basic human right to clean water (Source: GreaterGood.org)

Groundwater management challenges in a least developed country context

Groundwater has historically been a subject overlooked in planning processes across the water, agriculture and public health sectors of Laos. Coordination within government organizations, and between government, development partners, and users is fragmented. A review article by Pavelic *et al.* (2014) suggested that groundwater governance in Laos is poor, compromising its potential to contribute to national socioeconomic development, and likely also threatening the protection of aquifers from resource degradation in vulnerable areas. As groundwater use likely intensifies in the coming years, and despite critical gains made from such groundwater development, there is a real risk of unintentional and unsustainable outcomes from over-exploitation and pollution.

Management of groundwater resources remains in its infancy. Groundwater development generally occurs with inadequate exploration and planning and is thus prone to high levels of failure that typically go undocumented. As a result, some governmental and private organizations perceive investment in groundwater development as high risk, which leads to a bias towards other sources of supply (Knudsen *et al.* 2004).

The potential for utilizing groundwater for irrigation in the lowland areas of the country with the highest proportions of arable land has been discussed since the 1980s. However, limited knowledge of the groundwater resources, combined with technical, financial, institutional and capacity constraints has so far prevented groundwater from being used for this purpose at any appreciable scale. The means to extract and use groundwater effectively for agriculture have only been demonstrated in recent years, largely by the efforts of farmers themselves, sometimes supported by development organizations.

Overview of achievements

Major accomplishments of the project can be grouped into three critical areas ultimately supporting good groundwater governance: capacity development, knowledge generation, and policy support.

Capacity development across a broad front

The project enabled partners from government and academic institutions to develop improved knowledge and skills to carry out their mandates. Indicator parameters for project capacity development are given in Table 1. Several examples given below serve to illustrate the specifics:

- The DWR and NREI staff jointly carried out monitoring of groundwater resources across four districts of the upper Vientiane Plain after being trained by IWMI. NREI used the monitoring data to construct a numerical groundwater model with training and guidance from KKU (NREI 2017). Although the model has so far remained an academic tool, it is believed to be the first time that a Lao institution has undertaken modelling of this kind. DWR used the data to develop an initial groundwater management plan for the area, working together with their line agencies at the district level. The management plan was not only intended to support decision making, but also provide a means of strengthening the institutional capacity to formulate and execute policies and laws. It was

prepared through a series of tasks: (i) preparing an inventory of the existing wells in the area; (ii) characterizing the subsurface profile; (iii) developing groundwater regulations for the upper Vientiane Plain; and (iv) raising awareness of groundwater among stakeholders.

- A field experimental facility was set up on the campus of the Faculty of Water Resources (FWR) to allow Lao students to conduct practical studies linked to their curriculum (Fig. 6). The facility provided new possibilities for practical research on various issues relating to agricultural water management[1]. Research efforts were boosted through the placement of a bilingual, international team member at FWR to oversee the facility and assist academic staff to supervise students. During this arrangement, the students and their supervisors prepared a short video called '*The water under your feet*' to bring the topic of groundwater to the attention of a wider Lao audience (produced in Lao language with English subtitles).

- PhD-trained groundwater professionals are very rare in Lao. Two team members commenced PhD studies at Australian universities, having successfully applied for scholarship funding offered annually by ACIAR. Their research topics were aligned with the scope of the project. One student has completed his PhD thesis on groundwater-surface water interactions in Southern Laos and returned to teaching at FWR, whilst the second was still studying at the time of writing this piece. Three Lao team members completed MSc theses at universities in Laos and Japan, whilst nine BSc students were involved in project activities, all with support from the project. Overall, there was a good gender balance of students trained.

- Lecturers from NUOL started using training course materials prepared by the project (Fig. 7) in their curriculum.

INDICATOR	**TOTAL NUMBER** *[Male / Female]*
Number of PhD studies by Lao nationals	**2** [*2 / 0*]
Number of MSc studies by Lao nationals	**3** [*1 / 2*]
Number of BSc studies by Lao nationals	9 [*7 / 2*]
Number of Lao nationals from government and NUOL trained through academic studies, formal short courses, internships or on-the-job training	~100 [*70 / 30*]
Number of international students and young professionals involved in the project	17 [*10 / 7*]
Number of farmers and local government officials provided with on-site training	~40 [*30 / 10*]
Peer-reviewed papers and reports with authorship from above-mentioned trainees	10

Table 1. An overview of performance indicators related to capacity development in the project

[1] Research studies mainly focus on: (i) irrigation efficiency; (ii) soil fertility improvement using on-farm residues and water retention management; and (iii) groundwater management. Some further details are provided in: Keokhamphui K. *et al.* (2016). Enhancing cash crop production through groundwater and agricultural waste applications. *Scientific Journal of the National University of Laos* 11: 2-12 (written in Lao language).

Figure 6. A BSc student from FWR participates in field research at the experimental facility located on Tad Thong campus in Vientiane.
Credit: K. Keokhamphui /NUOL

Figure 7. The first short course on *Groundwater Fundamentals* in April 2013 attracted strong interest from the Lao attendees. The photo shows Dr Kriengsak Srisuk from KKU describing the hydrologeological system during a field mapping excursion to Tha Phra, Khon Kaen Province. Credit: B. Maokhamphiou /IWMI

Improving scientific knowledge

Advancements were made in understanding the hydrogeological environment in Laos at local to national scale:

- The first national hydrogeological map was prepared, building on a previous 1:1,000,000 scale geological map and collating and analyzing project data together with data collected from secondary sources over several years (Viossanges *et al.* 2017). Mean annual rates of groundwater recharge were also mapped at national and regional scale (Lacombe *et al.* 2017). Overall,

relatively high recharge rates suggest considerable potential for increasing groundwater use across wide parts of the country.

- At the four study areas across the country (Fig. 1) the hydrogeological framework, recharge rates, water quality, existing levels of usage and the potential for further development were studied in varying detail (K. Brindha *et al.* 2019; K. Brindha *et al.* 2017; Vongphachanh *et al.* 2017).

From an agricultural perspective, the research gave insight into the way groundwater is perceived, used and managed under different contexts and the costs and benefits of different modes of groundwater irrigation:

- Field surveys in the Vientiane Plain showed that groundwater use by individual farmers during the dry season in places is more widespread than previously assumed (Suhardiman *et al.* 2016). Privately owned and operated shallow groundwater wells allow better-off farmers, with available land and access to capital, to grow cash crops profitably.

- A community-managed groundwater irrigation trial was set up within Ekxang village on the Vientiane Plain to allow a greater number of smallholder farmers to participate in dry season cash cropping. The design irrigation area of 6 hectares was fed by two 30 meter deep wells and managed by a newly-formed groundwater user group. Adoption of groundwater irrigation by the farmers was governed by degree of access to land by the farmers, the availability of affordable labor and by existing livelihood options in this setting, which included work in the nearby capital. As the first such trial in the country, numerous challenges were encountered and resolved where possible within the existing constraints. This experience could help inform implementation in other areas (Clément *et al.* 2018).

- A study was carried out in Phousan village located on the elevated margins of the Vientiane Plain where there are water scarcity issues due to lack of surface water resources and limited groundwater supply from low-yielding sandstone aquifers. The findings suggest that local communities can construct social rules and effectively self-regulate groundwater use according to the limits of the resource to ensure that essential needs are met for all, even in the absence of external support. This includes limiting agricultural development in critical months to prioritize domestic water supply (Suhardiman *et al.* 2018). The key to the success in this case appeared to be linked to strong and fair local leadership.

Policy support

The reports, data and maps coming out of the project serve to guide future development and enable better management of groundwater resources by government authorities within the water resources and related sectors. A National Groundwater Action Plan, prepared in parallel through the National Integrated Water Resources Management Support Project (NIWRMSP) with many of the same partners, was supported by inputs from the research project team. DWR has since prepared groundwater management plans for sub-national areas. Overall, government officers from MONRE tasked with designing and implementing key water reform strategies, policies, laws and regulations, have benefited from the improved knowledge and skills gained during project activities.

Following a policy dialogue organized to present the project key findings in 2016, senior officials from MAF requested the findings to be distilled into a policy brief on the role of groundwater for irrigation (ACIAR 2017) (Fig. 8). The brief, available in English and Lao, presents policy options for private and community managed smallholder irrigation using groundwater, and suggests how to strengthen capacity and promote cross-sector coordination, and identifies priority areas for further research for development. Its messages have been communicated by MAF at high-level meetings within the ministry at national and provincial levels. Thus, the project has created greater recognition of the role of groundwater in agricultural development as well as the need for sustainable development to provide for multiple beneficial uses, including domestic, agriculture, industry and the environment.

It is perhaps useful to note that the project took place at a time when groundwater was beginning to receive broad recognition in the country. Before the project, national policy documents on water resources and climate change made scant reference to groundwater. Over the course of the project, groundwater received its first-ever explicit inclusion in the country's 5-year national socioeconomic development plan (the 8th plan for 2016-20), and it was also featured in the revised Water Laws finalized in 2017.

Figure 8. Policy brief on groundwater for irrigation, Lao version (ACIAR 2017)

Main lessons learnt

A number of lessons were learnt from the project that may add value to a recently initiated sequel project and more generally could be useful going forward:

1. Align the research with stakeholder priorities

In a developing country situation, it is especially important that research is tailored to meet the needs of the partners and stakeholders. When consortiums from vastly different backgrounds come together for the first time, the objectives of individual partners can sometimes be partially conflicting, despite the best of intentions. Hence, the work plans originally prepared had to be revised during the mid-term project review to better serve the priorities of partners and final beneficiaries. The ideas for the FWR experimental facility and the pilot management plan of the upper Vientiane Plain emerged during this period. As a result, productivity increased greatly in the second half of the project.

2. Don't operate in isolation

Synergy was created by linking between various projects with similar scope related to groundwater management, irrigation development and climate change. Interacting with a broad range of stakeholders from multilateral development banks, river basin organizations, national water authorities, academic institutions and others gave leverage that yielded benefits and spinoffs for all parties involved. As an example, the contributions made to the National Groundwater Action Plan capitalized on the synergies with the concurrent NIWRMSP project.

3. Learning by doing over extended timeframes

In the case of Laos, low-level sustained effort is critical. One-off training courses can be enjoyable events for attendees but often serve little purpose for skills development if there is no planned follow up. Short-term blanket approaches were initially applied in the project with limited success, but these were later changed towards supporting promising individuals who were given longer-term support and training. Excellent exchange and co-learning outcomes were achieved when pairing compatible Lao and international students/interns, building on complementarities in language, culture and scientific knowledge. The two PhD studies provide good opportunities for longer term impact.

4. Groundwater development depends on more than physical potential

Understanding the hydrogeological system and the suitability for groundwater irrigation is only the first stage towards generating positive and lasting development outcomes. Lao farmers will not necessarily engage in groundwater irrigation just because a good resource is available. They make decisions based on a mix of socioeconomic factors relevant to the local context. Other factors critical to successful implementation and management include: having adequate financing arrangements for groundwater irrigation in place; good markets for crops, and empowered farmers (both men and women) through knowledge and technical support.

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References

ACIAR (Australian Centre for International Agricultural Research) (2017). Groundwater for irrigation in Lao PDR: Promoting sustainable farmer-managed groundwater irrigation technologies for food security, livelihood enhancement and climate resilient agriculture. Available at: http://stage.aciar.gov.au/publication/GROUNDWATER-IRRIGATION-LAO-PDR-Policy-Brief-2017

ACIAR (Australian Centre for International Agricultural Research) (2016) Enhancing the resilience and productivity of rainfed dominated systems in Lao PDR through sustainable groundwater use. Final Report for ACIAR Project LWR/2010/081. Available at: http://aciar.gov.au/publication/fr2016-35

Clément C., Vinckevleugel J., Pavelic P., Xiong K., Valee L., Sotoukee T., Shivakoti B.R. and Vongsathien K. (2018). Community-managed groundwater irrigation on the Vientiane Plain of Lao PDR: Planning, implementation and findings from a pilot trial. Colombo, Sri Lanka: International Water Management Institute (IWMI). IWMI Working Paper 183, 52p.

K. Brindha, Pavelic P. and Sotoukee T. (2019). Environmental assessment of water and soil quality in the Vientiane Plain, Lao PDR. 8 *Groundwater for Sustainable Development*: 24-30.

K. Brindha, Pavelic P., Sotoukee T., Douangsavanh S. and Elango L. (2017). Geochemical characteristics and groundwater quality in the Vientiane Plain, Laos. *Exposure and Health* 9(2): 89-104.

Knudsen J.B.S., Ruden F. and Smith B.T. (2004). The online support and training project for the groundwater sector of Lao PDR. Proceedings of 30th WEDC International Conference 'People-centred approaches to water and environmental sanitation', Vientiane, Lao PDR, 2004. pp. 434–437.

Lacombe G., Douangsavanh S., Vongphachanh S. and Pavelic P. (2017). Regional assessment of groundwater recharge in the lower Mekong basin. *Hydrology* 4(4), 60.

NREI (Natural Resources and Environment Institute) (2017). Groundwater model development in Vientiane Plain. Draft Report (written in Lao language). Ministry of National Resources and Environment, Lao PDR.

Pavelic P., Xayviliya O. and Ongkeo O. (2014). Pathways for effective groundwater governance in the least-developed-country context of the Lao PDR. *Water International* 39: 469–485.

Suhardiman D., Pavelic P., Keovilignavong O. and Giordano M. (2018). Putting farmers' strategies in the centre of agricultural groundwater use in the Vientiane Plain, Laos. *International Journal of Water Resources Development* 1-21.

Suhardiman D., Giordano M., Bouapao L. and Keovilignavong O. (2016). Farmers' strategies as building block for rethinking sustainable intensification. *Agriculture and Human Values* 33(3): 563-574.

Viossanges M., Pavelic P., Rebelo L-M., Lacombe G. and Sotoukee T. (2017). Regional mapping of groundwater resources in data-scarce regions: The case of Laos. *Hydrology* 5(1), 2.

Vongphachanh S., Das Gupta A., Milne-Home W., Ball J.E. and Pavelic P. (2017). Hydrogeological reconnaissance of Sukhuma District, Champasak Province, Southern Laos. *Journal of Hydrology (NZ)* 56(2): 79-96.