PERFORMANCE REVIEW AND POLICY OPTIONS FOR SUSTAINABLE IRRIGATION DEVELOPMENT IN LAO PDR

Bounthong Bouahom[1], Paul Pavelic, Ian Makin, Matthew McCartney, Diana Suhardiman, Sonali Senaratna Sellamuttu[2], Jean-Philippe Venot[3]and KhammaiVongsathiane[4]

ABSTRACT

Over the past two decades, irrigation has been a vital and integral part of agricultural and rural development programs throughout Lao PDR. Areas under irrigation have more than tripled from 0.15 million ha (Mha) in 1991 to 0.46 MhA in 2014. Unlike many other parts of Asia, the irrigation potential of the country has yet to be fully realized, with adequate land and water for expansion and intensification in most provinces. Continued investments in irrigated agriculture are forecast in coming years, as reflected in the current (8th) National Socio-Economic Development Plan for 2016-2020 and related high level policies and plans.

The plans are ambitious, but also recognize the major challenges that constrain irrigation system management. Field observations and assessments are revealing mixed performance and a host of technical, economic, institutional and environmental issues are as yet unaddressed. There is a shared understanding that sustainable irrigation development and management implies intervention and guidance in, at least, four specific areas: i) improving market orientation and opportunities; ii) climate change adaption through improved water management; iii) informal private irrigation; and iv) ecosystem services protection and tradeoffs. These, and other areas, need careful consideration to support policy recommendations on the future development of the irrigated agriculture sector and related support services in Lao PDR.

Keywords: Irrigation schemes, public policy, participatory irrigation management; ecosystems, climate change adaption, Lao PDR.

1. INTRODUCTION

Irrigation remains one of the main thrusts of the government of Lao PDR as it seeks to rapidly develop and progress from Least Developed Country status by 2020 and attain more advanced status beyond. This ambition is reflected in the current 5-year Socio-economic Development Plan (GoL, 2015) and associated high level policies and strategies. Whilst the country was declared self-sufficient in rice in the year 2000 at the national level, food deficits and malnutrition still persists in the poorest districts of the country, and particularly in the remote mountainous areas that are home to multi-ethnic minorities. As a country rich in natural resources but limited off-farm development, it is still economically dependent on the agricultural sector for about 28% of GDP, and more critically to support 63% of the population living in rural areas.

[1] National Agriculture and Forestry Research Institute (NAFRI), Ministry of Agriculture and Forestry, Lao PDR; E-mail: bounthongbouahom@gmail.com

[2] International Water Management Institute (IWMI), Lao PDR and Sri Lanka; E-mails: P.Pavelic@cgiar.org, I.Makin@cgiar.org, M.McCartney@cgiar.org, D.Suhardiman@cgiar.org, S.Senaratnasellamuttu@cgiar.org

[3] Institut de Recherche pour le Développement (IRD), France; E-mail: jean-philippe.venot@ird.fr

[4] Department of Irrigation (DOI), Ministry of Agriculture and Forestry, Lao PDR; E-mail: khammaivst@yahoo.com

Unlike many other parts of Asia, the irrigation potential of Lao PDR has yet to be fully realized, with adequate land and water for expansion and intensification of irrigated agriculture in many provinces. Major investments from the Lao PDR government, but also from donor funds, have been made in public irrigation to address food/nutrition security, achieve socioeconomic growth and adapt to climate change. Yet, despite the significant achievements made, numerous practitioners report that irrigation projects do not always reach expectations, and this is reaffirmed by studies that have examined the performance of specific schemes (e.g. CES & AFD, 2008).

Whilst reviews of the irrigation sector have previously been carried out, these have either been at the regional level or have had a specific thematic focus (CES & AFD, 2008; Hoanh *et al.* 2009). These studies are also several years old and much has happened over the last few years. The aim of this paper is to examine the available evidence and identify a selected set of messages for policy makers that contribute to national and sub-national planning and implementation processes.

2. IRRIGATION PERFORMANCE

2.1 Current status

Nationwide, as of 2014, there are reportedly 18.067 irrigation schemes,of which 19% are dams/reservoirs, 10% are pump-lift and 71% are local weirs (MAF, 2015). The majority of the 3,400-odd officially registered schemes are small (<100 ha) weir-type schemes, with medium (100-500 ha) and large (>500 ha) scale schemes being pump- and reservoir- type schemes, largely confined to the floodplains of the Mekong and its tributaries (Table 1). Over seventy percent of the irrigated area comes from just 7 provinces, with Savannakhet highest overall.

Table 1. Registered irrigation schemes according to scale and type

Province	Scale			Head work type					Wet season irrigated area (ha)
	Small	Medium	Large	Diversion, gate, regulator	Pump	Reservoir	Weir	Other	
Attapeu	15	10	2	16	10	1	0	0	4485
Borikhamxay	85	42	1	6	43	3	76	0	4462
Borkeo	146	4	0	6	13	0	131	0	11482
Champasak	95	38	5	0	76	10	52	0	19626
Houaphan	219	4	0	5	2	11	205	0	4564
Khammounce	118	53	4	11	135	9	20	0	16846
Louangphrabang	192	7	0	0	0	0	199	0	5255
Luangnamtha	231	23	1	0	0	0	255	0	8668
Oudomxai	244	13	0	11	0	2	240	4	6814
Phongsaly	228	1	0	23	0	3	203	0	2401
Saravan	101	68	3	0	48	18	106	0	17766
Savannakhet	226	119	8	36	104	134	79	0	35029
Sekong	104	3	1	5	0	4	61	38	2464
Vientaine Capital	7	68	18	1	78	11	2	1	37523
Vientiane	277	90	6	14	45	23	291	0	34029
Xaignabouri	262	20	3	0	14	23	245	3	11430
Xiengkhuang	191	28	1	0	0	28	178	14	13114

Source: Department of Irrigation data, **Note:** survey of irrigation infrastructure was carried out before the most recent (18th) province was established

Over the period from 1991 to 2014, the area under wet season irrigation increased approximately 2-fold from 136,000 ha to 274,000 ha and the dry season experienced an 11-fold increase, from 16,000 to 182,000 ha. This represents a three-fold increase in the total irrigated area in a little more than two decades. Total (unmilled) rice

production has grown strongly and steadily from 0.46 million tonnes (Mt) in 1976 to a high of 3.2 Mt in 2014. Production of irrigated dry season rice has grown from 0.003 Mt in 1976 to 0.56 Mt in 2014. Rice yields have been steadily rising and latest records for 2014 indicate values of around 4.2 t/ha for wet season, 5.0 t/ha for dry season and 2.0 t/ha in upland areas (rainfed rice). Non-rice crop production (maize, coffee, sugar cane, cassava, soybean and others) was 9,700 and 45,800 ha for the 2014 wet and dry seasons respectively (irrigated and rainfed) and has been steadily increasing in recent years (MAF, 2015).

2.2 2020 targets

Bold targets are set within the National Agriculture Development Strategy to the year 2025 and Vision to 2030 for the expansion of irrigated rice production and other high value crops in areas with highest production potential (MAF, 2015). The development of the irrigation sector is premised on a dual approach: support towards market-oriented intensive irrigation in the lowland plains and a safeguard policy in the uplands that have highest rates of poverty and a lower physical potential. The major lowland plains have greatest development potential and the priority there is to maintain the pace of market-driven changes, ensure food security, and accelerate the process of cash crop diversification, intensified livestock and aquaculture development for the local market and for export by bolstering investments in irrigation and associated technologies. Identified strategies center around rehabilitating and expanding irrigation schemes, strengthening local and community-based management of irrigation systems, improving agricultural and farming systems, increasing and intensifying cash cropping, livestock and fisheries production. The uplands pose particular challenges, but are nevertheless important in seeking inclusive growth for the most needy minority communities. For the smaller plains, valleys and plateaus where the irrigation potential is limited by the hilly terrain and minimal infrastructure, the focus is towards rural poverty alleviation, stabilization of shifting cultivation and diversification of farming systems through expansion of community managed irrigation systems.

A target of 4.7 Mt of unmilled rice per annum (70% glutinous varieties) is set for 2020 to meet multiple purposes - food security, reserves, seed, domestic processing and domestic/ international sale (MAF, 2015). This is a 47% increase vis-à-vis production in 2014 (3.2 Mt). Targets are dependent on yield improvements from the current national average of 3.8 t/ha to 4.5 t/ha by 2020 and 5 t/ha by 2025 combined with expanding irrigated area from about the current 0.3 Mha (2015) to 0.4 Mha by 2020, and to about 0.45 Mha by 2025 (MAF, 2015).

3. ISSUES FACED AND PATHWAYS FORWARD

Despite the achievements mentioned above, field observations are revealing mixed performance of existing irrigation schemes. Small community scale schemes generally appear to perform well, bringing about significant socioeconomic gains to local farmers and have acceptably low environmental impacts. Larger schemes, on the other hand, have, in several instances, been designed and constructed sub-optimally; they are often not being adequately maintained or utilized (CES & AFD, 2008). Some of the issues that limit progress in the irrigation sector are listed in Table 2, partitioned into four main areas - technical, economic, institutional and environmental. A detailed analysis of these issues is beyond the scope of this paper; rather we focus on identifying pathways forward for a selected number of issuesin the following section.

Table 2. Issues affecting the irrigation sector in Lao PDR. Those selected for further discussion are highlighted by '(*)'

Aspects	Description
Technical	- inadequate or inequitable water distribution at the farm and system levels (*) - deteriorated infrastructure (supply networks, damaged or broken pumps etc.) - lack of technical capacity in managing headworks (e.g. pumping stations)
Economic	- limited interest by farmers in irrigating wet season rice or planning a second rice crop due to low market price, with stronger interest to plant higher valued crops for more income (*) - labor shortages and competition brought about by more attractive off-farm incomes and opportunities (locally or regionally) - ill-adapted design choices leading to high service fees and poor rates of collection of water fees - insufficient funds for timely and adequate support by government at all levels - lack of access to credit for agriculture and trade - poor returns from investments (both public spending and external assistance)
Institutional	- weak water user organizations and extension services leading to limited engagement and implementation of IMT/PIM - insecure land tenure leading to farm owners seeking off-farm employment and land rented out to those with less direct interest to invest in irrigation - overemphasis on top-down siting and design of projects - poor road access as market links not always considered due to high costs and/or responsibility of other sectors, and priority given to vulnerable areas - poor enforcement of regulations leading to ecosystem decline
Environmental	- negative irrigated ecosystem impacts from agro-chemical inputs (*) - degradation of watersheds due to unsustainable land management - fisheries and other biodiversity loss due to interventions, with important implications for food and nutrition security - high greenhouse gas emissions from large schemes

Sources: Adapted from CES & AFD, 2008; Gebbie et al. 2008; Hoanh *et al.* 2009

3.1 The need for increased market orientation and opportunities

At the heart of why many irrigation schemes are underutilized or underperforming is that farmers lack sufficient financial incentives to participate and maximize irrigated crop production. This poses a foreseeable policy dilemma for the government as it positions rice production, and therefore irrigation also, as a means to ensure food security and/or promote economic growth (e.g. through rice exports). This implies aiming to keep the price of rice affordable for urban and rural rice consumers, whilst providing incentives for farmers to intensify production to achieve larger development goals.

Irrigated rice farming in Lao PDR during both wet and dry seasons remains an economically marginal activity, providing limited financial incentive for farmers to intensify production beyond household consumption needs (Manivong *et al.* 2014). As most rice is produced for household needs, the domestic market remains small with low levels of competition amongst traders. For many irrigation production areas, the cost of transport to and from markets is high and reduces potential margins on crop production. Agricultural extension staff lack skills and resources to effectively provide advice on best available technologies and practices for irrigated paddy and other commercial crops.

Crop diversification and stronger market orientation is vital and necessary to expand market options and minimize risks for producers. There is already strong evidence to suggest that farmers are relying less on rice production and more on non-rice crops than in the past. Growing alternative crops on paddy land has been observed on the

Vientiane Plain where farmers are voluntarily diversifying their crop strategies to improve household income, particularly where the right enabling conditions are present (Suhardiman *et al.* 2015). A case study from Savannakhet shows that the capacity to pay irrigation service fees is least for farmers who cultivate rice only, intermediate for farmers who cultivate rice and cash crops, and highest for those growing only cash-crops demonstrating the important role of commercialization on farmer participation (Rasphone *et al.* 2006). Achieving greater crop diversification is best achieved in irrigation systems designed with differentiated land zoning within command areas and adequate operational flexibility to account for differential water demands. Examples of how to achieve this in practice are discussed below.

3.2 Climate change adaption through conjunctive water management

Conjunctive water use management (CWM) is becoming a globally important tool for adapting to climate change as it serves to reduce the gap between the demand and supply of water within irrigation command areas (Evans *et al.* 2013). Surface water-based irrigation often lacks the reliability of supply because of a high variability in water inflows caused by unpredictable rainfall patterns or inefficient water delivery. They also lack flexibility – a key aspect notably in regard to the need to diversify cropping patterns (see above). Larger irrigation schemes can under-perform due to over-supply to head-end farmers (bringing with it flooding and water logging problems), and under-supply to tail-end farmers.

CWM is not yet practiced in Lao PDR but has long-been applied in some neighboring counties (e.g. Thailand and China). Irrigation infrastructure could be modified to recharge aquifers, and if that groundwater were accessed, would provide farmers with greater reliability and control of water supplies. Waterlogging problems due to shallow water table normally addressed with drainage infrastructure could be better solved by groundwater pumping. Irrigation channels throughout the country are gradually being upgraded from earthen to concrete, although less than 20% have been lined (GoL, 2010). Under a CWM approach, its merits could be reconsidered on a case-specific basis given that conveyance losses generally serve to replenish aquifers.

Tapping groundwater provides a locally dependable source of supply if done effectively, but also creates additional pumping costs. Such costs would be highest where the original source of irrigation water was lifted and subsequently stored in aquifers and then re-lifted. The economics of CWM need to be carefully assessed to ensure net benefits are achieved. CWM would require the right enabling conditions to be viable - institutional and policy changes supported by strengthening of technical capacity in relevant fields (i.e. resource assessments, drilling and pumping technologies etc).

3.3 Greater emphasis on privately managed irrigation

Privately owned and managed forms of irrigation, either from small on-farm ponds, or more often, from groundwater wells, has undergone a dramatic expansion worldwide over the last few decades due to the need for more reliable and flexible water access (Mukherji *et al.* 2010). Across parts of Asia, the irrigation sector is being dramatically transformed, as large-scale formal government and medium community managed schemes witness a multiplication of informal, individually managed small-scale pumping that question management modalities and responsibilities. Much of this transformation has been achieved by farmers themselves who seek more flexibility (irrigation practices and crop choices), and has replaced or been leveraged from investments in public irrigation.

Groundwater-based irrigation has been taking place in Lao PDR over the last few years on a limited basis in lowland settings. There, most households rely on access to a borehole for domestic supplies and also use it for irrigation purposes on small areas. In the south of the country, increasing use of groundwater has been made possible through expansion of rural electrification which makes drilling boreholes and using electric pumps more affordable. In areas remote from perennial surface waters, where shallow aquifers can provide groundwater in sufficient quantity and quality, individual farmers are growing high value crops of their choice during the dry season (and to some extent in the wet season) to supplement their incomes (Vote *et al.* 2015). Groundwater irrigation can also be achieved with lower capital investments through construction of open dug wells powered by small diesel pumps by farmers with sufficient land and access to additional labor and proximity to markets, such as in parts of the Vientiane Plain where fresh, shallow watertables are present. To date, uptake has been constrained by scant information on the groundwater resources and a distinct absence of effort by extension services to promote the technology, although knowledge in these areas is improving (Pavelic *et al.* 2014),

3.4 Balancing irrigation development with ecosystem services

Rich levels of biodiversity in rice-based ecosystems are of great importance to all Lao people, particularly rural populations who rely not only on paddy rice, but also on a wide number of plant and animal species that are an integral part of the ecosystem and represent important sources of protein and micro-nutrients, traditional medicine and income. It is generally well-accepted that irrigation intensifies the use of agricultural inputs of fertilizers and pesticides and leads to reduced biodiversity. Across Southeast Asian countries, potentially including Las PDR, the growth in rice production has come at the expense of significant losses in aquatic and terrestrial flora and fauna, with knock-on impacts for peoples' wellbeing.

Linkages and tradeoffs between irrigation and environmental services are complex and site specific. Surveys of the upland paddy fields in Xiangkhouang province confirmed that the absence of pesticide use by local farmers contributed to the diverse range of aquatic, semi-terrestrial and terrestrial species used for direct consumption or sale (Pedersen *et al.* 2014). A community scale irrigation development in the lowlands of Attepeu province found no significant environmental impact on a downstream wetland which provided food security and livelihood benefits (Bhattarai et al. 2008). Whilst the use of agrochemicals in Lao PDR is apparently low compared with other Southeast Asian countries, there is mounting evidence to show that pesticide use in particular, is not only increasing, but that highly hazardous banned chemicals from the region are being routinely used by farmers throughout the country (Vázquez, 2013). Whilst new regulations have come into force concerning the chemicals allowed to enter the country, enforcement remains a key constraint, and furthermore there is little control on use.

The design and functioning of irrigation systems needs to be more holistic with adequate consideration given to the potential impacts on broader ecosystem services and associated implications for livelihoods and human health. In recent times government policy has been shifting in this direction. The high priority previously given to investments in irrigation construction is gradually being refocused towards agriculture development and extension (MAF, 2015). With this shift comes an opportunity to place greater emphasis on sustainable land use planning and management.

4. CONCLUSIONS

The irrigation sector has made a great contribution to achieving national food security and improving the livelihoods of farming communities in Lao PDR. Much remains to be done and four areas of improvement have been identified to more effectively advance the agricultural sector development plans that are earmarked in coming years as follows:

Increased market orientation and opportunities - To make irrigated farming more economically attractive activity greater inroads into crop diversification are needed. Achieving greater crop diversification requires a greater focus on new irrigation design models with appropriate land zoning within command areas.

Climate Change Adaption (CCA) and flexible water delivery through conjunctive water use management – a practical way to address this is to explore transferring investments from lining of canals to seepage recovery by way of 'collector wells', particularly in tail-end regions and other parts of the system where supplies are unreliable and 'infilling' is needed.

Individually managed small-scale irrigation in or outside existing irrigation systems – provides viable livelihood options for farmers. Greater recognition and emphasis should be given to decentralized systems of irrigation based on the use of shallow tube wells, dug wells or small on-farm ponds. Greater reliance on groundwater, be it outside of command areas, or within through CWM, must be facilitated by strengthening the technical and institutional capacity to promote the technology and provide necessary support.

Balancing irrigation development with ecosystem services – higher prioritization must be given to environmental impacts of irrigation development. It is important that opportunities for irrigation development are realized without undermining the living aquatic resources on which so many people currently depend and which make a significant contribution to the resilience of agricultural systems in Laos, particularly in the face of climate change. New irrigation projects should not be initiated without first conducting EIA's (now mandatory), widened to encompass social dimensions (including evaluation of nutrition and health impacts). This should also be supported by strengthened capacity and general awareness in sustainable agricultural practices for agricultural extension officials and farmers.

ACKNOWLEDGEMENTS

This paper was made possible through the support of the Australian Centre for International Agricultural Research (ACIAR) and the CGIAR Research Programs on Water, Land and Ecosystems (WLE). MrTouleelor Sotoukee (IWMI) assisted with the data analysis. We thank the two anonymous WIF2 reviewers for their constructive comments on the abstract originally submitted for consideration.

REFERENCES

Bhattarai, M., Kyophilavong, P., Aloun, P. & Hoanh, C.T. 2008 Smallholder Irrigation Impacts on Wetlands Livelihoods and Aquatic Resources: Community-level Study in Laos, Mekong River Basin. Poster Paper Presented at World Water Congress Montpellier, 1-4 September, 2008.

CES (Community and Environment Services) & AFD (AgenceFrançaise de Développement) 2008 Irrigation Diagnostic Study. Final Report (2 Vols.), January 2008, Vientiane, Lao PDR.

Evans, W.R., Evans, R.S. & Holland, G.F. 2013 Conjunctive use and management of groundwater and surface water within existing irrigation commands: the need for a new focus on an old paradigm. Groundwater Governance: A Global Framework For Action, Thematic Paper No. 2.

Gebbie, L., Glendinning, A., Braun-Lefroy, R. & Victor, M. 2008 Diagnostic study on Northern Uplands sustainable development. Report prepared for the Sub-Working Group on Northern Uplands Sustainable Development, Final Draft, November 2008.

GoL (Government of the Lao People's Democratic Republic) 2010 Strategy for Agricultural Development 2011 to 2020. Ministry of Agriculture and Forestry, Vientiane, Final Draft of 15 September 2010, English Version.

GoL (Government of the Lao People's Democratic Republic) 2015 Five Year National Socio-Economic Development Plan VIII (2016-2020). Ministry of Planning and Investment, Vientiane, Draft 5 of 25 February 2015, English version.

Hoanh, C.T., Facon, T., Thuon, T., Bastakoti, R.C., Molle, F. &Phengphaengsy, F.2009 Irrigation in the Lower Mekong Basin Countries: The Beginning of a New Era? In: F. Molle, T. Foran& M. Kakonen [Eds], Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance, ISBN 9781844077076, Chapter 6, pp.143-171.

MAF (Ministry of Agriculture and Forestry) 2015 Agriculture Development Strategy to the year 2025 and Vision to 2030. MAF, May 2015, Lao and English versions available.

Manivong, V., Cramb, R. & Newby, J. 2014 Rice and remittances: crop intensification versus labour migration in southern Laos. Human Ecology 42(3), 367–379.

Mukherji, A., Facon, T., Molden, D. & Chartres, C. 2010 Growing more food with less water: How can revitalizing Asia's irrigation help? Paper prepared by the International Water Management Institute for the ADB and Partners Conference on Water: Crisis and Choices on October 11, 2010, ADB Headquarters, Manila, Philippines, 16p.

Pedersen, O.S., Chertchai, F., Chanthavang, A., Khamvang X. &Yoysaykham, B. 2014 Aquatic organisms in rice-based ecosystems in Naxaithong, Paen and Poungmanh villages, Phoukhout District, XiengKhouang Province, Lao PDR. In: Halwart, M. et al. (Eds), Aquatic biodiversity in rice-based ecosystems: Studies and reports from Indonesia, Lao PDR, and the Philippines. Food and Agriculture Organization of the United Nations, pp. 21-43.

Rasphone, A., Osanami, F. & Kondo, T. 2006 The irrigation service fees and affordability after the management transfer: Empirical evidence from Ban Vuen-Tonhen WUA in Savannakhet Province, Lao PDR. In: 2006 Annual Meeting of the International Association of Agricultural Economists, 12-18 August, 2006, Queensland, Australia (No. 25695).

Suhardiman, D., Giordano, M., Bouapao, L. & Keovilignavong, O. 2015 Farmers' strategies as building block for rethinking sustainable intensification. Agric. Hum. Values, DOI: 10.1007/s10460-015-9638-3.

Vázquez, C. 2013 Illegal Pesticide Trade in the Mekong Countries: Case of Lao PDR. Report prepared by the Pesticide Action Network Asia and the Pacific (PAN AP) & Sustainable Agriculture and Environment Development Association (SAEDA).

Vote, C., Newby, J., Phouyyavong, K., Inthavong, T. & Eberbach, P. 2015 Trends and perceptions of rural household groundwater use and the implications for smallholder agriculture in rain-fed Southern Laos. International Journal of Water Resources Development 31(4), 558-574.

World Bank 2015 Lao Economic Monitor: Towards Restoring Macroeconomic Stability and Building Inclusive Growth. The World Bank Group: Washington and Vientiane, April 2015.