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Matthew McCartney & Jake Brunner

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Improved water management is central to solving the water-energy-food trilemma in Lao PDR

Matthew McCartney^a and Jake Brunner^b

^aInternational Water Management Institute, Sustainable Water Infrastructure and Ecosystems, Colombo, Sri Lanka; ^bIUCN Indo-Burma Group, Vietnam Country Office, Hanoi, Vietnam

ABSTRACT

Relying on published literature, we reviewed water-energy-food issues in Lao PDR in the context of a policy shift to more sustainable 'green growth' and significantly increased infrastructure investment resulting from China's Belt and Road Initiative. The BRI provides the prospect for the country to address its infrastructure deficit and transform from a 'land-locked' to a 'land-linked' country. However, great care is needed to ensure that future investments do not result in further environmental degradation and harm to communities. An integrated 'nexus' approach, in which enhanced water management is central, is a prerequisite for more inclusive and sustainable development.

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Introduction

Typically, in rapidly developing agrarian societies, increasing non-agricultural demands on water, growing food demands and changing food preferences all put increasing pressure on water resources. As a result, it is very often water scarcity (i.e. the proximate cause of competition) that reveals the complexity of the water-food-energy nexus trilemma: a multidimensional web that is structurally complex, not always intuitive, and comprises dynamic links that vary in weight and direction (Perorone & Hornberger, 2014). However, in some cases, it is not water scarcity per se but other dimensions of water security that reveal the essential need to manage the totality of the nexus through much better water management. As we demonstrate in this article, the Lao People's Democratic Republic (Lao PDR) is such a case.

In Lao PDR, although water resources are abundant, a rapidly growing and urbanizing population, in conjunction with government strategies for economic development rooted in hydropower, agricultural commercialization and mining, highlight the complex and dynamic interrelationship between water, food and energy. In such a situation, despite the lack of physical water scarcity, improving water management is crucial to sustaining national economic growth and advancing human development.

Geopolitically, Lao PDR is strategically very important to China, because it is a key gateway to markets in South-East Asia. In recent years, through its ambitious Belt and Road Initiative (BRI), China has invested heavily in the country, including in hydropower, mines and

CONTACT Matthew McCartney  m.mccartney@cgjar.org

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agriculture. A USD 6 billion, 414 km railway project connecting the two countries (from Kunming in China to Vientiane in Lao PDR) is currently under construction and due for completion in 2021. It is intended that this railway will accelerate the development of a China–Laos economic corridor with links to other countries in the region, create synergies with other BRI projects, and make a significant contribution to Lao PDR's strategy of turning itself from a 'land-locked' to a 'land-linked' country (Morris, 2019).

In this article, we describe the state of the country, how the water, energy and food sectors are tightly intertwined and co-dependent, the contemporary drivers of change – including a recent but significant policy shift to more sustainable 'green growth' – and the possible implications of the changes occurring in the context of interactions with China, specifically the BRI.

Lao PDR: overview

Lao PDR is a one-party communist state bordering Thailand, Cambodia, Vietnam, China and Myanmar. Over the past three decades the Government has introduced market-oriented reforms similar to those in China and Vietnam. However, the country is landlocked, which means Laotian products can only be accessed through third-party countries. This, in conjunction with insufficient infrastructure, greatly hinders the development of the national economy (World Bank, 2017a). The country is only partially integrated with regional and global markets. Gaps in infrastructure compound gaps in policy. Cross-regional integration, though improving, could be significantly strengthened. Today, Lao PDR is a lower-middle-income country with GNI per capita of around USD 1740 (World Bank, 2017b).

Covering a total area of 236,800 km² (Central Intelligence Agency, 2019), the landscape is diverse, comprising mountains in the north and east and the alluvial floodplains of the Mekong River's eastern tributaries in the west and south (Figure 1). Lao PDR remains a primarily agrarian society and is currently among the least urbanized countries in the Asia-Pacific (Epprecht et al., 2018). The population is approximately 7.23 million and growing at an average of 1.48% annually (Central Intelligence Agency, 2019). Approximately 66% of the population lives in rural areas, and most citizens rely on subsistence agriculture for their food and livelihood. Only 10% of Lao PDR's land is classified as agricultural, but 64% of the population works in the agricultural sector, mostly on family farms (World Bank, 2017b). There is significant migration to urban centres, and the estimated annual rate of growth of the population in current urban areas is about 4.7% (Epprecht et al., 2018).

Over the past two decades, Lao PDR has grown economically and has made significant development progress, including halving poverty, reducing hunger and improving education and health outcomes. However, impressive improvements at the national level mask significant differences between regions and socio-economic groups. Poverty is particularly severe in remote upland areas, especially among ethnic minorities. Harsh natural conditions, unpredictable weather and poor transport and communications infrastructure limit access to markets and major social services (e.g. medical facilities), undermining livelihoods and constraining opportunities to escape poverty (Baird & Shoemkaer, 2008). Traditional rural livelihoods are largely dependent on rice cultivation, supplemented with fisheries and forest products. Chronic malnutrition remains a major problem, with on average 44% of children under five suffering from stunting (World Bank, 2017a). Although most households now have acceptable levels of food consumption,



Figure 1. Map of Lao PDR.

nourishment is typically undermined by lack of diversity and poor quality in both nutritional content and food safety (Bouapao et al., 2016).

The climate is tropical monsoon, alternating wet (May to October) and dry (November to April) seasons. With significant annual rainfall (1800 mm), abundant internal freshwater resources (240 km³/y) and a relatively small population, Lao PDR has a very high volume of available water per capita (28,000 m³) (World Bank, 2017b), even more than 'water-rich' countries like Finland (20,000 m³), Sweden (18,000 m³) and Malaysia (19,000 m³). Currently, water withdrawals (primarily for irrigation) amount to just 1.8% of the annual water available (World Bank, 2017b).

Lao PDR remains one of the poorest countries in South-East Asia. In the two decades from 1985 to 2016, the government's economic strategy focused on the exploitation of natural resources: forestry, mining and hydropower. In the agricultural sector, a focus on rice production for food security gradually shifted, once production levels were sufficient, to commodity production for economic growth (International Water Management Institute, 2019). However, in 2016, the new government leadership heralded a new approach. It acknowledged that patterns of growth and development that consume rather than renew natural capital undermine the source of livelihood of the poor and most vulnerable and are not sustainable in the long term. As a result, one of the most significant policy shifts by the new leadership was away from a focus on development through industrialization and modernization (with commercial agriculture perceived as key to industrialization) to a much more explicit and substantive commitment to sustainability and green growth. The government's 15-year vision, 10-year strategy and 5-year National Socio-Economic Development Plan (NSEDP) all reinforce the commitment to the larger paradigm shift (World Bank, 2017b). The overarching outcomes of the 8th NSEDP (2016–2020) are summarized as equitable economic growth, improved socio-economic conditions, and environmental protection, with improved responsiveness to natural disasters (Government of Lao PDR, 2016).

Water security

The Mekong River dominates Lao PDR's water resources. Ninety percent of the country is in the Mekong River Basin, and tributaries rising in the country contribute 35% of the river's annual flow (FAO, 2011). The main stem of the river forms most of Lao PDR's western border. Although it is well-endowed with water, there is significant spatial and temporal variability. The higher elevations of the southern part of the country receive 3700 mm of rainfall annually, on average, while the northern valleys receive about 1,300 mm. About 80% of the surface water availability occurs in the wet season, and weather extremes are common. The country experienced five severe droughts and 15 severe floods between 1970 and 2010, resulting in loss of life and damage to infrastructure, agriculture and fisheries. The areas most vulnerable to flooding and drought are the fertile lowland plains (FAO, 2011). Households dependent on agriculture and fisheries are the most vulnerable to extreme weather events (World Bank, 2017b), which undermine both water and food security. It is estimated that 46% of the rural population of Lao PDR is vulnerable to drought, mostly in the lowlands, and 188,000 households are at risk of food insecurity caused by drought (Mahachaleun & Phongpachith, 2014). Floods also undermine food security. For example, in 2018 flooding during tropical storms Son-Tinh and Bebinca damaged more than 600 irrigation schemes across the country, reducing agricultural production and undermining government efforts to create a national rice reserve (*The Nation*, 2018).

Along the Mekong and its tributaries, river levels vary greatly between the wet and dry seasons, and the flooding brings benefits as well as costs. The annual 'pulse' plays a vital role in maintaining both biodiversity and important ecosystem services. Flood-deposited sediments improve soil fertility, cleanse the water of pollutants and recharge groundwater tables. Many rural livelihoods are founded on the integrated use of a wide range of natural resources, adapting to the seasonal changes of flooding and recession. Three main cities –

Thakhek, Savannakhet and Pakse – are on the southern section of the Mekong, and the people along the river store the floodwater in ponds for dry-season irrigation. The cycle of flooding also maintains an environment that supports a substantial number and diversity of fish, the primary source of animal protein for the population (Baran & Myschowda, 2009). About 70% of the country's farmers supplement their income with fishing on a seasonal basis (USAID, 2015).

Both floods and droughts reduce food production and hinder economic development. The National Disaster Management Plan (2012–2015) identifies floods and droughts as the primary hazards. It is estimated that annual losses from floods and droughts – a significant proportion of which are in the agricultural sector – amount to between 3% and 4% of GDP (World Bank, 2017b). For example, flash floods in 2006, 2007, 2011, 2013 and 2018 – perhaps exacerbated by changing rainfall patterns together with degradation of upstream watersheds – all caused extensive damage to infrastructure and the agriculture sector. In 2018, estimates of flood damage and production losses in the agricultural sector were USD 150 million, including USD 13.8 million of damage to irrigation schemes (Government of Lao PDR, 2018). Climate change projections include further increases in temperature and greater intensity and frequency of extreme events, including more intense rainfall, resulting in greater flood risks during the wet season (Eastham et al., 2008). Improving the country's ability to manage such events is now a key priority of the government (Government of Lao PDR, 2016).

The construction of large dams, primarily for hydropower, has had significant environmental and social impacts, both for communities displaced by the dams and reservoirs, and for communities downstream (Scudder, 2019). Weak enforcement of laws, a lack of capacity to regulate development, lack of transparency in decision-making processes and weak civil society have resulted in what has been termed 'water grabbing': powerful political elites and private-sector actors (from within and outside Lao PDR) working together to control the financial benefits of hydropower while the dams disrupt livelihoods and ecosystems (Matthews, 2012).

There are limited data or specific information, but water pollution, particularly from the agricultural and mining sectors, is widely perceived to be an increasing threat to both ecological and human health, particularly in sub-basins where these activities are concentrated and in communities that continue to depend on untreated river water for domestic supplies. In relation to mining (i.e. alluvial gold mining as well as sand and gravel abstraction), particular concerns relate to mining methods and their impacts on water quality and turbidity, as well as erosion of riverbeds and banks. Communities in southern Lao PDR have complained of water pollution from gold mining (Radio Free Asia, 2013). As a consequence of environmental and social concerns, including water pollution, in 2012 the government implemented a four-year nationwide moratorium on new mining projects which, despite pressure from mining companies, was extended in 2016 (*Vientiane Times*, 2016).

Cascades of dams and increasing competition between hydropower, urbanization, irrigation and the environment are changing river basin contexts. Limited opportunities to engage in cross-sectoral planning and decision-making processes and mechanisms for data sharing that enable sectors to inform collaboration and discussion, hamper sectoral development and disaster management. For example, hydropower presents risks but also provides opportunities for irrigation. Poorly coordinated releases from dams during

periods of high flow can, as they did in 2018, aggravate flooding and damage agricultural land and irrigation schemes, as well as the roads needed to transport produce. However, well-managed reservoir drawn-down prior to the inflow of large volumes of water – increasingly practicable with telemetry and modern techniques for forecasting rainfall and river flows – can provide storage for floodwater, reducing damage to agriculture and infrastructure. In addition, elevated dry season flows downstream of hydropower dams can provide additional resources (and reduced pumping costs) that may be exploitable in some irrigation systems. In several places, irrigation schemes are being developed in conjunction with large dams. For example, Nam Theun 2, Theun-Hinboun, Xepian-Xenamnoy and Nam Ngiep 1 are all developing canal irrigation schemes to enhance livelihood opportunities for resettled and relocated communities (International Water Management Institute, 2019). Studies in the Nam Ngum basin have shown the potential for joint development of hydropower and irrigation. In this instance, full hydropower development could enable dry-season irrigation water use to triple without harming the environment (Lacombe et al., 2014).

Lao PDR is a member of the Mekong River Commission (MRC), established in 1995 to strengthen transboundary water governance and promote the application of Integrated Water Resource Management. Compared to other river basin institutions worldwide, the MRC has a mandate and an organizational structure that are well constituted to link regional and national development. However, since its creation the MRC has faced a number of challenges, including a disconnect between national and regional priorities and decision making; inability to overcome sectoral fragmentation in water resource management at the national level; limited involvement of China, which has only committed to being a ‘dialogue partner’; limited interaction with other regional development initiatives, such as the Greater Mekong Subregion (GMS) programme, supported by the Asian Development Bank; and limited grass-roots participation (Middleton & Allouche, 2016; Suhardiman et al., 2012). As a result, the MRC has struggled to translate the outcomes of its regional programmes into policy formulation at the national level, and the riparian countries, including Lao PDR, have largely continued to focus on national development plans, regardless of MRC initiatives and potential transboundary effects (Suhardiman et al., 2012).

Improved water resource management is seen as critical to the green-growth agenda and is important to ensure sustainable development of the hydropower potential in the country (see below). Recognizing the importance of water management for sustainable development, a new Law on Water and Water Resources was approved by the National Assembly in May 2017 (Government of Lao PDR, 2017). Developed through a process of stakeholder engagement, the new law includes provisions on water rights and use, including wastewater discharge permits, wetlands and water resources protection, groundwater management, and river-basin management. It also expands the terms and conditions of large, medium and small-scale uses and includes articles on environmental flows for hydropower, as well as stipulations on irrigation use. Responsibility for strategic planning of water resources (at the basin level) lies with the Ministry of Natural Resources and Environment (Government of Lao PDR, 2017). A new National Water and Water Resources Management Strategy is currently being developed, with a key element being more coordination between government and non-government agencies to improve sustainability in water use and water infrastructure. The challenge is to convert

the legislation and strategy into actions on the ground. This challenge is further complicated by devolution and decentralization processes – currently focused on irrigation and upland forest management – which in theory increase the power of provincial governments and local communities but in reality are hampered by lack of resources and technical capacity (Sylavong, 2014).

Food security

Despite strong economic growth in recent years (6.9% in 2017 and 6.3% in 2018), food deprivation remains a critical issue. On average, 1.1 million people (16.5% of the population) were undernourished in 2016–2018 (FAO, 2019). There are few recent data, but in general households overconsume staples (primarily rice) and underconsume protein, fat and micronutrient-dense food groups (i.e. below the WHO recommended minimum intake). Micronutrient deficiencies, especially iron, vitamin A and iodine, are a major concern. These problems translate into poor performance in many indicators of nutrition status, including, as mentioned, unacceptably high levels of under-five stunting.

There are many underlying causes of undernutrition in Lao PDR, including inequities in wealth, health, education and food security (European Union, 2015). Ethnic minorities tend to endure more social disadvantage, which translates into much higher rates of malnutrition than in the dominant Lao Tai ethnic group. With up to 80% of the population relying on subsistence agriculture and 72% of all food consumed sourced from household's own production (Lao Statistics Bureau, 2012), poverty (and inability to purchase healthy foods) is a major contributing factor. In addition, poor access to water and sanitation facilities (countrywide, 28% of the people have no access to clean drinking water, and 37% have no access to improved sanitation) results in high levels of infections and diarrhoea, which limit one's capacity to absorb nutrients. Frequent floods and droughts not only undermine food production (as mentioned earlier) but also have a devastating impact on households, further undermining their ability to access nutritious diets. Cultural practices that impose restrictions on what infants consume, and lack of education of mothers, have also been found to be significant factors in malnutrition (Annim & Imai, 2014).

In the past, the government of Lao PDR has focused on increasing food availability and access; there has been much less emphasis on nutrition and health. Since it is the sector generating income for most people, growth in agriculture continues to be perceived as critical, both for the national economy and for poverty alleviation (World Bank, 2017b). The National Growth and Poverty Eradication Strategy aims to maintain a growth rate in agricultural output of 4–5% annually (driven by village and district level action), promote commodity production and exports, and diversify and modernize agriculture (Government of Lao PDR, 2013). Nationally, there is a focus on rice, which is the national staple, but also on corn, coffee, sugar cane, cassava, yellow beans and Job's tears (Government of Lao PDR, 2016).

Although it is not well documented, past efforts to increase agricultural production through both expansion and intensification damaged ecosystems and undermined water security (e.g. through deforestation, soil erosion, nutrient runoff and water pollution). In the north, fish kills have been attributed by local communities and government officials to agro-chemical pollution downstream of irrigated bananas (Radio Free Asia, 2019). Farmers

are typically unable to read the labelling on the imported Chinese fertilizers and pesticides that are widely available throughout the country, and are unaware of the instructions for safe application, with potentially dire consequences for both their own health and the environment.

Against this background, the 2016 policy shift to a green economy is echoed in statements pertaining to agriculture in the 8th NSEDP with greater focus on the improved management of natural capital, nutrition-sensitive agriculture and greater resilience to natural disasters and climate change. Although irrigation has reduced poverty and increased food security, the 8th NSEDP makes clear that in recent years it has largely failed to live up to expectations. Plans to increase the irrigated area have only been partially successful, undermined in part by flood damage and limited finances for rehabilitating existing schemes (Government of Lao PDR, 2016).

There are broadly two main types of irrigation in the country: lowland pumped schemes and upland gravity-fed schemes. Most irrigation is used for rice production, with some horticulture near major markets. Poor water management is one of the main reasons both types of irrigation are underutilized and underperforming. Many schemes cannot supply water effectively during droughts or resist flooding without damage. In many lowland schemes, irrigation service fees are insufficient to cover the electricity costs of pumping, and many schemes have accumulated substantial debt with Électricité du Lao, the national electricity provider. As a result, national and international funding for irrigated rice have not produced a concomitant increase in production. Many upland schemes lack water storage, and dry-season flows are often insufficient. In many places this has been exacerbated by watershed degradation, leading to further reduction of dry-season flows and sedimentation upstream and downstream of weirs and in irrigation canals. Watershed degradation is a concern throughout Lao PDR: 84% of Lao PDR's land is at least moderately degraded (FAO, 2000). Degradation is particularly severe in the uplands because steep slopes, heavy wet-season rainfall and poor soil quality exacerbate erosion. This is an ongoing problem arising not only from land clearance and swidden agriculture (still practiced in places) but also illegal logging and poor land management in some economic land concessions. Watershed degradation is aggravated in places by agrochemical misuse and climate change impacts (International Water Management Institute, 2019).

Despite the failure to meet previous targets, irrigation remains a central element of the agricultural development proposed by the 8th NSEDP, and the National Indicative Plan (for Climate Change Adaptation) highlights sustainable agriculture as a focus area – specifically, improving irrigated agriculture to raise crop productivity and food security for small farm households (Government of Lao PDR, 2012). Hence, in line with the new focus on sustainability and green economy, much greater emphasis is now being placed on medium-sized and small schemes and on improving the robustness of schemes to cope with climate change and natural disasters.

In Lao PDR, significant large-scale concessions have been granted to national elites, with investment support from overseas (e.g. China, Vietnam, Thailand, Singapore and the Middle East). Agriculture and forestry concessions encompass coffee, cassava, rubber, and sugar cane. For example, the privately owned Vietnamese company Hoang Anh Gia Lai and the state-owned Vietnam Rubber Group have both acquired land concessions. Hoang Anh Gia Lai works partly through subsidiaries and is estimated to have 266 km² under

rubber in southern Laos, while Vietnam Rubber Group owns more than 380 km² of rubber across the whole country (Hirsch & Scurrah, 2015). Most of these concessions have come from land earmarked as fallow but which in reality have been forested or have been part of fallow cycles important to farmers for grazing livestock (Kenney-Lazar, 2010). Very often households lose access to land that is important for cultivation, livestock grazing and forest products, reducing income and food security (Kenney-Lazar, 2010). Furthermore, large-scale land conversion can have significant impacts on local stream flows, sediment loads, agrochemical pollution and ecosystem services. Plantations effectively compete with community food production for land and water (Fullbrook, 2013; Pech, 2013).

Another aspect of food that is intertwined with the water-energy-food nexus of the Mekong is fish. Across the Lower Mekong, fisheries make a vital contribution to the livelihoods and well-being of millions of people. In Lao PDR, most of the catch is harvested by part-time subsistence fishers who are poor and generally fish opportunistically as part of a diversified livelihood strategy (Baran & Myschowda, 2009). Rural families harvest fish and other aquatic animals, such as crabs, shrimps, snails, frogs, insects and plants, from nearby fields, canals, ponds, rivers, streams and lakes. Although per capita daily volumes are modest and largely go unrecorded in government statistics, the cumulative total is large, and the fishery is critically important for peoples' well-being, providing many people with their primary source of protein and micronutrients (Meusch et al., 2003).

Despite its importance, data on fisheries yields are sparse, contradictory and invariably underestimated. Differences in methodology and inconsistency in the way data are presented in different studies make comparisons difficult. According to FAO statistics (certainly underestimated), the wild fisheries catch of Lao PDR varies annually but produces on average 35,000 t/y (Figure 2). Although there are no statistically significant trends, per capita capture fisheries are believed to be declining in the Lower Mekong, partly through increased fishing pressure but also as a consequence of dam construction and increasing agrochemical pollution. There is some evidence that the size of fish caught is declining, indicating fisheries under pressure (Mekong River Commission, 2017). Dams and other water control infrastructure (e.g. flood embankments and irrigation off-take

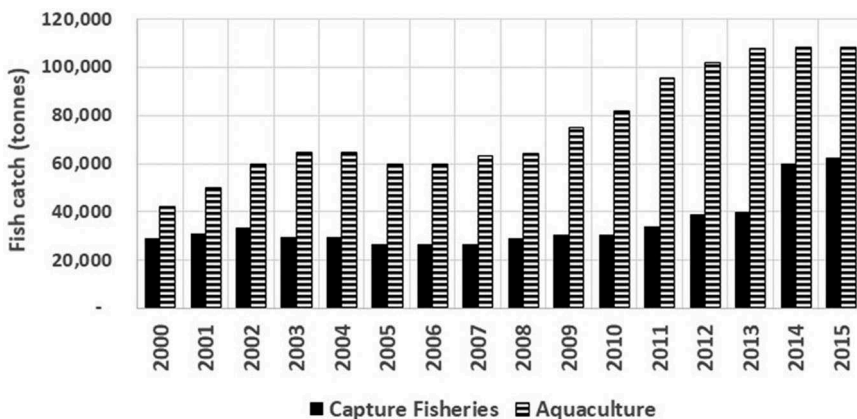


Figure 2. Wild capture fisheries and aquaculture yield in Lao PDR from 2000 to 2015.

Sources: FAO global capture fisheries production (<http://www.fao.org/fishery/statistics/global-capture-production/en>), FAO global aquaculture fisheries production (<http://www.fao.org/fishery/statistics/global-aquaculture-production/en>).

structures) are contributing to the decline by blocking fish migration routes both up and downstream, as well as to and from floodplains, preventing breeding (McCartney et al., 2019). Agrochemicals are also harming fisheries. Research has found pesticide residues (e. g. DDT and other organochlorine compounds) in sediment and molluscs in the Vietnam Delta (Carvalho et al., 2008). It is possible that if investigations were undertaken these results would be replicated in Lao PDR.

The government is promoting aquaculture, particularly small-scale culture fisheries in ponds. Official FAO statistics indicate that at the national level, aquaculture production already exceeds capture fisheries, with total production on average 2–3 times greater than official capture fisheries (Figure 2). Integration of fisheries and aquaculture within irrigation schemes is not yet common practice but is a way the performance of irrigation schemes could be enhanced, with both livelihood and broader economic benefits (McCartney et al., 2019).

Energy security

Hydropower has been one of the single biggest drivers of change in Lao PDR over the past 20 years. As in much of the rest of the world, the prevalent paradigm of governments and financial institutions of South-East Asia is that huge infrastructure investments (including those needed for electricity generation) are a precursor to economic growth and hence social development (Asian Development Bank, 2013). Although in reality the links between electricity generation and economic development are complex, analyses present a simple and seemingly compelling national-level narrative for policy makers in Lao PDR and its neighbours: increasing electricity generation increases GDP, and increasing GDP reduces poverty.

The country's mountainous terrain has good potential for hydropower generation, which in the context of an emphasis on renewable, non-fossil-fuel generation, the availability of private financing and power lines that facilitate inter-country transfers, the government has prioritized as the engine of development. Electricity consumption in the country has increased rapidly over the past two decades, and despite uncertainty in the exact magnitude, is forecast to continue increasing with rising living standards, rural electrification and industrial development. The 2012 Law on Electricity promotes development of electricity in an economical, effective and sustainable manner and as an export commodity (Government of Lao PDR, 2012). Lao PDR aims to expand the electricity network to full coverage, primarily through the construction of small and medium-scale projects, including hydropower, solar and wind (Government of Lao PDR, 2013). Rural electrification has been very successful, increasing from approximately 20% of households in 1995 to 90% of households now (World Bank, 2017b).

The rapid development of hydropower has been used primarily to boost economic growth through the sale of electricity to neighbouring countries. In this context, water resources are viewed as a mechanism for wealth creation and economic development in a country with few advantages over its neighbors. Until recently, the government sought to brand the country as the 'Battery of South-East Asia', and the export of electricity is an increasingly important source of income for the country. In 2017, total installed hydropower capacity was 4,984 MW (International Hydropower Association [IHA], 2018), from a

total exploitable potential of around 23,000 MW (Vongsay, 2013). Increasing cross-border transmission lines is a key component of the government's 'land-linking' initiative.

Electricity generated from hydropower has increased more than 18-fold since 1991 (Figure 3), and the percentage of generated electricity exported increased from approximately 65% in the early 1990s to as much as 82% in 2014 (Government of Lao PDR, 2015). Currently, electricity accounts for about 30% of total export value (IHA, 2016), with existing exports to Vietnam and Thailand and ongoing negotiations with Cambodia and Myanmar (IHA, 2018).

The 8th NESDP foresees the continued development of electricity generation as an industry, focusing on renewable energy and hydropower, as a way of turning the power sector into a sustainable income-generating sector (Government of Lao PDR, 2016). There is an emphasis on sustainability and competitiveness, with energy development and utilization being clean and environmentally friendly and protecting forests and water sources. The intention is to expand the electricity sector by an average of 32% per year and limit electricity imports to no more than 20% of total usage by 2020 (Government of Lao PDR, 2016).

More than 50 hydropower projects are under development across the country, representing 8000 MW of new capacity (IHA, 2018). However, the sector may be reaching its limits for growth in the absence of improved water resources management, including coordination with non-power uses of water. Although there have been some cases of large hydropower schemes being integrated with irrigation, typically (as noted above) hydropower and irrigation are planned, developed and managed in isolation, a fact highlighted by the flooding in 2018, when damage to irrigation infrastructure and the agricultural sector was aggravated by uncoordinated releases of water from hydropower dams.

How to balance the benefits of hydropower against the social and environmental costs is increasingly controversial. Although civil society in Lao PDR has limited opportunities to protest, population displacement, reduction/alteration of downstream flows, and creation of barriers to migrating fish and downstream sediment movement create complex (and often transboundary) challenges that are difficult to mitigate and are increasingly recognized to have economic and political implications (MRC, 2018). Furthermore, concerns are

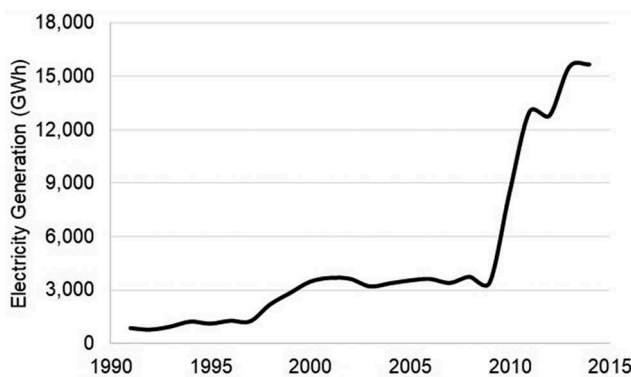


Figure 3. Hydro-electricity generated in Lao PDR between 1991 and 2014.

Source: Government of Lao PDR (2015).

growing that large-scale development projects have benefited urban areas while local populations suffered the environmental and social costs (Matthews, 2012). It is also realized that further regulation of rivers may result in projects that could undermine future options to adapt to market, environmental, social and climate changes (World Bank, 2017a).

Displacement of the people living in the area that will be inundated by the reservoir is recognized as one of the worst social impacts of dams. Throughout Lao PDR tens of thousands, possibly hundreds of thousands of people, mostly of ethnic minorities, have been or will be displaced by large dams. The economic and social values of livelihood strategies followed by communities before their displacement are often undermined. Relocated people typically lose not only their land but also access to the resources that they once relied on. This forces a greater reliance on cash incomes, and breadwinners often have to seek wage-earning jobs. In general, displaced people are more landless, unemployed, indebted and hungry after displacement. Funds for resettlement and rehabilitation are almost always inadequate (Scudder, 2005).

For example, in Lao PDR, the Nam Theun 2 project has been controversial, with differing views on the extent to which it can be deemed a success, despite a concession agreement that required it 'to materially improve resettler livelihoods on a sustainable basis' and its being superior to other similar projects in Lao PDR (Souksavath & Nakayma, 2013; Scudder, 2019; World Bank, 2019a). What is clear is that within dam-affected communities, some groups are better positioned to benefit than others (Souksavath & Maekwa, 2013). For example, well-connected and educated young men tend to be the primary beneficiaries of the employment opportunities created by dams, while women and children are disproportionately affected by the loss or degradation of forest and water resources (World Bank, 2010). Such socio-economic and demographic factors can combine in ways that broadly enhance prospects or exacerbate vulnerabilities and inequality (Asian Development Bank, 2013).

The energy sector in South-East Asia is evolving rapidly. The Association of Southeast Asian Nations (ASEAN) has set an aspirational target of securing 23% of its primary energy from modern, sustainable renewables by 2025 (34th ASEAN Ministers on Energy Meeting, Na Pyi Taw, Myanmar, September 2016). Although in their definition hydropower is classified as renewable, there is a recognition that non-hydropower renewables (primarily solar, wind and bioenergy) can also make a significant contribution to this target (IRENA and ACE, 2016).

Globally record-low prices for utility-scale photovoltaics and wind in 2016 (as low as USD 0.03 per kWh¹), as well as more and more examples of how variable renewables can be integrated into existing grids while maintaining or even improving supply reliability, are increasing both the economic and technical viability of these energy sources. Most projections are that the global price of solar and wind will continue to fall as a result of economies of scale and the rise of alternative funding frameworks (Weatherby & Eyler, 2017). Although the very low prices of non-hydropower renewables have yet to reach the Mekong region, Lao PDR (and neighbouring countries) could all benefit from these global trends. And although electricity generation will remain dominated by hydropower in the near future, the non-hydropower renewables are likely to be increasingly competitive on price (and environmental and social returns) and, over time, should reduce the number of dams that need to be built. Such a scenario is more likely with better system-scale

planning and if a region-wide grid and framework for power trade can be established (Weatherby & Eyler, 2017).

Lao PDR and the Belt and Road Initiative

China is Lao PDR's largest trading partner and foreign direct investment partner (International Monetary Fund, 2019), but Lao PDR is only partially integrated in the global trading system. It trades and attracts investment at rates well below potential, partly due to its poor infrastructure and partly because of inefficient policies (i.e. policies that do not result in desired outcomes or in some instances produce unintended adverse outcomes). The density and quality of transport infrastructure and services are low, resulting in above-average trade costs and trading times. Furthermore, policies that would boost trade and investment remain more restrictive, and trade agreements less comprehensive, than those typically found in high-income countries (World Bank, 2019b). As an example, market demand for high-value crops (maize, watermelon, vegetables) is increasing, and in some places in Lao PDR farmers grow these crops, not only for small domestic markets but also for export to Thailand, China and Vietnam. However, market risks remain high. Many market chains for products are dominated by small operators (mostly low-volume and low-margin traders). In these circumstances, supply chains are often based more on cooperative than contractual arrangements, and for many small producers, the market risks outweigh the climate and production risks. Thus, the agribusiness sector growth needs direction and support to capitalize on current and emerging market opportunities (Asian Development Bank, 2018).

The BRI is not happening in isolation but is one of many ongoing development activities. Greater economic cooperation is promoted by ASEAN, of which Lao PDR is a member. There are also several regional infrastructure initiatives, such as the GMS, which is intended to enhance economic relations between the six countries of the Mekong River region (Cambodia, China, Lao PDR, Myanmar, Thailand, and Vietnam). The Ha Noi Action Plan (2018–2022) provides direction and operational focus to the GMS programme and guides identification of projects in transport, urban development, energy, agriculture, environment, tourism, trade and information and communication technology (Asian Development Bank, 2018). The GMS includes considerable investment in cross-border infrastructure development, as well as mechanisms to facilitate cross-border trade and investment.

The Lancang-Mekong Cooperation framework, signed by leaders from China, Myanmar, Thailand, Cambodia, Laos and Vietnam in March 2016, is a new initiative intended to enhance geopolitical relationships and cooperation between China and mainland South-East Asia. It commits the six countries to cooperation in five priority areas, including economic integration and water resources management. As such it provides an important framework for BRI investments. The inclusion of water resources alongside economic development is important because it potentially bridges a long-standing divide between the MRC and the GMS programme and is especially significant given China's past reluctance to engage deeply with the MRC (Middleton & Allouche, 2016).

Economic analyses show that BRI investments (such as the Vientiane-Kunming railway) could substantially improve trade, foreign investment, and living conditions for citizens in participating countries. Although precise predictions are difficult, it is estimated that

through stronger regional integration and better access to export markets, Lao PDR would be one of the biggest beneficiaries of the BRI, with its economy expanding by approximately 3.1% and with significant potential to lift many people out of poverty (World Bank, 2019b). GDP per capita might grow from USD 1751 in 2014 to USD 4030 in 2030 (Maliszewska & van der Mensbrugge, 2019). However, it is recognized that such gains would not be evenly distributed throughout the country and are also associated with considerable risks. Lao PDR already has high debt levels (ca. 53% of GDP, 42% of which is held by China) and low levels of international reserves (IHA, 2018). In these circumstances, the trade-offs of BRI investments must be considered very carefully. Great care is needed to ensure that the large costs of infrastructure investments and the resulting large debts do not undermine the welfare gains (Hurley et al., 2019; World Bank, 2019b).

There is considerable uncertainty about how BRI investments will impact the environment, and in particular water resources. Impacts will vary by location, type of infrastructure and local context, but there is little doubt that BRI projects will impose additional direct and indirect pressures on water resources. Many BRI infrastructure projects in Lao PDR are in areas vulnerable to degradation, flooding and landslides, and some are in ecologically important landscapes. The additional risks in Lao PDR, as elsewhere in South-East Asia, include higher pollution and illegal timber and wildlife trade. Large infrastructure projects are also associated with the need to resettle people, which, as noted above, almost always has negative impacts on peoples' livelihoods and well-being. Furthermore, the damaging environmental impacts of different development projects (e.g. concessions for hydropower, mines and agribusiness) often overlap, increasing their severity. BRI projects could contribute to these cumulative impacts, which are rarely recognized and never adequately compensated (Baird & Barney, 2017).

Although China has acknowledged social and environmental concerns, there are no statutory requirements for environmental and social safeguards for BRI projects, nor any clarity on which safeguard standards would apply (i.e. Chinese, host country, or international best practice) nor how stringently they would be applied (Morris, 2019). Current environmental and social impact assessment procedures in Lao PDR are good on paper but are poorly implemented. Too often there is little attention to the actual effects of project construction and operation, and there is little systematic follow-up on decision making. Thus, environmental and social impact assessments often become a tool for project justification rather than a planning tool to bring about real environmental and social benefits. Key limitations are the weak regulatory and institutional framework; lack of relevant expertise in the project management teams; lack of monitoring, which means that managers are unable to make informed decisions; lack of public participation; and the absence of a strong civil society to follow up and ensure that the recommendations following environmental impact assessment are implemented (Wayakone & Makoto, 2012).

Discussion

Although Lao PDR is not water-stressed in the conventional sense of insufficient resource availability, the multiple interlinkages between water, food and energy complicate the outlook. Water security is undermined by inability to cope with water variability and by uncoordinated efforts to enhance economic growth, food and energy security.

Vulnerability to natural disasters, in particular floods and droughts, affect economic growth and undermine efforts to reduce poverty. Opportunities for integrated solutions that achieve multiple objectives (e.g. designing hydropower in tandem with irrigation and fisheries) are overlooked because of institutional fragmentation, the political economy and technical difficulties of holistically managing water, energy and food.

Nationally there are very few initiatives on cross-sectoral decision making. Few approaches, if any, have addressed the broader interdependencies, and as a result there are no incentives for cooperation between sectors, between government and affected communities, between local and national governments, or between the public and private sectors. For Lao PDR the silo effect extends across international borders, not only of adjoining countries sharing watersheds but also of countries increasingly connected through trade, supply chains and movement of people. Such siloed approaches hinder comprehensive management and undermine opportunities to implement sustainable development options.

With its extensive natural resources and its geographical proximity to China, Lao PDR is critical to the implementation of the BRI. For Lao PDR the BRI is an opportunity to improve connectivity and transform economic conditions by building much-needed infrastructure, strengthening regional integration and enhancing trade opportunities (Cox et al., 2018). Currently, there are about 20 BRI-related infrastructure projects under construction or planned in the country. These include hydropower (e.g. a cascade of dams on the Nam Ou, a major tributary to the Mekong River), electrical grid network construction, and road and rail construction, including the railway from Vientiane to southern China (Morris, 2019; Sayavong, 2018). Total BRI-related investment in the country is estimated to be USD 47.7 billion. Anticipated positive social-economic outcomes include lower poverty through job creation, higher productivity and faster economic growth (Cox et al., 2018).

By pouring billions of dollars into a county with limited human resource capacity and no integrated planning process, BRI projects risk exacerbating rather than alleviating Lao PDR's development challenges. For example, better regional transport links will improve opportunities for commercial agriculture (e.g. plans exist for agricultural expansion in close proximity to the Vientiane-China railway), which could increase water abstraction for irrigation and use of agrochemicals. Similarly, further investment in hydropower dams increases the risks of drought-induced dry-season power outages, as well as changing patterns of market demand as Thailand focuses more on domestic power production. There is also growing realization of the political consequences of dams for regional food security and delivery of sediment and nutrients to Vietnam's Mekong Delta (MRC, 2018). Research has shown that BRI investments will tend to bring benefits to urban hubs, particularly those near border crossings, while more remote and isolated regions, with little comparative advantage, will be relative losers (Lall & Lebrand, 2019). The risk is that in Lao PDR, those regions that are already disadvantaged will not gain from BRI investments and may even end up worse-off.

In the context of the BRI, the 'green growth' the government desires can only be achieved through investments that take into account the water-energy-food nexus. The imperatives of sustainability and greater inclusiveness require a radically different approach from the past, in which development investments are considered not in isolation but as critical elements of the landscapes in which they are located. Infrastructure needs to be planned and managed not only for the primary purpose for which it is

constructed but also taking into account critical ecosystem services. This requires a systematic approach, considering investments in the context of the landscape/basin in which they are located and the associated interconnections with upstream and downstream aquatic and terrestrial landscapes. It means considering cumulative impacts across scales and communities.

This requires cooperation across the agriculture, energy, infrastructure, water, land and natural environment sectors. A 'nexus approach' is essential to reveal complex interrelationships and enable so-called 'nexus solutions' to be identified (those that explicitly account for intersectoral trade-offs, compromises or synergies across the sectors). In this context, there has been a call for decision-making processes around BRI investments to embrace three key characteristics: transparency, participation, and commitment to international standards (Hong & Johnson, 2018). Only by openly acknowledging trade-offs between competing priorities and taking into account the latest scientific understanding can unnecessary negative impacts be avoided. To this end the 8th NESDP and the associated policy changes are a good first step in aligning policies that reconcile economic prosperity, social equity and ecosystem protection with the actions required to bring about sustainable development.

To build sustainability the government should be asking what alternatives BRI investments could support (e.g. nature-based solutions, enhanced fisheries in existing reservoirs, and organic production of nutritious food crops – not just rice – for domestic consumption and export) beyond those currently envisaged. Priority must be given to initiatives compatible with national development priorities, those with a large social impact, and those which will mitigate natural disasters. Synergies with development projects conducted through other initiatives should be identified, because optimizing value from individual BRI projects will be contingent on realizing others, both within and beyond the BRI. Improving coordination and cooperation, not just between China and Lao PDR but also among all the countries of the GMS and the BRI economic corridor, will help BRI investments reach their full potential (World Bank, 2019b). To address environmental and social concerns, it is important to conduct rigorous and comprehensive strategic assessments of all BRI infrastructure projects. Such assessments should be focused on the entirety of the BRI development projects, as well as those associated with other development programmes (eg. GMS), and should address cumulative direct and indirect risks.

A nexus approach, with water as a central integrating attribute, provides a mechanism for promoting cross-sectoral cooperation and for better understanding the complex interactions and cumulative cross-sectoral (and cross-boundary) effects of multiple development options and investments (Smajgl & Ward, 2013). Given the increasing interconnectedness across sectors and in space and time, reducing negative economic, social and environmental externalities is a prerequisite for increasing overall resource use efficiency, delivering more equitable benefits and achieving the ambitions of the BRI.

Conclusion

In Lao PDR the water, food and energy sectors are tightly intertwined and co-dependent. High levels of poverty, household food insecurity and water insecurity, as well as the environmental pressures that the present patterns of economic growth are creating, indicate that the current development trajectory is unsustainable in the long term.

China's BRI is a significant opportunity for socio-economic development, but great care is needed to ensure that the infrastructure investments it supports do not exacerbate rather than alleviate development challenges. The future of Lao PDR depends in large measure on stewardship of natural resources, including water, and greater inclusiveness in the benefits of resource exploitation. This reality is now recognized by the government that has recently reoriented to a green-growth strategy. In this context, a nexus approach that reveals interrelationships, linkages and complex associations is essential, even in the absence of physical water scarcity. Sustainable and resilient resource use is inherently integrative, and a nexus approach, focused on enhanced water resource management, is the best way to achieve that integration.

Note

1. In comparison, hydropower costs are very site-specific but typically USD 0.02–0.19 per kWh (IRENA, 2012).

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